NATURAL CAPITAL ACCOUNTING FOR THE MINING SECTOR

BEENUP SITE PILOT CASE STUDY

Prepared by Syrinx Environmental for BHP
A Collaboration between BHP, CRC TiME, CSIRO, Curtin University, Syrinx Environmental, The University of Western Australia and the Western Australian Biodiversity Science Institute (WABSI)

Content

Legal Disclaimer

Pilot Case Study and Use of Best Estimates

This document is a pilot case study intended to support mining industry, regulatory and finance community discussions on how natural capital accounting (NCA) approaches can be applied in the context of a mining operation. BHP acknowledges that natural capital accounting is an evolving field, and cautions that this pilot natural capital accounting case study should be read accordingly and not interpreted to present either financial accounts or a resolved set of natural capital / environmental accounts for BHP or the Beenup site. In particular, in some instances incomplete data or the absence of consistent and continuous measurements (particularly due to the retrospective nature of this study) meant that estimation methods (modelling and proxy data) were used to derive some of the study outputs. The study has used a best estimate approach to the assessment of the changes to the physical stocks and flows at the Beenup site over the course of pre-mining, mining and rehabilitation land-use phases, and adjustments to the illustrative-only value of these natural capital assets with time. Refer further to the limitations to the pilot case study's applicability to an operational mine site and association with data availability, costing and valuation described in the final sub-section of the About Natural Capital Accounting section of this document.

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Acknowledgements

Acknowledgement of Country

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BEENUP SITE AT A GLANCE

153 ha

Threatened ecological community protected

4

Nationally listed flora threatened species and four internationally listed fauna species supported post-restoration

15

Ecological communities restored

251

Plant species restored after mining

~AUD$40m+

Estimated potential natural capital asset value

~AUD$1m

Per annum potential annual societal benefits

~40%

Increase in natural capital asset value per hectare

~7,000 t

Carbon (CO_2-eq) sequestered annually

LETTER FROM BHP'S VICE PRESIDENT ENVIRONMENT

BHP is proud to share this pilot case study as a contribution to the development of Natural Capital Accounting (NCA) for the mining industry. This study is an important first step in developing and testing how BHP can better integrate our environmental and business reporting in a way that makes clear our impacts and dependencies on the environment. This is in alignment with the United Nations (UN) Sustainable Development Goals and BHP's new social value framework and 2030 sustainability goals.

We see that one of the challenges for managers of nature assets is finding a way to consistently and objectively measure the extent and condition of those assets – and assess how these change over time. We believe that tools such as NCA are one of the enablers we need for better decision making if society is to halt and reverse current trends in nature loss by 2030. NCA will not tell us if the asset base is sufficient to ensure healthy functioning ecosystems, but it can help inform which practices and actions we should be taking to support nature, and track outcomes relating to those actions over time.

This Beenup site pilot case study is a special project that has shed a positive light not only on key considerations for applying NCA in a mining context, but also on the impact that high quality land restoration can make on building valuable ecosystem assets and supporting ecosystem services, such as carbon sequestration, water quality improvement, and habitat provision for threatened species. It provides us with a starting foundation for evolving NCA concepts and expanding learnings to our operational sites, to help us along our pathway towards effectively and transparently contributing to nature positive outcomes, and meeting our 2030 social value goals.

Anne Dekker

Vice President Environment BHP

We believe that tools such as NCA are one of the enablers we need for better decision making if society is to halt and reverse current trends in nature loss by 2030.

FOREWORD – TECHNICAL ADVISORY GROUP

The ongoing global challenges of climate change, biodiversity loss and degradation of nature has come to be seen as a material risk to the way organisations operate, and is gaining momentum as a driver for change in the mining sector. NCA has emerged as an approach to enable organisations to better account for and disclose their impacts and dependencies on nature. The premise of NCA is that ecosystems produce a range of goods and services that support production and are critical inputs into the profitability and sustainability of an organisation. Traditionally the domain of national accountants, the increasing sophistication of investors and the growing calls for disclosure of nature-related impacts and dependencies has seen a rapid growth of interest in NCA applications in the private sector.

Against this backdrop, BHP has taken an early lead in the mining sector to trial NCA on one of its closed Australian mineral asset sites (Beenup Titanium Project) to help inform how it might be adopted across their operations and within the industry more broadly. This Beenup pilot case study represents one of the first attempts at developing a set of natural capital accounts within the mining sector.

The Beenup site provided a unique opportunity to trial NCA spanning pre mining, operational and closure phases of a mine's life cycle, and within a global biodiversity hotspot in southwest Western Australia. The case study provides an invaluable perspective on the outcomes for nature associated with changing land use regimes: from agriculture to mining to the restored ecosystems of today that provide habitat for a range of threatened species and communities. This pilot study is an important first step that has opened the door for broader adoption of NCA in the sector. It has demonstrated the potential for developing a natural capital balance sheet as an approach to summarising the wealth of environmental and operational data mining companies typically hold in a format well aligned to existing financial reporting statements.

NCA is a multidisciplinary exercise that builds on a range of skills and backgrounds. A key outcome of the Beenup site pilot case study was the collaboration between industry (through BHP personnel), consultants, academics and research providers, which is critical to building capability within the sector and tackling some of the deeper conceptual challenges. A Technical Advisory Group was established to guide this case study and provide a collaborative expert forum for understanding and distilling the key gaps, challenges, and opportunities for natural capital accounting in a mining sector application.

Integrating nature into our decision making across society will be an important component of responding to the challenges of the next decade. The Beenup site pilot case study has been an amazing opportunity to explore this through the lens of natural capital accounts. It has helped to demonstrate what is required to make natural capital accounts achievable in a mining sector context.

Anthony O'Grady

Senior Principal Research Scientist, CSIRO Environment
Chair, Beenup Technical Advisory Group

PURPOSE

The Beenup pilot case study is the first attempt at Natural Capital Accounting (NCA) within the mining sector. It is not a financial report but rather an illustrative analysis, and to that extent includes example natural capital accounts that can be used as a guide for future studies and a basis of learning and improvement.

This case study applies to the BHP Beenup Mineral Sands closure site ('Beenup site') in southern Western Australia. It shows the inputs and analyses needed to enable a set of natural capital accounts to be developed for use alongside conventional financial accounts to highlight the relationships between a business and its environment.

The Beenup site pilot case study is not a financial report but is rather an illustrative analysis, and to that extent includes example natural capital accounts. The approach taken builds on the principles and theories already embedded in NCA and reporting elsewhere and highlights the key gaps and learnings.

What is natural capital accounting?

Natural capital refers to the stock of renewable and non-renewable resources (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people (ecosystem services) (Natural Capital Coalition, 2016).

Natural capital accounting (NCA) is an environmental accounting framework that provides a systematic way of measuring and reporting on natural capital assets (stocks) and ecosystem services (flows). Its underlying premise is that since the environment is important to society and the economy, it should be recognised as an asset that must be maintained and managed, and its contributions (services) be better integrated into commonly used frameworks like the System of National Accounts (United Nations *et al.*, 2010).

NCA is emerging as a standard method for nations, states and corporations to better articulate the relationship between business and society and the environment. It aims to put nature related impacts (positive and negative, and direct and indirect) and dependencies (the natural resources used to generate profits) on the balance sheets and profit and loss statements of businesses and governments. Presenting natural capital balance sheets and environmental profit and loss statements as analogues of financial accounts is intended to provide information for decision makers in a more familiar format. The hope is that this will enable the consideration of nature in their decisions and encourage funds to be directed towards investments that create 'nature-positive' outcomes and away from those that may have negative outcomes for nature.

Why does natural capital accounting matter to BHP?

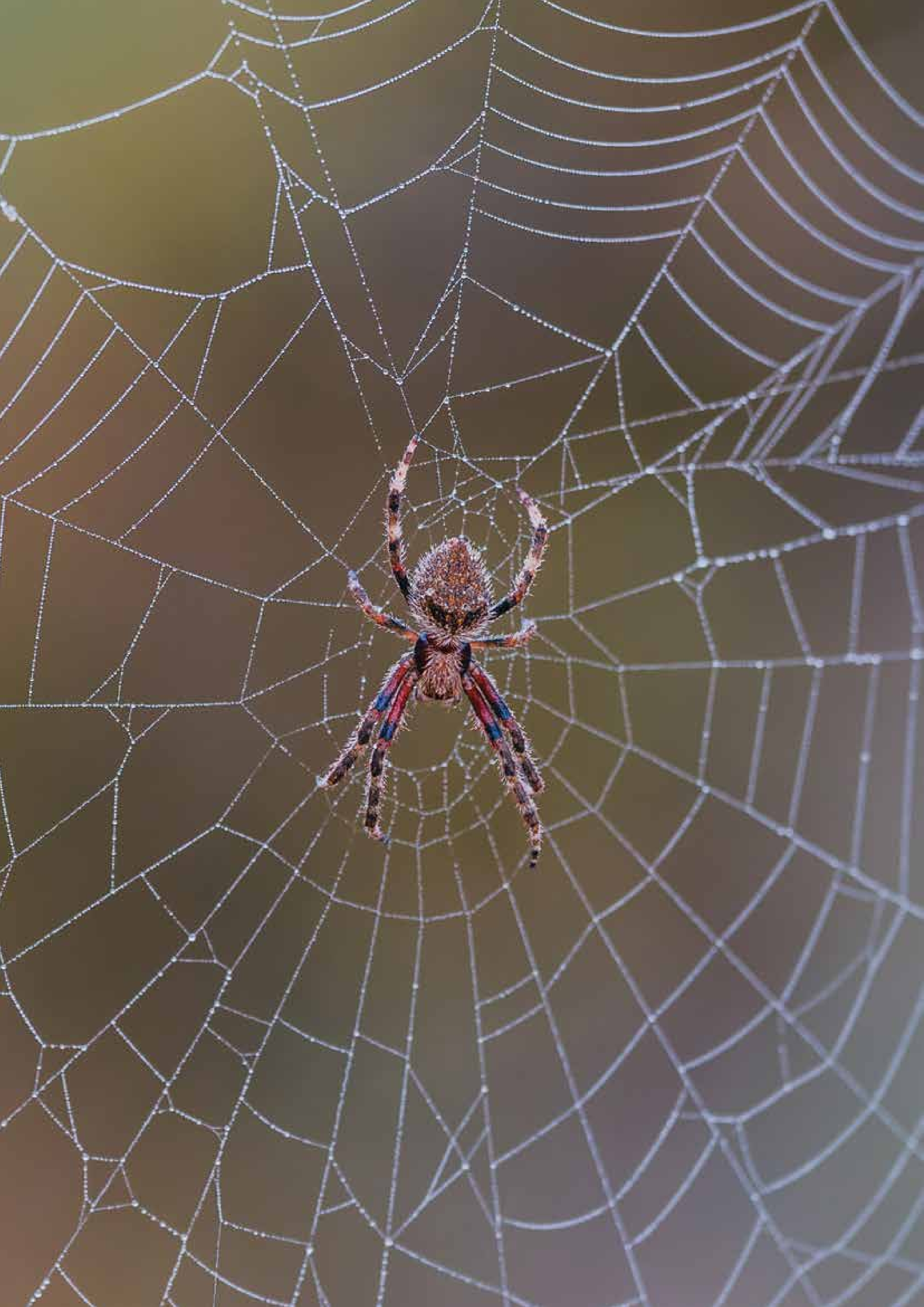
BHP recognises that it is a steward of significant areas of land and water. As at 30 June 2022, BHP owned, leased or managed over 8 million hectares, of which just under 6.5 million hectares relates to its Minerals Australia and Minerals Americas assets and just over 1.5 million hectares is in greenfield exploration licences (or equivalent tenements), which are outside the area of influence of our existing mining operations. Only around 2% of those ~6.5 million hectares is within BHP's mining operational disturbance areas. BHP therefore has much opportunity to positively influence nature-positive actions, considering the scale of nature assets it stewards.

In light of this, BHP recently launched its 2030 'Healthy environment' goal, which is to *'Create nature-positive[1] outcomes by having at least 30% of the land and water we steward under conservation, restoration or regenerative practices. In doing so, we focus on areas of highest ecosystem value both within and outside our own operational footprint, in partnership with Indigenous Peoples and local communities.'*

BHP has also joined the Taskforce on Nature-related Financial Disclosures (TNFD) Forum as it recognises the importance of the TNFD objective to 'develop and deliver a risk management and disclosure framework for organisations to report and act on evolving nature-related risks, with the ultimate aim of supporting a shift in global financial flows away from nature-negative outcomes and toward nature-positive outcomes.'

BHP acknowledges that companies need better information to incorporate nature-related risks and opportunities into their strategic planning, risk management and capital allocation decisions. Natural capital – how we assess it and how it changes over time – is at the heart of the TNFD framework and BHP's 2030 Healthy environment goal. BHP is therefore seeking to gain and share insights on the options and approaches for developing NCA in a mining context that could be adopted at an organisation-wide level.

1. Nature-positive is defined by the World Business Council for Sustainable Development (WBCSD) / TNFD as "A high-level goal and concept describing a future state of nature (e.g., biodiversity, ecosystem services and natural capital) which is greater than the current state." It includes land and water management practices that halt and reverse nature loss – that is, supporting healthy, functioning ecosystems.



ABOUT NATURAL CAPITAL ACCOUNTING

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A number of existing international standards have been globally adopted for natural capital accounting. These provided the basis for the example accounts in this pilot case study, in the absence of current mining sector standards or guidance.

1. The current and most widely used international standard for NCA is the United Nations Statistical Commission's *System of Environmental and Economic Accounting (SEEA)* framework, which is also used in Australia for national reporting (Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW)). The two key frameworks are:
   - The Central Framework (SEEA-CF) which is the international statistical standard for measuring the environment and its relationship with the economy (United Nations *et al.,* 2014).
   - The Ecosystem Accounts (SEEA-EA), which is an integrated and comprehensive statistical framework for organising data about habitats and landscapes, measuring the ecosystem services, tracking changes in ecosystem assets, and linking this information to economic and other human activity (United Nations *et al.,* 2021).
2. The Natural Capital Protocol (NCP) is also widely used internationally, which is a standardised framework used to identify, measure and value the impacts and dependencies of businesses on natural capital (Natural Capital Coalition, 2016).
3. The Corporate Natural Capital Accounting (CNCA) framework was developed for the UK Natural Capital Committee (eftec, 2015) and, while it aligns with SEEA, it provides an approach for developing natural capital accounts for managers of natural capital assets, where the key purpose is to assist private organisations to monitor and measure the health and value of natural capital.

SEEA and the Natural Capital Protocol (NCP) have been applied to forestry (e.g., by Forico, Tasmania's largest private forestry management company) to date. The CNCA framework has largely been tested on owners of large natural capital assets in the UK, such as the National Trust (eftec. 2015).

Further research is continuing to develop new net biodiversity impact accounting and disclosure methods to better align with financial accounting standards and business reporting models (e.g., Houdet *et al.*, 2020, Bagstad *et al.,* 2020), while expanding SEEA standards to other businesses (e.g., Ingram *et al.*, 2022).

Currently, SEEA-aligned natural capital accounts are not widely used to inform business decisions but have the potential to help meet some of the business community's natural capital data needs related to a range of critical decisions and actions (Ingram *et al.*, 2022). Using SEEA as a framework at the business level supports the standardisation of methods and accounts, which can allow comparative assessments in a common language, and facilitates alignment and integration with other corporate and sustainable accounting standards, including independent auditing.

Although the current emphasis of NCA for businesses is on developing natural capital balance sheets and environmental profit and loss (EP&L) statements, ultimately social capital accounting will also be needed if companies are seeking a comprehensive assessment against global environmental, social and governance sustainability standards.

Ultimately social capital accounting will also be needed if companies are seeking a comprehensive assessment against global environmental, social and governance sustainability standards.

NCA in the mining sector

Although private-sector approaches to measuring, valuing, and integrating natural capital into business decision making are diverse and growing, there are currently few precedents for NCA in mining.

Alignment with the existing SEEA frameworks is important to ensure an accord with international statistical standards, with the national direction being worked on by DCCEEW, and with the Taskforce on Nature-related Financial Disclosures (TNFD) framework. Standardised approaches will also help ensure that as natural capital accounts develop, in time they can be embedded in existing sectoral reporting and disclosure systems and accounts can be compared across the sector.

In adapting these frameworks and developing a mining appropriate set of corporate natural capital accounts, the specific characteristics of the mining sector need to be factored in. Some of these likely to be common to most mining operations are considered to be:

- **The treatment of mineral resources in NCA:** large revenues and the quantum of value associated with mineral resources (which are environmental natural capital assets that are monetised) can cloud the value of ecosystem natural capital assets (which are typically orders of magnitude smaller currently), if mineral resources are included on NCA balance sheets and the EP&L statements. This can reinforce the false notion that ecosystem assets are not material to business decision making and be contra to the purpose of NCA. However, equally it is important to capture the diminished value of the mineral resources to society as the resource is depleted (as physical stock at least), which is typically not captured in current financial reports and disclosures (Hoang, 2017). Mineral resources are included in this Beenup pilot case study.
- **Scope of natural capital assessments:** there is a tendency to focus primarily on current and direct nature impacts and dependencies in assessing risk (and therefore effort in gathering data) such as on access to land and water; environmental, health and safety regulatory compliance; and on work needed to obtain environmental approvals and support operational efficiencies. These are predominantly operational, rather than whole of life-cycle, focussed and hence are concerned with impact minimisation and rehabilitation, not on positioning for potential future natural capital industries.
- **Consideration of the landscape context:** the scale of land ownership or leases under a mining company's control, the long-time horizons for most mine sites, the proportion of the area under control that is disturbed for mining operations and the large open areas that often abut or fragment rehabilitated or remnant areas can affect the quality or flow of ecosystem services (both negatively and positively).
- **Exclusion of other activities during operational mining:** the exclusion of public access and synergistic businesses make the realisation of natural capital flows and benefits during the operational phase difficult. At this stage, most 'nature-positive' conversations in mining are usually preceded by 'after mining'.

ABOUT THIS PILOT CASE STUDY

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The Beenup site was chosen by BHP as a pilot case study for NCA in the mining sector because it enabled retrospective tracking of different land uses over a short period of time, was supported by a rich knowledge bank and had nature-positive outcomes as an early intent.

The Beenup site has a number of advantages for exploring the application of NCA in the mining sector:

- Firstly, it provides an opportunity to follow changes to natural capital through four land use modifications over a relatively short time frame. The site has hosted primarily beef and dairy farming, to mining activities, to remediation, to its current post-mining land use as an ecologically restored site comprising native vegetation and freshwater habitats.
- Secondly, there has been long and continuing corporate, consultant and stakeholder involvement with the Beenup site, which brings experience, a longer-term consistency in approaches to management, monitoring and data, and a valuable memory bank to a case study such as this.
- Finally, there was an early focus on ecological restoration to achieve 'nature-positive' outcomes, and hence there is a rich ecological dataset available that is not typical of many operational mines.

Objectives

The specific objectives of this pilot case study were to:

- Assess, adopt, test and adapt elements from current international NCA standards, within a mining sector application.
- Identify the datasets and lenses of analysis needed to build NCA accounts for the mining sector.
- Endeavour to generate an example set of natural capital accounts (environmental profit and loss statements, balance sheets) for the Beenup site, to cover its four land use changes (agriculture, mining, rehabilitation works and post-rehabilitation), for illustrative purposes only.
- Better understand what would be needed to facilitate the integration of environmental accounts for each asset or enterprise within a group's consolidated financial statements.

- Support BHP's contribution to the TNFD Forum. BHP is exploring ways to incorporate nature-related risks (threats and opportunities) into its strategic planning, risk management and capital allocation decisions, and wishes to share insights and learnings to support other companies with similar interests in improving their understanding of approaches to valuing nature assets.

This pilot case study breaks new ground in exploring the opportunities and challenges for progressing NCA within the mining sector. There is not yet consensus among ecologists, economists, and accountants as to how to best capture the physical assets and flows, where these should sit on a balance sheet, who the beneficiaries should be, and how ecosystem services or their benefits should be valued. This example set of mining natural capital accounts is intended to help identify the knowledge gaps, capture the conceptual challenges and provide learnings to build on and resolve in further case studies and standards.

This document is envisaged to be used as a communication tool across multiple stakeholders to share insights and learning with other companies with similar interests.

BHP is also interested in exploring opportunities for future uses of the Beenup site, and there may be options for realising ecosystem services and beneficiaries in the future (assuming no other agreements are in place) as part of the restoration economy.

Approach

The example set of natural capital accounts resulting from this pilot case study does not conform to any one framework, however, has taken elements from these three frameworks:

1. The SEEA framework, which was predominantly used to guide the classification of environmental and ecosystem natural capital assets, and to build the physical accounts (stocks). SEEA-EA was used to develop the ecosystem extent and condition accounts and ecosystem services (flows).
2. The NCP was used to develop the dependencies and impacts and materiality assessment.
3. The CNCA framework was used to inform the way the environmental profit and loss statements were developed. While consistent with SEEA, these do not include the full positive and negative impacts and dependencies, but rather focus on valuing the costs and benefits (i.e., positive impacts only) associated with managing an area of land using an ecosystem services framework. This was an intentional focus since the interest was in comparing natural capital changes over various land use scenarios and identifying potential benefits from enhancing or better utilising these assets in the future.

A process flow diagram showing the steps followed in preparing this NCA pilot case study is shown in Figure 1.

1 Scope

- What are the boundaries of the Beenup site pilot case study?
- What are the historic land use scenarios?
- What are natural capital impacts and dependencies for each of the scenarios?
- Which impacts and dependencies are material for the case study?

2 Measure

- What are the natural capital assets relevant for each of the scenarios?
- What type of ecosystems characterise each scenario?
- What datasets are needed to define assets and services?
- What are the methods of measuring changes in flows and stocks?
- What are the appropriate valuation methods?
- What are the gaps and limitations?

3 Assess and Report

- What are the changes in land cover for each scenario?
- What are the changes in ecosystem asset extent and condition over time?
- What are the changes in natural capital stocks and services (functional analysis)?
- What do the monetary accounts for the Beenup site pilot case study show?
- What are the next steps?

Figure 1. The Beenup site pilot case study - process diagram

Limitations

The study team found several limitations in developing the example accounts related to the specific context of Beenup, and the data. This pilot case study does not purport to solve all of the challenges and there is much to build on in future work. Some of these are listed below, with more detailed points made within this document in the relevant sections.

Limitations in the pilot case study's applicability to an operational mine site include:

- The Beenup site only had a very short mine production life.
- The Beenup site is a closed and fully rehabilitated site that has had limited public access (guided visits only) for around 30 years. Apart from brief periods (e.g., seed supply for rehabilitation), the ecosystem services have not (at this point) been realised transactionally and are essentially classed as non-market benefits. The Beenup site is effectively a 'nature park' with minimal maintenance and monitoring activities.
- The Beenup site was subject to a separate Mineral Sands (Beenup) Agreement Act 1995 rather than the Mining Act 1978.
- Some of the normal impacts and dependencies or risks associated with the mine and associated costs of mine development and production, particularly during its pre-mining and production stages, were not available to support a detailed EP&L statement in this study. This is an important component of the NCA process and would need to be adequately completed for operational mines.

Limitations associated with the pilot case study include data availability, costing and valuation challenges:

- The example natural capital accounts were prepared retrospectively, and annual data was not available for most parameters for all periods of the study. Considerable effort was needed to sort and classify data in order to produce the extent, ecosystem asset and condition accounts for the different land use periods (Scenarios). For ease of preparing the accounts, it was assumed that all land transactions were made at the start of a Scenario and therefore that the benefits or costs associated with changes in land extent took effect from the start to the end of each period.
- Scenarios are shown for financial year periods (1 July to 30 June), although the actual start and end of a land-use period does not directly align with financial years (the mineral sands project at the Beenup site commenced production on 13 January 1997 and operations ceased on 16 April 1999). Note that BHP financial years ended on May 31st of each year prior to 2000.
- Best efforts were made to source reasonable data and use standard best practice methods (as described in SEEA-EA) for valuation of ecosystem services and assets; however, these would benefit from refinement. The example accounts are intended to trial an application of NCA techniques only, and any valuation should be viewed as an illustrative estimate only and in no way intended for use as realisable values. In the absence of applicable Australian or International Accounting Standards for NCA, these accounts have been guided by the principles of the Australian and International Financial Reporting Standards applied in the preparation of BHP's consolidated financial statements.

SUMMARY OF INSIGHTS

Highlights and key learnings from the Beenup site pilot case study are both particular to the story of the Beenup site and borne out of the NCA process undertaken. The project generated considerable discussion and thought around how to practically apply the intent of the various international frameworks and guidance documents (specifically SEEA and the Natural Capital Protocol) to a mining business based on extraction of non-renewable resources. Some learnings are very specific to this context, while others reflect more broader and pressing issues currently part of the global discussions around NCA.

Highlights

Beenup Site Highlights

The natural capital story of the Beenup site is shaped by its setting within the unique Scott Coastal Plain of the southwest of Western Australia, and by the transition of land uses – from agriculture, to mining, to restored ecosystems. Whilst each of these various land uses has been characterised by environmental, social and economic impacts, the Beenup site today is an example of a 'nature-positive' outcome for a post-mining landscape, which contributes a range of valuable ecosystem services.

As Beenup is a closed mine and, more materially, had a very brief operational life, the Beenup site is not typical of most operational mines. However, this pilot case study serves to demonstrate a process, and to help identify the gaps and challenges that need further work to facilitate the adoption of NCA in business reporting for the mining sector.

The example natural capital accounts developed as part of this pilot case study highlight the significant ecological value of the Beenup site, and the potential to plan and deliver 'nature-positive' outcomes as part of BHP's business more broadly. Using a range of valuation approaches, the financial year (FY) 2020/21 natural capital balance sheet shows, for illustrative purpose only, that Beenup's restored ecosystems could have an estimated net present value (NPV) of AUD$30-40m. The annual ecosystem service flows are significant.

For example, the potential annual societal benefits associated with carbon sequestration at the site (if it were eligible through the current legislative regime and markets) is estimated to be approximately AUD$1M per annum. Because the wetlands at Beenup are constructed systems, the carbon sequestration potential is also increasing over time due to the gradual build up of the detrital layer.

The Beenup site has already played a role in providing genetic material for threatened species breeding and is still used for the translocation of species as part of ongoing Recovery Plans being implemented by the Government of Western Australia (Department of Parks and Wildlife, 2015; Department of Environment and Conservation, 2008.; Luu and English, 2004; Luu and English, 2008). The wetlands play a significant role in water quality improvement of the Blackwood River and Hardy Inlet. There has also been increasing interest in using the site for a range of compatible economic activities that are complementary to the site as a nature area. This includes beekeeping, seed collection and potentially habitat for the relocation and breeding of other threatened fauna.

320 ha

seasonal and permanent wetlands created

Protection and restoration of a threatened ecological community (TEC)

153 ha of an endangered TEC (Scott River Ironstone Association) transferred to the Government of Western Australia and protected under the Biodiversity Conservation Act 2016 (WA).

70 ha of this ecological community restored after mining of former pasture.

Four nationally listed threatened plant species supported within this restored critical habitat.

Net gain in the number of threatened fauna and flora species returned to site compared with pre-mining scenario.

Net gain in habitat extent and geomorphic diversity

633 ha of 'very good' to 'excellent' condition habitat (382 ha restored, 94 ha of remnant improved, and 153 ha of TEC transferred to the conservation estate).

110 ha net gain of native aquatic and terrestrial ecosystems compared with the pre-mining land use scenario.

Eight wetland and terrestrial geomorphic landforms and 15 ecological communities restored, in a condition typical of the Scott River Plains global biodiversity hotspot.

320 ha of seasonal and permanent wetlands created, supporting the conservation of significant waterbirds and invertebrates, including three internationally significant and one nationally significant migratory bird species.

300 ha of remnant and restored woodlands supporting two nationally threatened bird species (Baudins Cockatoo and Forest Red-tailed Black Cockatoo).

251 plant species restored after mining, with now more than 300 species across the site.

Net gain in ecological connectivity

Increase in landscape connectivity over the pre-mining and mining land use scenarios (measured by the percentage of patches and patch size and edge length).

Habitat linkages with the surrounding Scott River National Park restored, supporting safe passage for fauna and of gene flow.

Restoration of natural capital values

~AUD$30-40m of potential natural capital asset value (on an NPV basis) estimated.

~40% increase in natural capital asset value per hectare (pasture and native) over the pre-mining scenario due to the carbon and wetland components of the restored native ecosystems.

Combined value of the main ecosystem assets (carbon, wetlands, habitat) equivalent to pre-mining conditions.

Net gain in carbon storage and sequestration

~1M t of carbon stocks (CO_2-eq), of which the wetlands are the dominant stores.

~7000 t of carbon (CO_2-eq) sequestered annually, strongly influenced by the wetlands.

Improvement in water quality and flows

~11 t of nitrogen, ~6 t of phosphorus and ~130 t of suspended sediments removed annually from agricultural run-off via the wetlands.

~1500-2000 ML/annum of environmental flows to the Blackwood River maintained.

Opportunities for natural products

The Beenup site has an unrealised value for a variety of natural products such as native seed supply, wildflower harvesting and beekeeping. These represent potential industries that are becoming increasingly important due to the contraction of land suitable to support these services, and because of the increasing focus on the use of native provenance seeds for restoration to maintain genetic diversity. Indeed, the Beenup site itself was restored using seeds collected from the remnant lands leased and acquired by BHP at mine closure.

Social and educational opportunities

The Beenup site offers an excellent opportunity to become a 'living laboratory', which could support on-site teaching and learning, as well as tourism and associated facilities. There is a need to conduct appropriate social value research to identify what potential ecosystem services have interested beneficiaries, and how these may be developed as future markets.

NCA Pilot Case Study Process Highlights

The initial key steps for building the ecosystem asset and extent register are well informed by existing international frameworks.

The SEEA-EA framework embeds globally applicable classification systems and criteria for land, ecosystem types and ecosystem condition, including the IUCN Global Ecosystem Typology (GET). The Natural Capital Protocol was also readily applied here to inform the impact and dependency pathways and support materiality assessment. Both frameworks have utility to the mining sector NCA.

IUCN GET was used as the foundation for classifying ecosystem units and was relatively easily adapted at the lower orders to suit the variability and specificity of ecosystems locally. Adapting this framework makes it both simple for ecosystem assets to be aggregated into the common global reporting language and means that the current environmental datasets held by businesses can be ordered into the register without being completely overhauled to suit the specifics of the framework. That is, adapting the framework to suit the data has been shown to be a useful and efficient method for starting the natural capital accounts.

Spatial data were useful to derive the area and extent of ecosystem units and spatial maps greatly assisted communicating changes over time.

Data that were largely contained in easily retrievable databases and document storage systems underpinned the success of this study in terms of identifying and measuring environmental assets through time.
The transition of most mining monitoring to remote sensing will make spatial data even more valuable as a method of tracking and presenting these components of the physical accounts and may also drive a welcome change in the industry to better manage data important for NCA.

The Beenup site pilot case study developed a sound method of assessing ecosystem condition, using both the SEEA-EA framework and the Society for Ecological Restoration (SER) International Standards Rating system (Gann *et al.*, 2019).

The resulting method is easily transferable across mining (and other) businesses and presents a standardised approach that uses an international rather than local or national basis for assessment. This can overcome the problems associated with the many and diverse methods currently used in the different states of Australia and elsewhere.

The comprehensive data sets collected before, during and post-mining were able to support the development and testing of NCA in a mining context, and the preparation of a detailed and defensible example set of physical accounts.

This pilot case study has helped identify the data requirements for a mining business in order to produce a set of natural capital accounts (detailed in later sections). Many of these are already collected as part of the regulatory and rehabilitation requirements; however, this data would also need to be built into robust and retrievable systems for future use.

~11 t

nitrogen removed annually from agricultural run-off

~1500+

ML/annum of environmental flows to the Blackwood River maintained

Key Learnings - Preparing Natural Capital Accounts

Preparing Natural Capital Accounts

How do we resolve accounting for the mineral resources in the natural capital accounts so that it does not cause under-representation of the value of other natural assets?

This study highlighted that the overwhelming challenge for NCA in mining is in how the mineral resource, which is a non-renewable natural capital asset, is treated within the natural capital accounts. Key issues to resolve include: who owns the asset?; how should the asset be valued?; how should resource depletion be captured?; how should the costs of extraction and associated impacts be apportioned over the life of the resource; and how do these interplay with the reporting of mineral resources in a company's financial accounts?.

Mineral resources (subsoil reserves) are included in the definition of natural capital assets (United Nations *et al.*, 2014) and are fundamental ones for mining companies, however the depletion of the resource by extraction and the impact this has to society is often not fully captured in financial accounts. Added to this, in Australia and many other countries, subsoil minerals are typically only included in the financial balance sheet when they are economically proven and probable and only when there is a cost associated with them. They are also only treated as natural capital assets under SEEA when there is a 'flow of benefit to people'. As such, mineral resources are often only treated as natural capital assets if they are extracted (depleted) which means a resource can appear and disappear from both the financial and natural capital balance sheets over time - they 'exist' or 'don't exist' based on associated costs or profit potential on the one hand, or depletion and flow of services on the other.

Recent commentators assert that the current economic and financial accounting practices have resulted in an overinflation of wealth (shown as profit to a business and productivity to a nation), or an underestimate of natural capital value (shown as a negative value or loss to a business and zero value to the nation) (Dasgupta, 2021; Hoang, 2018). Whilst the need for incorporating mineral resources into natural capital accounts is clear (e.g., Valero and Valero, 2018), agreeing on a method as to how this should be done is notoriously difficult due to significant uncertainties (e.g., lack of data, pricing assumptions, accounting for change) and there is little consensus at this stage.

For this pilot case study, the position taken was to include the mineral resources in the natural capital accounts to move the debate forward. The method applied is not intended to be viewed as the right approach, but hopefully will flag the need for further thought and research into this issue for future case studies.

How do we assign the natural capital assets and their values on the balance sheet?

One of the main aims of NCA is to drive organisations to view natural capital as an asset rather than an unlimited resource, but recognising this on the balance sheet is conceptually challenging. The issue of how natural capital assets should be presented on the balance sheet is a question of perspective and statement use, with no clear consensus on a preferred method found during this pilot case study. Here, the value of the asset itself (store of future value) was used in the natural capital balance sheet without assignment to society or the BHP business, even though the benefits provided arise from BHP owned or controlled lands. The flows are all currently assigned to society since, apart from one exception (seed supply), society is deemed to be the beneficiary.

Because there has been no realisation of the benefits to the BHP business from most of the natural capital assets, they could be viewed as belonging to society but subsidised by BHP. While ecosystem services are indeed subsidised by BHP for the benefit of society and are treated this way in the example EP&L statements in this document, the initial build-up of the ecosystem asset values is technically a cost expended by BHP as part of its closure commitments. Although historically the concept of closure has in mind the return of rehabilitated lands to society, in many instances this does not occur (or does not fully occur) in practice due to the risk and uncertainty associated with the land and its legacy.

At present, BHP is managing the Beenup ecosystem assets, although it has no residual legal obligations to do so. As such, BHP could either sell its lands and the ecosystem assets residing on those lands in the private market (not the case if they were true societal assets), or transfer them to a non-government organisation or government entity, in which case they could be deemed societal assets. A range of factors is likely to influence whether mining companies retain or transfer rehabilitated sites that hold ecosystem assets, including legal requirements, the timeframe required to implement closure plans, community preferences for post-closure land uses and further opportunities that may arise if the company retains the assets (and has them on the business balance sheets).

There currently are no guidelines that can inform this decision process. Businesses will need to determine how best to communicate asset value to stakeholders such that it strikes the right balance between aligning with NCA standards as they develop, while demonstrating 'nature-positive' outcomes or other social value commitments in the right way.

One of the main aims of NCA is to drive organisations to view natural capital as an asset rather than an unlimited resource.

How do we capture biodiversity as an ecosystem service in natural capital accounts without double-counting?

There are significant challenges in adding biodiversity to the natural capital balance sheet and in particular to the EP&L statement, and there needs to be an agreed approach for valuing biodiversity that does not double count. Biodiversity is already captured by many ecosystem services, including carbon sequestration, and habitat provision which are influenced by the structural and functional attributes of ecosystems that are components of biodiversity. Hence, any valuation method must ensure that the ecosystem services associated with biodiversity are not already captured in other services. In this pilot case study, biodiversity was valued by defining the genetic material (provisioning service) as an ecosystem service, in this case measured as the number of nationally listed threatened ecosystems and species, using a contingent valuation method. This method used the actual spend on recovery plans and maintenance of lands set aside for conserving matters of national environmental significance (MNES) in the Warren bioregion of south-west Western Australia. This avoided double accounting and created a realistic relationship between the asset and a measurable service but did not fully address the challenges of dealing with biodiversity in the NCA process.

How can we establish a standardised way of maintaining detailed physical accounts as an underpinning requirement for natural capital EP&L statements and balance sheets?

When preparing monetary accounts, the preceding requirements for ordering of each of the physical accounts in a standardised manner should not be overlooked. This was complex due to the retrospective nature of this pilot case study and the inclusion of four land use scenarios with different timeframes. Tracking changes in the physical accounts over the accounting period should be completed early in the process, before the monetary accounts are developed. A template for each of the core accounts would help this transition and strengthen the supporting notes to the accounts.

How do we account for transfers of high conservation lands to the conservation estate (and other changes in land tenure) that are not representative of a real loss in natural capital?

Complex land tenure arrangements can make interpretation of NCA difficult when accounts are presented from a business perspective. Accounts built using the geographic boundary rather than the corporate boundary do not have these challenges since the accounts are agnostic in terms of land ownership. The Beenup site pilot case study showed that the simple transfer of land to the conservation estate translated to a loss of high value natural capital on the business side of the NCA balance sheet, even though this is clearly a positive environmental outcome (and belongs on a society balance sheet entry). Not resolving the split between business and society can create apparent 'losses' in natural capital. Capturing this benefit, perhaps using other environmental, social, and governance (ESG) metrics, is key to promoting these initiatives within mining businesses.

Communicating natural capital asset value to stakeholders must balance aligning with standards, while demonstrating 'nature-positive' outcomes and social value commitments in the right way.

Data

Sound and comprehensive data is the foundation of natural capital accounts.

This pilot case study has demonstrated the importance of consistent and curated data management for supporting the generation of natural capital accounts.

Although there were data limitations associated with each of the land use scenarios assessed, sufficient data was available to develop detailed ecosystem asset extent and condition accounts. Where data was limited (e.g., inflow and outflow water flows and quality over the full land use scenarios), sensitivity analysis was undertaken, and in other cases such as carbon, data gaps were able to be filled by follow up site investigations.

NCA requires a review of current data collection requirements. Mining monitoring programs and datasets tend to be driven by environmental approval and reporting requirements, which would need review to ensure capture of data (types and frequency) needed to inform natural capital accounts and be robust for audit purposes. NCA requires a review of current data collection requirements. As the Beenup site is located in a global biodiversity hotspot surrounded by a national park and two sensitive receiving catchments (Blackwood River and Scott River), BHP invested in a higher-intensity monitoring and data acquisition program for the mine operational phase. Combined with a comprehensive understanding of the risks associated with the mine, (e.g., pyrite and potential acidification of groundwater, threatened species), many additional studies were commissioned which provided data that may not be as easily attained for the purpose of NCA in other mines.

For current and future NCA studies, modern techniques such as higher quality satellite imagery, aerial photography and drone surveys should be considered for use. These may allow for a greater range and continuity of data to be captured in a way that could not be replicated in this pilot case study.

Contextual Boundaries and Land Management

NCA needs to contemplate the wider local context and various post-mining futures at the start.

Awareness of the location of a mine within its broader ecological and social setting can better reveal the potential for creating positive outcomes rather than simply assessing potential negative impacts associated with mining. In this pilot case study, improvements in surface water quality were identified as a significant ecosystem service to society. This was not previously identified as an obvious benefit, since an analysis of the wider catchment issues and water quality trends had not been undertaken.

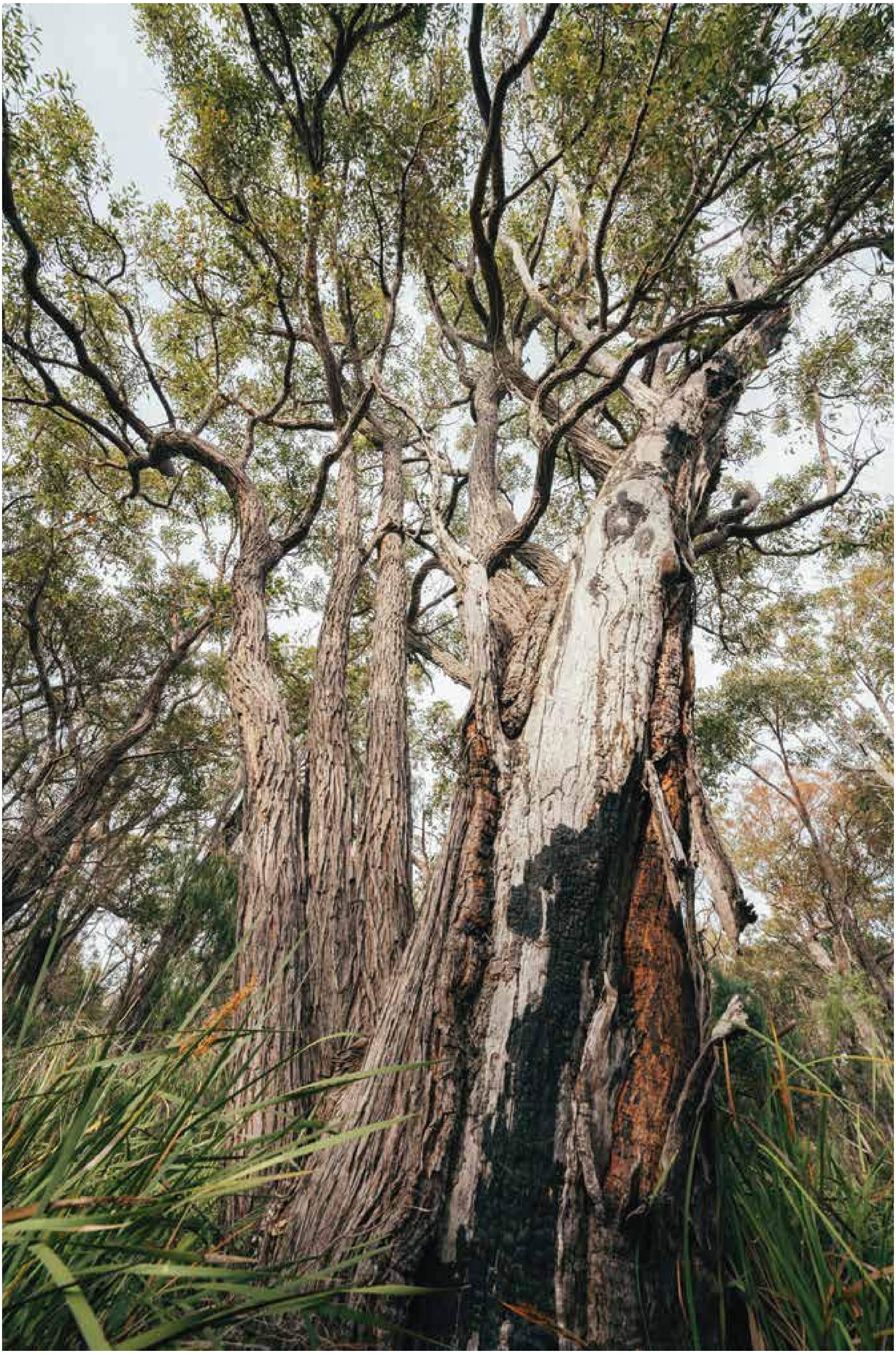
The Ecosystem Accounting Area (EAA) needs to be defined early in the process.

The ecosystem accounting area is the defined geographical area for which an ecosystem account is compiled. This was challenging to determine for the Beenup site pilot case study due to limited data, particularly that related to lease and sublease agreements, and frequent changes to land tenure associated with expansion and contraction of the mining lease area, sublease of pasture lands for later potential mining, and transfers of other lands to third parties. This is likely to be a wider issue across the mining sector. In the mining business context, the study outcomes suggest EAA should include the full area owned or controlled (e.g., leased) by the entity and which will normally appear on the company's financial accounts. This would exclude lands for which there are lease agreement only for access or specific other purposes but for which the business has no influence over operational activities.

Protection of the natural values of land owned or controlled should be considered, even if subleased to others.

It is common in the mining sector to control lands by ownership or lease, but then to sublease some lands to third parties, who operate under the terms of the sublease agreement. At the Beenup site, this resulted in 60 ha of remnant vegetation being cleared on subleased lands. Current sublease agreements at the Beenup site prohibit clearing and require best practice management.
The study outcomes highlighted that these types of conditions should be considered when entering into land use agreements to protect the extent and condition of natural capital assets held by a mining company.

Awareness of the location of a mine within its broader ecological and social setting can better reveal the potential for creating positive outcomes.



Next Steps

NCA seeks to provide a way for businesses to understand and measure their impacts and dependencies on nature to inform investment risk assessments, decision making and disclosures and reporting. Whilst this may ultimately be most effectively achieved by integrating natural capital and financial accounts in the consolidated business accounts, in the short term, there is much to do to advance the adoption of NCA across BHP businesses and the mining sector more broadly.

This pilot case study has provided the project participants with valuable insights and a framework which sets out a pathway for guiding future studies and applications of NCA. It has also highlighted some key gaps and conceptual challenges that need to be resolved before the longer-term vision of 'valuing nature' can be achieved for the mining sector. Some of these gaps need further research and discussion, while others can be filled by improved data collection and management methods.

Developing Standards

New accounting standards and approaches that can specifically assist mining companies in assigning natural capital assets on the balance sheet to either the business or to society are needed.

The right balance is needed between acknowledging the stewardship role (and responsibilities to minimise impacts and contribute to society's efforts to 'restore nature' for prosperity), and the ownership or management role (and responsibilities to shareholders and other stakeholders associated with the right to mine and 'use nature' for productivity), in addressing the complexity of separating impacts.

Comprehensive natural capital accounts could better capture the intangible assets. Use of cashflow accounts to capture changes and annual account updates may help to facilitate more efficient tracking of changes and enable progressive decision making. There are also valuation difficulties associated with recognising public goods (social value), versus merely marketable values, which also calls for consideration of what other types of accounts could be incorporated into a mining NCA Chart of Accounts best suited to disclosure and reporting..

Addressing the Gaps

Support research to develop a methodology for determining how mineral resources should be treated in natural capital accounts and how natural capital accounts can be integrated with financial accounts.

This should include both leading accounting, corporate reporting and statistical research agencies addressing these issues at the national reporting scale, along with the strategists, accountants and analysts within the mining sector who understand the corporate landscape and ultimately will be responsible for implementing these changes.

Research and develop mining specific criteria for undertaking materiality assessments in the context of natural capital accounting.

A materiality assessment identifies the causal impact and dependency pathways that link specific business activities and natural capital and assesses the likelihood and magnitude of changes in these pathways that may lead to negative or positive outcomes for the business. These assessments generally encompass legal, regulatory, operational, reputational, social and financial considerations, however, there is a high degree of subjectivity in these assessments.

BHP and other mining companies would benefit from the development of mining-specific criteria to assist in the materiality assessment of dependencies and impacts and the ecosystem services that may be disrupted. These criteria should be assigned under the above categories to help frame an objective assessment of each of them equally. These criteria should also build in considerations of potential links between natural capital and social capital in future scenarios.

Research and develop methods for including the full value chain in NCA mining assessments.

Whilst this pilot case study is a useful basis for stimulating discussions as to how integration of natural capital accounts and financial accounts could work, significant additional work is needed to understand how this could occur in practice. In this study, only the direct operation (gate-to-gate) component of the value-chain boundary was included, however, the upstream and downstream parts of the value chain are important in providing a full picture of impacts and dependencies; these should be further researched.

Leveraging this Case Study

Leverage the currently identified natural capital of the Beenup site to identify and develop future ecosystem services and continue to use the site as a model for linking natural capital and social capital value.

There are now clearer pathways for developing and expanding the natural capital assets and ecosystem services of the Beenup site. As a model site for both ecological restoration, and now for the development and testing of NCA in mining, the Beenup site is important for education and research, and citizen science. Other potential services could be explored using non-market valuation methods such as choice modelling and group deliberation (Legesse *et al.*, 2022).

Leverage the learnings from the pilot case study to test at an operational mine site.

Adopt and further develop the methodology used in this study to develop a pilot case study for NCA at an operational mine site. This would provide further early insights on challenges to be addressed in application of NCA to the mining sector.

Consider climate related impacts and dependencies on natural capital stocks and flows.

While the Beenup site is in a high rainfall region, potential changes to the seasonality of rain and the frequency of extreme wet weather events may be material to the resilience of the site. The use of NCA to inform decision making relating to climate change resilience is an area of interest which was not explored in this pilot case study.

ABOUT THE BEENUP SITE

5

The Beenup site is located in a region dominated by agriculture and globally significant natural areas.

Location

The Beenup site is located in south-western Australia, and is surrounded by the Scott River National Park and agricultural land (Figure 2). The area is essentially low lying with local topographic relief in the order of only a few metres.

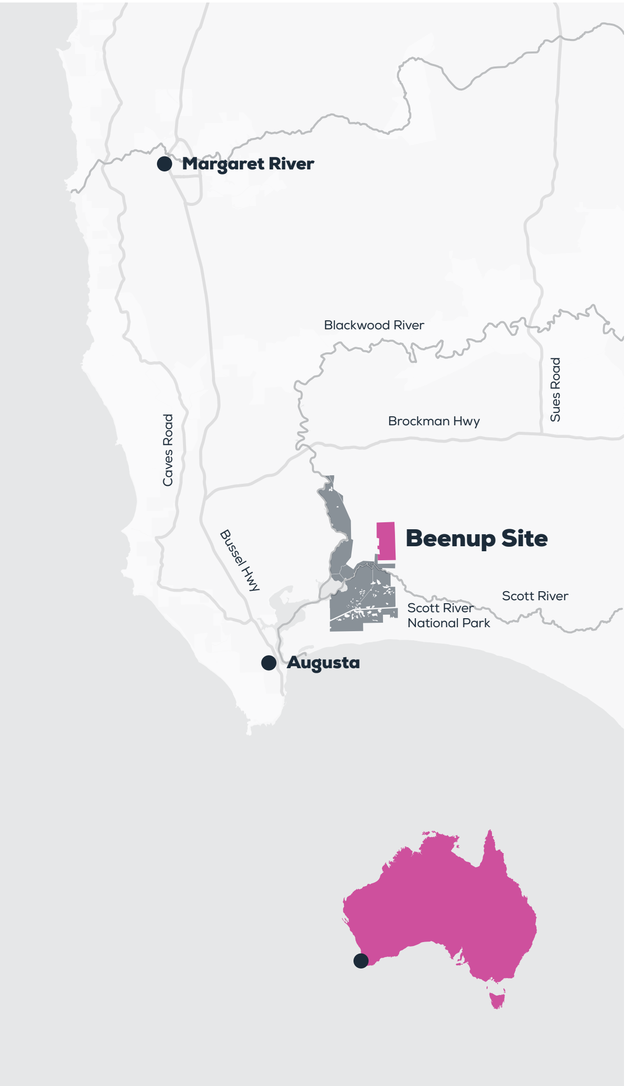


Figure 2. Location of Beenup former mine and current restored site.

Beenup Site History

A brief Beenup site timeline, including key events, is shown in Table 1.

When BHP acquired lands at Beenup for mineral sands mining in the 1980s, most of the land had been cleared for pasture and beef and dairy grazing. The mine was commissioned in 1997 but operated for only two years before it was closed due to technical difficulties. The original anticipated mine life was 25 years with an estimated total production of 600,000 t of ilmenite per annum, while mining to a depth of up to 50 m by dredging. Only 400,000 t of ilmenite was produced at the mine before its closure in 1999.

Remedial earthworks were completed in 2003 with rehabilitation and restoration of the site completed over the period from 2000 to 2015. The remediation and restoration phase was driven by a clear intent to restore natural values, driven by the community (Beenup Consultative Group). In August 2014, the Environmental Protection Authority (EPA) approved BHP's request to remove the unmined parcels of land and reduce the original proposal area from 2,900 ha to 697 ha.

Although the mining phase was brief and impacts well managed, the task of restoring community trust and addressing the environmental impacts was significant, and considerable technical work and stakeholder engagement was required to switch from 'mining to mending' in a very short period (Norrish *et al.*, 2019).

Environmental Context

The Beenup site is located within the Scott River region, which is of global significance due to its high biodiversity and high proportion of plant endemism and rare flora, reflecting a unique geology and associated hydrology (Gibson *et al.,* 2000). The Scott River is an internationally recognised biodiversity hotspot (Conservation International, 2007; Beard *et al.*, 2000).

Prior to clearing for agriculture, the site was dominated by the Scott River Plain Ironstone Association, which is a Threatened Ecological Community (TEC) now listed as endangered under the Australian Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). The site also abuts the Scott River National Park and is within the catchment of the Blackwood and Scott Rivers. The former is a significant river that discharges to the sea at Augusta. These rivers are considered major environmental assets and are a focus of water quality improvement plans to reduce nutrient inputs, predominantly associated with surrounding agricultural land uses.

The closure plan developed for the site under the consultative process had an agreed final land use and set of objectives as follows:

- Rehabilitation goal: – 'to re-integrate the mine site with the surrounding natural ecosystems, and to protect the water quality of the Scott and Blackwood River systems, which will receive drainage through the wetland system' (BHPTM, 1999).
- Final land use goal: – development of the site into a conservation/recreation reserve with some surrounding pasture (linking to adjacent land uses).

Two further objectives were adopted at a later stage through the process of developing rehabilitation implementation plans and completion criteria (Meney and Pantelic, 2019).

- Biodiversity: restoration and maintenance of biodiversity to a level that has conservation value to flora, fauna and people.
- Sustainability: creation of a sustainable site that requires minimum maintenance intervention.

Twenty-one rehabilitation completion criteria were developed to track progress, and in 2018, 19 years after closure, the site achieved regulatory sign-off against these. The site is now being managed by BHP and in a process of opportunity framing to determine potential future uses.

Socio-Cultural Context

The local community within the Shire of Augusta-Margaret River formed a significant part of the Beenup project from before mining commenced (Norrish *et al.*, 2019). The Beenup Consultative Group (BCG), set up prior to project development, was utilised to enable the community to influence the rehabilitation planning, and in later stages to 'audit' and contribute to the post-closure outcomes. The early closure of the mine resulted initially in a level of negative sentiment; however, this was reversed and ultimately the relationship between the community and BHP became a positive one, largely achieved by BHP's decision to operate under a transparent, 'open-book' consultative process. The BCG still functions as an advisory group and will continue to participate in future planning for the Beenup site.

The potential social and cultural values of the Beenup site have not been fully explored given the site is still closed to the public. However, these could become an important part of the story moving forward.

Closure and Rehabilitation

The approach to closure and rehabilitation at the Beenup site was driven by:

1. A substantial stakeholder consultation process to agree on the goals and transparency mechanisms for data sharing and assessment of rehabilitation success.
2. A technically rigorous approach to rehabilitation, based on comprehensive technical studies and the development of a detailed and prescriptive set of restoration and completion criteria. This allowed greater certainty of outcomes and enabled quantitative measurements of restoration success.
3. The incorporation of sustainability and resilience objectives, which are global indices of success used in ecological restoration projects outside of mining, that were applied to guide both the approach to restoration (designed to enable the site to adapt to changing climates and unpredictable events) and to the measurement of success (completion criteria). This was one of the first instances globally within the mining industry where ecological concepts were embedded as key success categories for rehabilitation (Meney and Pantelic, 2019).

Table 1. Brief Beenup site timeline and key events

Scenarios		Year	Events
Scenario 1	**Pre-Mining** (pasture & remnant vegetation) Jul 1982 - Jun 1991	1982	Beef and sheep grazing - pre-exploration
		1986	Exploration commenced
		1987	Beenup project first referred to EPA
		1988	BHP commenced land acquisition
		1989	Notice of Intent lodged with DMIRS and start of community engagement
		1990	ERMP submitted to EPA (March)
Scenario 2	**Mining** Jul 1991 - Jun 1999	1991	EPA approval of Beenup project (land parcel 3196 ha and boundary of NCA assessment)
		1992-1993	Trial mining operation
		1995	Construction of mine (Jan)
		1996	Increase to approved operational mine area; construction and commissioning
		1997	Operations commenced (Jan)
		1999	Operation ceased (April)
Scenario 3	**Phase 1** Rehabilitation Works Jul 1999 - June 2005	1999	Commencement of irrigation of dairy pasture and rehabilitation
		2000	Rehabilitation works commence
		2003	Earthworks completed
		2005	Rehabilitation works completed
	Phase 2 Post-Rehabilitation Jul 2005 - Jun 2020	2005-2020	Maintenance and monitoring
		2012	Completion criteria formally approved (EMP 2012)
		2018	DWER approval of rehabilitation completion
		2020	End of Scenario 3 Phase 2
Financial Year 2020 to 2021		2021	Present (NCA reporting commenced)

Today, the Beenup site comprises around 480 ha of native ecosystems and 179 ha of grazing pasture. The Beenup closure and rehabilitation phase has achieved the successful restoration of 9 ecosystem types, 15 vegetation communities and over 300 species (including rare and priority species) in a modified post-mining environment.

Details

The Beenup site is situated on privately owned land which is used for grazing by cattle and sheep. BHP purchased ~ 937 ha of this land, which contains the area to be mined. The previous landowners are continuing to occupy the land under a lease-back arrangement with the Company.

May 1991, BHP obtained authorisation under Ministerial Statement 140 to mine and concentrate heavy mineral sands at the Beenup site in the Shire of Augusta – Margaret River, within a total operations area of 1,000 hectares (ha).

Mine Development Storage Area (MDSA) Trial pit area cleared.

MDSA and first dredge pond.

November 1996, BHP obtained authorisation under Ministerial Statement 434 to extend the existing Heavy Mineral Sands Mine operations at Beenup to 2,900 ha.

Operation ceased and closure commences.

Irrigation continues to Mar-Apr 2002. After this time, bore licenses were transferred to the dairy farmer.

DWER sign off received on 13 Nov 2018. Reporting against Completion Criteria no longer required.

A single financial year for 2020 to 2021 was completed.

SCOPE OF BEENUP SITE PILOT CASE STUDY

Setting up natural capital accounts requires the development of separate accounts for the natural assets (stocks) and the services they provide (flows).

The ecosystems and mineral resources are the assets that are recorded in the stock account. This account contains the asset register and provides information on the state of those assets (e.g., quantity, quality). For ecosystem assets, this includes the extent and condition of individual assets.

The services provided by natural assets are regarded as *flows*, and are recorded cumulatively over a defined time period.

The quantity or extent of the natural assets, combined with information on the physical state and condition of the assets, represents the natural capital assets, which support the flows of ecosystem services.

Both stock (asset) accounts and flow (services) accounts are recorded in *physical* and *monetary* terms. The stock account parallels the concept of a balance sheet and records assets at the start and end of the accounting period. The flow account captures changes in the environmental profit and loss accounts, similar to the financial P&L.

A critical step in developing natural capital accounts is the *scoping* stage, which determines what is included in the assessment (Figure 3). The approach taken for the Beenup site pilot case study is aligned with the Natural Capital Protocol Framework (Natural Capital Coalition, 2016), specifically with the Stage 3 of this framework ("What"), which outlines a pathway for determining the most relevant natural capital impacts and/or dependencies through a materiality process. The analysis, assessment and prioritisation of impacts and dependencies helps identify those assets and services that are, or potentially could be, material to the business and/or society and should therefore be included in the natural capital assessment and development of accounts.

Scope	**Determining case study scope**	
	Setting up boundaries	Spatial, temporal and value chain boundaries
	Impacts, dependencies & materiality assessment	Impacts / pressures and dependencies on natural capital assets and services
Natural capital assessment	**Developing example physical accounts**	
	NCA asset register	Environmental assets – ecosystems, land, mineral resources
	Ecosystem extent & condition integrated account	Land tenure, cover, use, ecological units, condition
	Ecosystem services account	Provisioning, regulating, maintaining, cultural
Natural capital accounts	**Developing example monetary accounts**	
	Valuation methods	Valuation of non-ecosystem environmental assets Valuation of ecosystem assets
	Environmental profit and loss statements (EP&L)	Historic scenarios EP&L statements FY2020/21 EP&L statement
	Natural capital balance sheets	Historic scenarios balance sheets FY2020/21 balance sheet

Figure 3. Steps taken in developing the NCA accounts for the Beenup site pilot case study

Defining the Pilot Case Study Boundaries

The first stage in undertaking this pilot case study (Figure 3) was to:

1. Define the relevant <u>spatial</u> project boundaries for the natural capital assessment.
2. Define the relevant <u>temporal</u> boundaries and NCA assessment scenarios based on Beenup project timelines.

It should be noted that only the direct operation (gate-to-gate) component of the value-chain boundary was included in this pilot NCA case study. Upstream and downstream parts of the value chain were excluded due to the historical nature of available data required to address the entire business value chain boundary.

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Notes
Glossary

Ecosystem Accounting Area (EAA)

There were several options for defining the spatial boundary of assessment (Ecosystem Accounting Area (EAA) under the SEEA framework) for undertaking the Beenup site NCA assessment. One option was to constrain the assessment to the operational area, however, as is the case with almost all mining operations, a broader footprint is impacted. These may include road and rail, leasehold areas for exploration, and lands purchased or leased for buffers or future expansion, often leased back to previous landowners for other uses (most commonly agricultural activities). Moreover, the extent of land held by BHP changed significantly between each of the time periods that defined the Scenarios for the assessment, hence land transactions themselves had a significant influence on natural capital stocks and flows at any point in time (Figure 4). To align with usual impact and risk assessment practices in mining, it was considered that the assessments of natural capital assets and flows were best done with the full approved mine lease footprint in mind, and the full extent of impacts. Because this is a business NCA assessment, the boundaries were set at the Beenup site, not the environmental, boundary level.

For the Beenup site, three spatial boundaries were identified and used throughout this pilot case study (Figure 5):

- **Mine Lease boundary:** the initial region approved for mining
- **Beenup Project Area boundary:** the region disturbed during mining
- **Rehabilitation Area boundary:** the region rehabilitated post-mining

The area used for the hydrological and ecological components of this assessment (i.e., native ecosystem types and extent, surface water catchments and ecosystem flows) comprised the mine lease area (termed Mine Lease Boundary) as shown in Figure 5. This included the mine approved area, lands owned and leased by BHP (i.e., lands under its control), as well as private lands within the approved mine lease area. Conveniently, this boundary captured the full extent of surface water catchments inflowing to and outflowing from Beenup; in most cases the hydrological boundary will be the largest defining area for assessment.

The boundary for the monetary accounts only comprised the lands owned or controlled by BHP in each Scenario (i.e., it excluded private lands within the mine lease area and access agreement leases). This was because BHP can only consider natural capital assets within the lands under its control, although the ecosystem services or impacts that flow on from these may of course be beyond the physical boundary of the assets. Although no mining activities occurred on lands leased for pasture activities, BHP was also concerned that any impacts on these lands (e.g., clearing) undertaken by third parties were captured in the accounts since BHP has stewardship as the landowner.

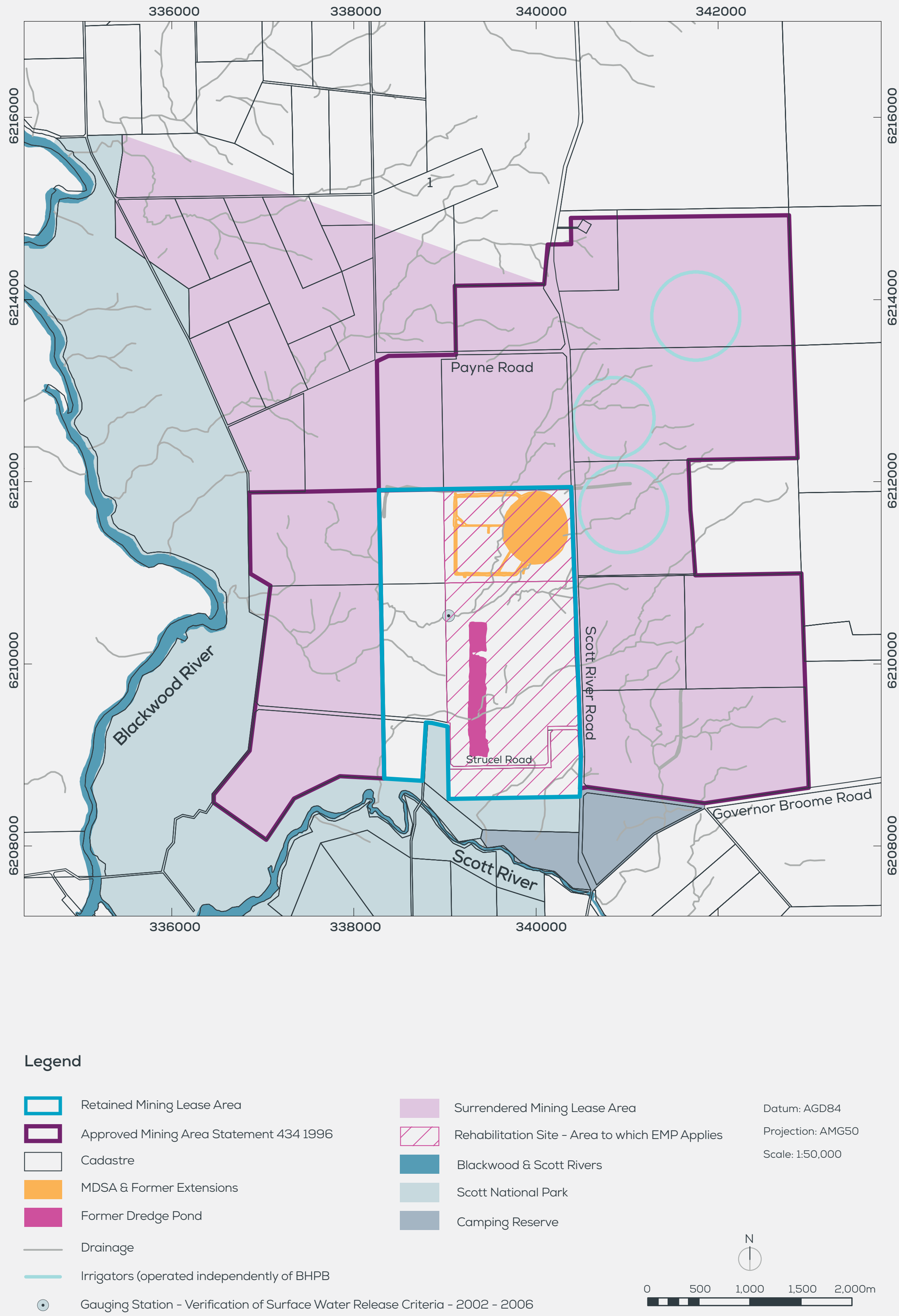

Figure 4. The Beenup site land tenure map

Figure 5. Spatial boundaries used for the Beenup site pilot case study

Temporal Boundary - Scenarios

Table 1 provides an overview of the timeline and major events over the years 1982 until 2021. For the Beenup pilot case study, this time period was divided into four land use scenarios. Scenario 3 covers the 22-year period from the closure of the mine until the present day, and was divided into Phase 1 and 2 to separate active rehabilitation works (Scenario 3 Phase 1) and maturity and maintenance (Scenario 3 Phase 2).

Scenario 1 Pre-Mining (July 1982 to June 1991)

The first scenario covered the pre-mining period, which is the nine years from BHP's first interest in the site until initial EPA approval. During this scenario, ecosystems were predominantly cattle grazing pasture with some remnant vegetation and wetlands.

Scenario 2 Mining (July 1991 to June 1999)

The second scenario covered the eight-year period from first mining approvals until the closure of the mine. It was characterised by clearance of land in the Beenup Project Area (operational footprint) and acquisition and lease of lands required for supporting mining activities and future mining.

Scenario 3 Phase 1 Rehabilitation Works (July 1999 to June 2005)

This phase covered the six-year period from closure of the mine until the rehabilitation works were complete. Most of the rehabilitation work was undertaken and finalised during this time period. Land was characterised by restored ecosystems, predominantly wetlands and low topographic relief dunes and plains. Some areas were artificial (pools/lakes) within the regional surrounds that were formed to more or less tie in with and connect to the surrounding landscapes.

Scenario 3 Phase 2 Post-Rehabilitation (July 2005 to June 2020)

This phase covered the 15-year period from the end of rehabilitation works with primarily observation and maintenance of the site until the beginning of FY2020/21. Remaining rehabilitation work was finalised in this phase, including work on the Mine Development Storage Area (MDSA). The site achieved regulatory sign-off against completion criteria from DWER in November 2018, and the site is now under minimal monitoring and maintenance.

Separate accounts were also completed for FY2020/21.

For each of the Scenarios as well as the single FY2020/21, accounts were developed in both physical and monetary terms.

The changes in land ownership across these Beenup site NCA Scenarios is presented in Figure 6.

The various scenarios have complex land tenure changes that largely reflected the shifts in strategy from:

1. **Scenario 1:** land acquisition to support the mining proposals and expected expansion of the mine over time.
2. **Scenario 2:** further acquisition of land BHP considered promising for mineral resources and lands that may be required for mine water management and infrastructure.
3. **Scenario 3 Phase 1**: relinquishment of lands no longer needed for mining, transfer of lands to the conservation estate, and retention of high value land adjacent to the National Park.
4. **Scenario 3 Phase 2:** no change in land, however 35 ha of pasture to the south was added to the rehabilitation area.

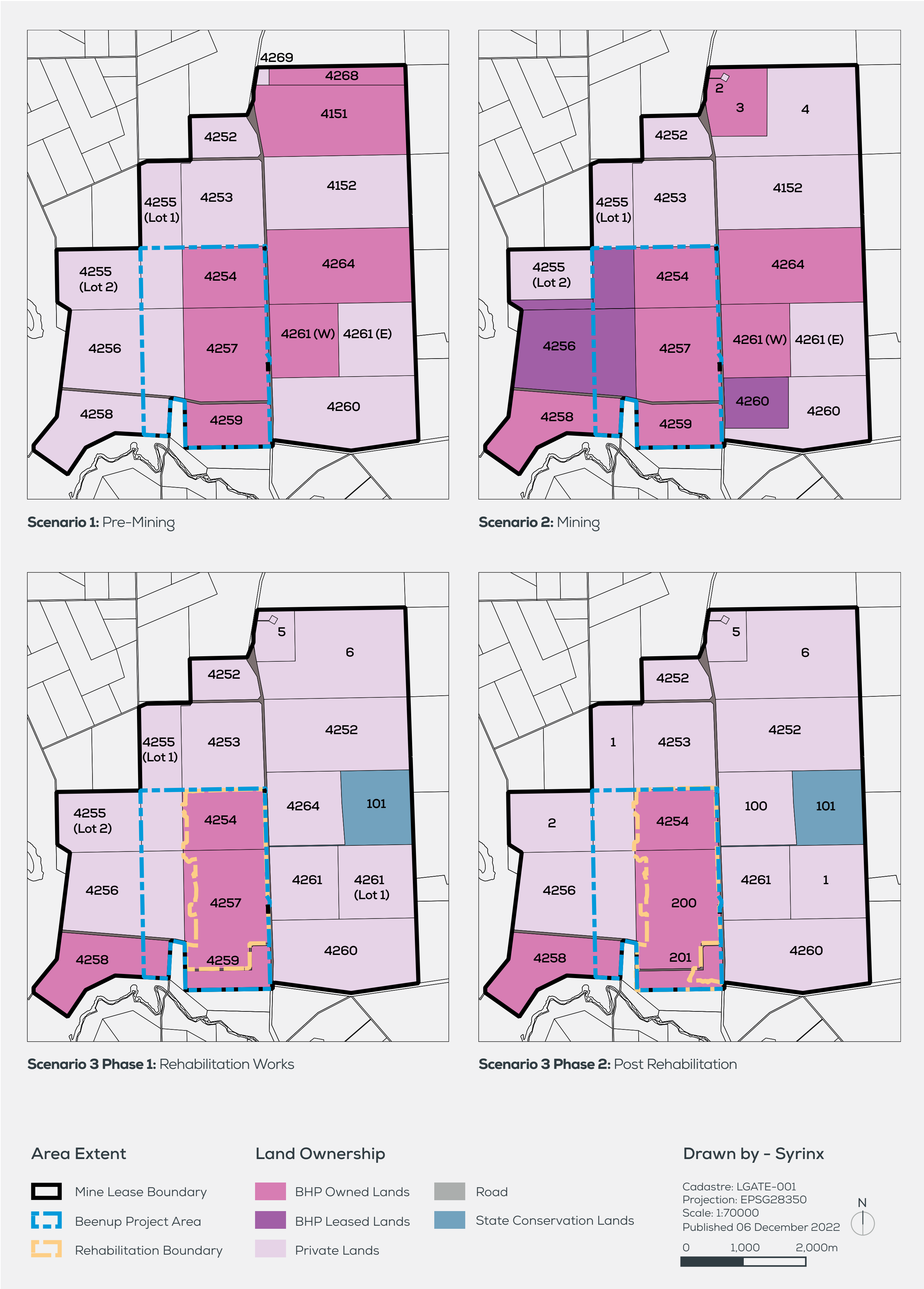

Figure 6. Change in land ownership across Beenup site Scenarios

Impacts and Dependencies

Identifying the dependencies a company has on its natural assets, and the impacts it makes, is a key part of the NCA assessment (what risks, and opportunities, are there for the business and what ecosystem services are most relevant?).

The NCP Framework (Natural Capital Coalition, 2016) defines natural capital impacts as *'the negative or positive effect of business activity on natural capital'* while dependencies are defined as *'a business reliance on or use of natural capital'*.

This framework also outlines a multistep approach to undertaking a natural capital impacts and dependencies assessment, with the first step being identification of potentially material impacts and/or dependencies.

For the Beenup site pilot case study, this first step also included identification of ecosystem services that are applicable to the study. This was then used to compile a short list of potentially material issues (impacts and dependency drivers), which were included in the materiality assessment.

Ecosystem Services Applicable to Case Study

Classification of ecosystem services in the Beenup site pilot case study was aligned with the main global classification system (Common International Classification of Ecosystem Services (CICES) for Integrated Environmental and Economic Accounting V5.1).

A tiered approach to selection of ecosystem services applicable to the Beenup site pilot case study was applied, with several criteria used to determine relevance and materiality of services:

- Users (past, current and potential future) - *Were there / are there relevant beneficiaries? Will there be likely future users? Who are they?*
- Flows of services - *Is there or was there a flow of services to the user/s? Will there be a likely flow of services to user/s in the future?*
- Realisable benefits (user-flow link) - *Were there / are there any realisable benefits? Will there be any realisable benefits in the future? Are the benefits Monetary or Non-monetary?*
- *Are the services material to be included in the Beenup FY2020/21 account?*

The following ecosystem services were determined to be relevant to the Beenup site pilot case study and were further included in scoping the natural capital accounts:

- **Provisioning:** provision of grazed biomass from agricultural land, provision of genetic material associated with natural ecosystems, and provision of water for third party uses (irrigation).
- **Regulating and maintenance:** carbon sequestration by native ecosystems and agricultural land, and regulation of water flows and quality by native ecosystems (wetlands).
- **Cultural:** contributions to research and education. The Beenup site has supported world class research, attracted many scientific and technical visitors (conference delegates etc) and citizen scientists, and has a high potential to increase these services in the future.

The Beenup site has good potential to provide a range of additional services in future years. A summary of identified relevant services, together with their CICES definition, is presented in Table 2. Quantitative indicators/metrics for each of the identified services have also been developed and included in this table.

Table 2. Ecosystem services applicable to the Beenup site pilot case study

Applicable Ecosystem Services (ES)			Ecosystem Type: Natural Ecosystems	Ecosystem Type: Pasture
Provisioning	Grazed Biomass	Provision of pasture - leased to private farmer/s	×	✓
	Genetic Material	Native seed supply	✓	×
		TEC, threatened flora & fauna	✓	×
	Water Supply	Water supply agricultural uses (irrigation)	treated mine water	
Regulating & maintenance	Global Climate Regulation	Carbon sequestration & storage	✓	✓
	Water Purification	Agricultural drainage nutrient buffering	✓	×
	Water Flow Regulation	Baseline flow maintenance	✓	✓
Cultural	Education, Scientific & Research	Intellectual interactions with nature	✓	×

Impacts and Dependencies Identification and Materiality Assessment

The NCP Framework (Natural Capital Coalition, 2016) defines materiality as follows: *"an impact or dependency on natural capital is material if consideration of its value, as part of the set of information used for decision making, has the potential to alter that decision".*

In line with this framework, a list of impacts and dependencies relevant for the Beenup site pilot case study was developed (Table 3). These include impacts and dependencies related to the pasture lands BHP control, as well as the mine area across all four of the scenarios.

The materiality of these impacts and dependencies was then assessed against criteria, which are broadly based on the extent to which the natural capital impact or dependency can affect one or more corporate aspects of the BHP risk management framework:

- **Operational:** business operations, project implementation, or the value of existing or new product(s)
- **Legal and regulatory:** a legal process or liability
- **Financial:** access to capital, investor interest, or insurance conditions
- **Reputational:** company image, or relationship with customers and other stakeholders
- **Societal:** impacts to society and communities

The result was a list of material impact drivers and dependencies which were included in the development of the natural capital accounts (Tables 3 and 4).

It should be noted that the retrospective nature of the Beenup site pilot case study (and lack of information to inform this analysis at the time the mine was operational) made assessment of impacts and dependencies difficult. Specifically, while greenhouse gas emissions and climate change related impacts and dependencies were identified as possible impact drivers, they were not included in further assessment and development of accounts due to incomplete data. Furthermore, the assessment of impacts and dependencies upstream or downstream in the value chain was also excluded from this pilot case study, due to insufficient available data.

Clearly these are gaps in this study, and future mining NCA studies, would need to determine an approach to this part of the process.

CICES Definition		Physical Metric for the Service
1.1.1.1	Contributions to the growth of grazed biomass that is an input to the growth of cultivated livestock.	tonnes/ha
1.2.1.1	Contributions from all biota (including seed, spore or gamete production) that are used (i) to develop new animal and plant breeds; (ii) in gene synthesis; or (iii) in product development directly using genetic material.	seeds collected (no. or kg/ha)
		no. of MNES restricted to the Warren subregion managed for collection and propagation of genetic material.
4.2.1.2	Contributions of water flow regulation, water purification, and other ecosystem services to the supply of water of appropriate quality to users for various uses.	volumes supplied (GL)/ annum to third party for pasture irrigation
2.2.6.1	Contributions to reducing concentrations of GHG in the atmosphere through the removal (sequestration) of carbon from the atmosphere and the retention (storage) of carbon in ecosystems.	carbon sequestration rates tCO_2-eq/ annum
2.2.5.1	Contributions to the restoration and maintenance of the chemical condition of surface water and groundwater bodies through the breakdown or removal of nutrients and other pollutants.	mass nutrients removed (tonnes N or P removed / annum)
2.2.1.3	Contributions to the regulation of river flows and groundwater and lake water tables.	volumes (GL) discharged /annum
3.1.2.1. / 3.1.2.2	Contributions that enable people to use the environment through intellectual interactions with the environment.	no. technical visitors

Table 3. Impacts materiality assessment for the Beenup site pilot case study

		Impact Category	Specific Impacts	Notes
Outputs		GHG emissions	Volume of carbon dioxide equivalent (CO_2-eq) emitted	Emissions associated with mining operations (Scenario 2) and agriculture
		Non-GHG air pollutants	Volume of particulate matter released to air	Emissions associated with mining operations
		Water pollutants	Discharge to surface water - amount of total nitrogen, total phosphorus, total suspended solids	Agricultural runoff impacting water quality of the Scott and Blackwood Rivers
			Discharge / infiltration to groundwater	Acidic plume during mining but has not migrated off site
		Disturbances	Noise and odour	Noise and odour emissions associated with mining activities. These are only limited disturbances given the distance to residential areas
Resource use	Provisioning	Biomass	Grazed biomass	Provision of pasture for livestock
			Wild animals, plants and other biomass	Production of wildflowers, honey, etc.
		Genetic material	Genetic material from plants to maintain populations and for breeding	Native seed supply
				Threatened Ecological Communities, Threatened flora and fauna
		Water supply	Water volume supplied to third party	Water supply for agricultural uses (irrigation)
		Habitat	Extent and condition	Restoration/rehabilitation works (post mining scenarios) increased habitat extent and geomorphic diversity
	Regulatory & maintenance	Global Climate Regulation	Removal (sequestration) of carbon from the atmosphere and the retention (storage) in ecosystems	Above and below ground stored and sequestered carbon
		Solid quality regulation	Storing and recycling of nutrients; biomass decomposition and fixing processes	Increased soil fertility and productivity facilitating revegetation/restoration success, including improved condition of TEC
		Water filtration / purification	Surface water	Reduction in nutrient loads to Blackwood River due to wetland interception and treatment
			Groundwater	Retention/stabilisation of buried pyrites protects groundwater acidification
		Water flow regulation	Surface water	Baseline flow maintenance
	Cultural	Recreation	Recreational and physical health	Multiple recreational and eco tourism and nature-based recreation activities applicable to Beenup project, although currently limited due to access restrictions
		Visual amenity	Contributions to the aesthetic qualities of the region and sensory benefits.	Post-mining Scenarios have significant impacts to visual amenity and improved aesthetic appreciation
		Education, scientific and research	Intellectual interactions with Nature	The Beenup site has supported world class research, attracted many scientific and technical visitors (conference delegates etc) and citizen scientists, and has high potential to increase these services

Likely to be significant
Potentially significant
Unlikely to be significant or not applicable

O Operational
L&R Legal and regulatory
F Financing
R Reputational and marketing
S Societal

	Scenario 1			Scenario 2			Scenario 3 (Phase 1 and 2)			Included in Natural Capital Accounts	Materiality Criteria
	Mining	Agriculture	Ecosystem (condition & services)	Mining	Agriculture	Ecosystem (condition & services)	Mining	Agriculture	Ecosystem (condition & services)		
										✓	S
										✓	L&R, R, S
										✓	S
										✓	R, S
										✓	L&R, R, S
										✓	S
										✓	L&R, F, R, S
										✓	R, F, S
										✓	
										✓	R, F, S
										✓	R, S
										✓	R, S

Table 4. Dependencies materiality assessment for the Beenup site pilot case study

Inputs	Dependency Category	Specific Dependency	Notes
Consumptive	**Energy**	Fossil Fuels	Transport, vehicles
	Water	Rain	Rain seasonal with heavy winter rains countered by hot dry summers; recharges streams and groundwater
		Groundwater	Groundwater is recharged during winter causing spring flows, and supporting wetlands and groundwater dependent ecosystems. Groundwater used as the main water supply during mining
		Surface	Very little surface water pre-mining and channel flow seasonal
		Quality	Diversity of aquatic fauna and wetland health dependent on good water quality
	Materials	Ilmenite	The mineral resource supporting mining
		Lime sand	Import of lime sand needed to neutralise acid plume and pyritic materials
	Land	Availability	Land and access to land needed for activities in each of the phases
Non - Consumptive	**Regulation of Physical Environment**	Flood Attenuation	Creation of wetlands increases attenuation capability, with flood spillways now present
		Water Quality Regulation	Wetlands regulate agricultural runoff, removing nutrients and sediments before discharge of flow to the Scott and Blackwood Rivers
	Regulation of Biological Environment	Rare Flora Seed Bank	Biodiversity value of the land and flow-on services
		Birdlife Breeding	Wetlands provide particular habitats for birds of significance
		Fauna Refuge	Extends the habitat area and quality adjacent to national park supporting resilience of fauna
	Climate Change	Changes in rainfall	Natural ecosystems and pasture productivity dependent on sufficient, and seasonally distributed rains
		Changes in temperature	Ecosystem condition dependent on stable temperature trends (within thresholds)

Likely to be significant
Potentially significant
Unlikely to be significant or not applicable

O Operational
L&R Legal and regulatory
F Financing
R Reputational and marketing
S Societal

	Scenario 1			Scenario 2			Scenario 3 (Phase 1 and 2)			Included in Natural Capital Accounts	Materiality Criteria
	Mining	Agriculture	Ecosystem (condition & services)	Mining	Agriculture	Ecosystem (condition & services)	Mining	Agriculture	Ecosystem (condition & services)		
										✓	O, F, S
										✓	O, F, S
										✓	L&R, S, F
										✓	O, F, S
										✓	O, F, S
										✓	O, F, R, S
										✓	O, F, R, S
										✓	O, F, R, S
										✓	O, F, R, S
										✓	O, F, R, S

EXAMPLE PHYSICAL ACCOUNTS

These example physical accounts capture the changes in stocks and flows of natural capital assets, along with changes to ecosystem extent and condition across the different land use scenarios.

The key approaches taken in developing the example physical accounts (stocks and flows) for the Beenup site pilot case study included:

1. Establishing the Beenup natural capital Asset Register (STOCKS).
2. Determining ecosystem extent and changes in extent across defined assessment scenarios.
3. Analysing ecosystem condition changes across defined assessment scenarios.
4. Developing the ecosystem services account (FLOWS) – the separate account is not presented here since it has been incorporated with the EP&L statements.

A detailed explanation of the methodology is provided in the Notes to Physical Accounts section of this document.

It should be noted that the example Beenup natural capital accounts are presented from the viewpoint of the Company, not society, hence the opening accounts are treated as zero for BHP (since BHP did not own or control any of the natural capital at commencement).

NCA Asset Register

Details on the Beenup NCA Asset Register are contained in the Notes to Physical Accounts.

The following Environmental Asset types (as defined by SEEA -EA) were included in the Beenup site pilot case study:

1. Environmental assets – ecosystems
2. Environmental assets – other:
   - 2.1 Land (as provision of space)
   - 2.2 Mineral resources (mineral sands)

The SEEA-CF classes mineral and energy resources as 'other' environmental assets. They are not considered as ecosystem assets since the benefits they provide are not the result of current ecosystem processes. They are recorded in the extended balance sheet under 'other environmental assets'. Land (as provision of space) has also been included under this category.

There were extensive datasets available for assessing ecosystem assets at the Beenup site because of its sensitive environmental context, stakeholder driven restoration objectives, final land use goals, and the diversity of landforms and habitat types. The required data types and requirements for NCA is shown in Table 5, with an indication of what was used in this pilot case study.

Perhaps unusual compared with many other mines, the restored habitats at the Beenup site support several Matters of National Environmental Significance (MNES), which means that they are protected by conservation legislation; these are also used as a source of genetic material for breeding of some endangered plant species by the Western Australian Government Department of Biodiversity, Conservation and Attractions (DBCA). These ecosystems fall within BHP's definition of Important Ecosystems and Biodiversity and/or Ecosystems, hence the MNES within the Beenup site were also incorporated in the Asset Register, including a) nationally threatened species and ecological communities; and b) migratory species.

Table 5. Data types and data requirement needs to develop the natural capital asset register, and stock and flow accounts

Data Purpose	Data Types	Data Requirements	Used in Beenup Accounts?
Natural Capital Assets Register			
Land tenure	Owned and leased lands under the control of the mining entity	Areas, year and value of each lot acquired; spatial maps showing changes annually.	Y
Land cover and land use	Natural, semi-natural and artificial land cover and land uses	Natural and modified land cover (e.g. pasture, natural systems, terrestrial, aquatic etc, following FAO and adapting IUCN GET frameworks). Land use (e.g. intensive uses, dryland agriculture etc), should follow national standards (in this case the ALUM V8 primary and secondary classes were used). More detail, such as if land is improved or unimproved should also be captured.	Y
Ecosystem units	Geomorphic units and vegetation assemblages	Broad geomorphic units as defined by landform, hydrology, soils and adapting IUCN GET frameworks. Vegetation assemblages defined using national standards for vegetation classification (in this case NVIS Level 4 or 5). Ecosystem units defined as the geomorphic unit described by the dominant vegetation assemblage (e.g. Tall eucalyptus forest or woodland on dryland plains).	Y
Mineral resources	Reserves (amounts and projected life)	Extraction volumes, projected life of resource, depletions over time, interdependencies of other ecosystem assets (e.g. vegetation communities) on the resource.	Y
Stock and Flow Accounts			
Ecosystem condition account	Chemical and physical state	Data on water & soil quality within and beyond the sites (receiving environments and baseline sites).	Y
	Structural state	Structural properties (e.g. relative cover of trees, shrubs, herbs; weed cover, plant density) for each ecosystem unit and its main biotic components (species, TEC).	Y
	Compositional state	Diversity of ecological communities, species richness, abundance of flora and fauna, TECs, vulnerable species.	Y
	Functional state	Biological, chemical, & physical interactions (soil health variables; diversity of vegetation types, diversity of fauna assemblages, dry matter productivity of pasture).	Y
	Ecosystem / landscape connectivity	Landscape diversity, connectivity, fragmentation metrics including the number of isolated remnant vegetation patches, the size of these patches and the edge length.	Y
Water account	Climatic data	Temperature, rainfall, evaporation (annual and seasonal).	Y
	Groundwater	Depth to groundwater (min, max, seasonal), flow rates, direction of flow, aquifer properties, and water quality in baseline and receiving environments using key physical and chemical parameters (pH,nutrients, sediment, metals, pollutants) as a minimum.	N
	Water storages	On site storages (measured or calculated from reservoirs, dams, wetlands).	Y
	Anthropogenic water use	Water balance showing volumes extracted, imported, exported for use in mining operations, rehabilitation, irrigation, dust suppression.	Y
	Catchments	Catchment boundaries (needed to determine inflow and outflow of surface water). Subcatchment modelling based on topography for greater accuracy.	Y
	Surface water	Surface water flows in and out of the catchment, and water quality in baseline and receiving environments using key physical and chemical parameters (pH, nutrients, sediment, metals, pollutants).	Y
Carbon account	Greenhouse gas emissions	Greenhouse gas emissions resulting from mining and other land uses over the life of mine and closure, reported as tonnes of CO_2-equivalent.	Y
	Vegetation biocarbon	Stored & sequestered carbon in above-ground vegetation for each ecosystem unit and reference sites.	Y
	Soil biocarbon	Stored & sequestered soil carbon at depth intervals for each ecosystem unit and reference sites.	Y
Ecosystem services (Flow account)	Users/flows/benefits for each of the identified ecosystem services	Data that enables identification and measurement of ecosystem service benefits with user groups, including type and number of visitors, number of research projects, natural products harvested etc.	Y
	Potential future ecosystem services	Data that enables identification and development of potential future ecosystem service benefits, including opportunity framing, surveys with potential user groups (industry, community), market analysis.	N

Ecosystem Extent

The ecosystem is the level of assessment (analytical unit) adopted for natural capital accounts. Ecosystem assets were grouped into a) Native ecosystems; and b) Pasture.

For this pilot case study, ecosystem assets were also aligned with geomorphic units, which were the main guiding ecosystem units used to design the restoration methods at the Beenup site and are the umbrella units that vegetation communities are mapped within. In total, nine ecosystem (geomorphic) units were defined within Native Ecosystems, with pasture and plantations defined as Intensive Land Use Systems. The rest of the extent comprises of Artificial Surfaces and Associated Areas.

Although the site is closed, BHP has retained ownership of, and currently manages, 480 ha of native ecosystems and 179 ha of pasture. The ecosystem assets at the Beenup site are associated with the ecologically restored former mine operational area, the remnant vegetation on lands acquired outside of the former operational area, and the lands subleased to farmers for pasture and grazing (under managed lease agreements). The proportions of these vary through the different land use scenarios.

Changes in the extent of these ecosystem units across the defined NCA Scenarios is presented in Figure 7 and Table 6 and summarised below. For each of the analysed scenarios, the extent presented represents the closing account extent for the given assets and for the given timeframe (i.e., it is the extent recorded at the end of the given scenario).

- **Scenario 1 (S1)** Pre-Mining (June 1991 extent) – 1319 ha total dominated by pasture (802 ha) with a natural and semi-natural ecosystem extent of 514 ha.
- **Scenario 2 (S2)** Mining (June 1999 extent) – 1712 ha total. Most of the land in the Beenup Project Area (operational footprint) was converted from pasture (194 ha) and natural ecosystems (167 ha) to artificial surfaces and associated areas (mining operational area) during this Scenario. 227 ha of natural ecosystems were acquired by BHP.
- **Scenario 3 Phase 1 (S3P1)** Rehabilitation Works (June 2005 extent) – 660 ha total characterised by a major reduction in pasture extent (reduction of 671 ha, sold back to private farmers) and conversion of artificial surfaces and associated areas (mining operational area) into natural and modified ecosystems, and transfer of 153 ha to the conservation estate.
- **Scenario 3 Phase 2 (S3P2)** Post-Rehabilitation (June 2020 extent) – 660 ha total. No major changes in the extent occurred between the previous (S3P1) and this (S3P2) Scenario. The only change was conversion of 35 ha of pasture into natural ecosystems (Dryland Plains and Palusplains).

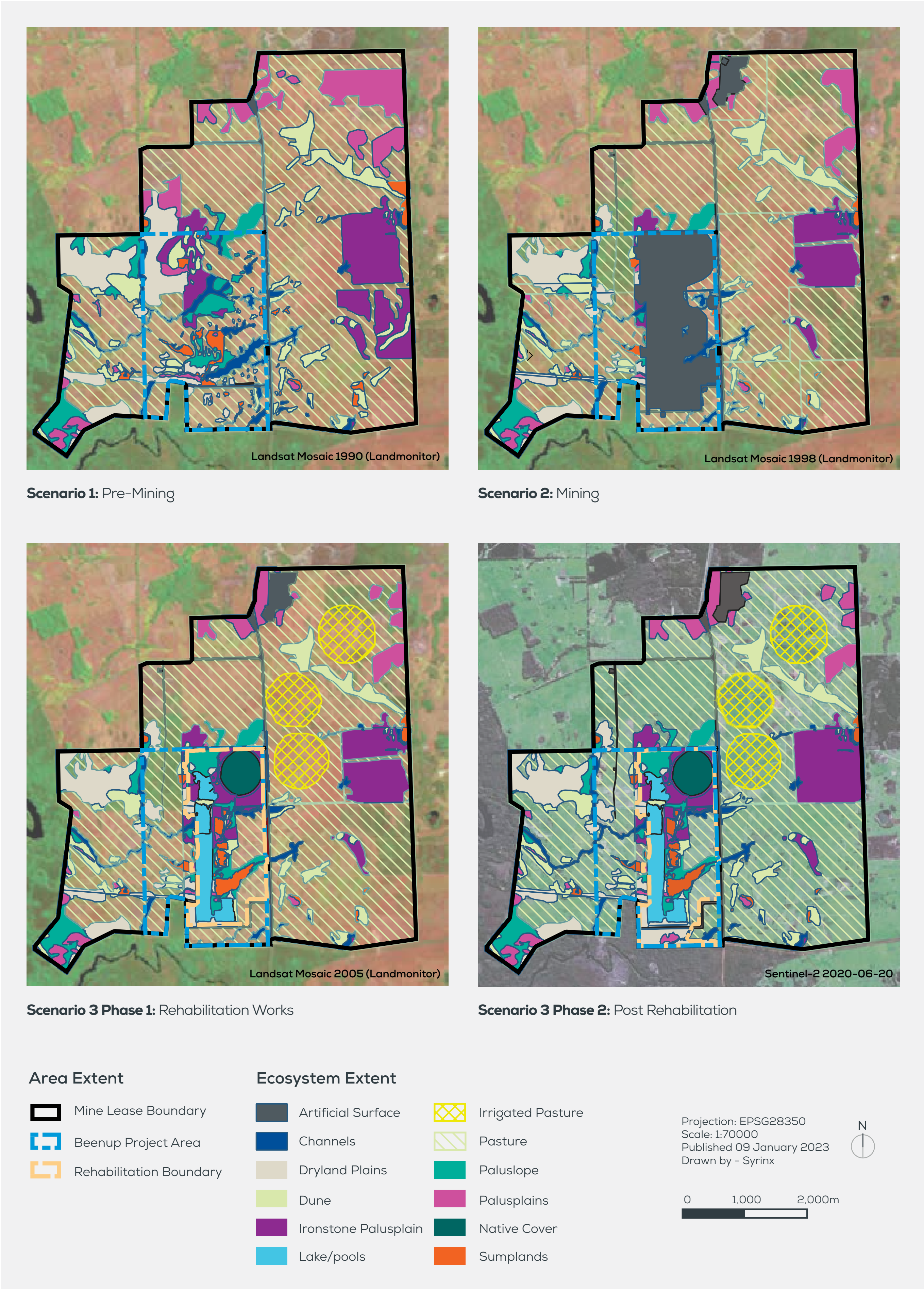

Figure 7. Changes in ecosystem asset extent across different NCA scenarios

Table 6. Change in ecosystem asset extent for BHP controlled land (owned, leased)

	Land Use Type (area in ha)					
	Artificial Surfaces & Associated Areas	Native Cover (MDSA)	Pasture	Plantation	Natural Ecosystems	Total - BHP owned & leased areas
Scenario 1 - July 1982 (opening)	**-**	**-**	**-**	**-**	**-**	**-**
change due to sale or purchase/lease of land	-	-	802	3	514	1,319
transfer to conservation estate	-	-	-	-	-	-
conversion due to direct mining operations	-	-	-	-	-	-
conversion to natural ecosystem (rehabilitation/restoration)	-	-	-	-	-	-
Net Change	-	-	802	3	514	1,319
Scenario 1 - June 1991 (closing)	**-**	**-**	**802**	**3**	**514**	**1,319**
Scenario 2 - July 1991 (opening)	**-**	**-**	**802**	**3**	**514**	**1,319**
change due to sale or end of lease	-	-	-158	-	-109	-267
change due to purchase or lease of land	1	-	434	-	227	662
transfer to conservation estate	-	-	-	-	-	-
conversion due to direct mining operations	360	-	-194	-1	-167	-2
conversion to natural ecosystem (rehabilitation/restoration)	-	-	-	-	-	-
Net Change	361	-	82	-1	-49	393
Scenario 2 - Jun 1999 (closing)	**361**	**-**	**884**	**2**	**465**	**1,712**
Scenario 3 Phase 1 - July 1999 (opening)	**361**	**-**	**884**	**2**	**465**	**1,712**
change due to sale or purchase/lease of land	-30	-	-691	-	-178	-899
transfer to conservation estate	-	-	-21	-	-132	-153
conversion due to direct mining operations	-	-	-	-	-	-
conversion to natural ecosystem (rehabilitation/restoration)	-330	40	41	-1	250	-
Net Change	-360	40	-671	-1	-60	-1,052
Scenario 3 Phase 1 - June 2005 (closing)	**1**	**40**	**213**	**1**	**405**	**660**
Scenario 3 Phase 2 - July 2005 (opening)	**1**	**40**	**213**	**1**	**405**	**660**
change due to sale or purchase/lease of land	-	-	-	-	-	-
transfer to conservation estate	-	-	-	-	-	-
conversion due to direct mining operations	-	-	-	-	-	-
conversion to natural ecosystem (rehabilitation/restoration)	-	-	-35	-	35	-
Net Change	-	-	-35	-	35	-
Scenario 3 Phase 2 - Jun 2020 (closing)	**1**	**40**	**178**	**1**	**440**	**660**

Notes:

64 ha of the clearing of remnant vegetation was undertaken by the neighbouring farmer on Lot 4255 (later Lot 1). This has been included because BHP controlled these lands at the time of clearing.

Where the number of hectares does not precisely add up, this is due to limitations of the spatial datasets used in this pilot case study and due to rounding discrepancies.

Since plantation is such a minor landuse type, it was combined with pasture for calculating monetary values.

This table has been derived from the SEEA template tables as a summary. The SEEA tables are required in the NCA process so as to track the additions and subtractions of land as opening and closing accounts through each scenario or time period selected.

Ecosystem Condition

The approach adopted for developing ecosystem condition index accounts for the four NCA Scenarios is aligned with that described in SEEA-EA and the current published literature e.g., (Keith *et al.*, 2020). For each of the analysed Scenarios, the ecosystem condition included in summary Tables and Figures (Table 6, Table 7, and Figure 8) represents the closing account condition values for the given Scenario timeframe (i.e., it is the ecosystem condition recorded at the end of the given Scenario). The numbers shown have been averaged from the detailed condition tables which show the breakdown of condition for each ecosystem unit.

Scenario 1 (S1) Pre-Mining – June 1991 extent. Characterised by pastureland of LOW condition and HIGH condition of all natural and modified natural ecosystems.

Scenario 2 (S2) Mining – June 1999 extent. Characterised, outside of the mining operational area (Beenup Project Area), by remnant vegetation condition mostly rated as HIGH and pastureland of LOW condition. Within the Beenup Project Area, most of the area was converted to artificial surfaces that have no ecosystem value.

Scenario 3 Phase 1 (S3P1) Rehabilitation Works – June 2005 extent. Due to the rehabilitation work undertaken during this period, this Scenario was characterised by MEDIUM to HIGH condition of remnant vegetation outside of the Beenup Project Area, and of the rehabilitated ecosystems within the operational area. The newly created MDSA geomorphic unit/ecosystem had LOW value, as did the pastureland parcels.

Scenario 3 Phase 2 (S3P2) Post-Rehabilitation – June 2020 extent. As a result of successful rehabilitation and associated land management, this Scenario was characterised by HIGH condition of all natural and semi natural ecosystems within the assessment boundary, with only the highly modified MDSA and pasture ascribed a LOW value.

Table 7. Summary of extent and condition in relation to land use types for each scenario

	Scenario 1 Pre-Mining		Scenario 2 Mining		Scenario 3 Phase 1 Rehabilitation Works		Scenario 3 Phase 2 Post-Rehabilitation	
Ecosystem Assets	**Extent (ha)**	**Condition**	**Extent (ha)**	**Condition**	**Extent (ha)**	**Condition**	**Extent (ha)**	**Condition**
Natural	443	HIGH	323	HIGH	210	HIGH	345	HIGH
	-	MEDIUM	81	MEDIUM	100	MEDIUM	-	MEDIUM
	-	LOW	-	LOW	-	LOW	-	LOW
Modified / Semi-Natural	71	HIGH	-	HIGH	-	HIGH	95	HIGH
	-	MEDIUM	61	MEDIUM	95	MEDIUM	-	MEDIUM
	-	LOW	-	LOW	40	LOW	40	LOW
Pasture	-	HIGH	-	HIGH	-	HIGH	-	HIGH
	-	MEDIUM	-	MEDIUM	-	MEDIUM	-	MEDIUM
	805	LOW	886	LOW	214	LOW	179	LOW
Artificial	-		361		1		1	
TOTAL	**1,319**		**1,712**		**660**		**660**	

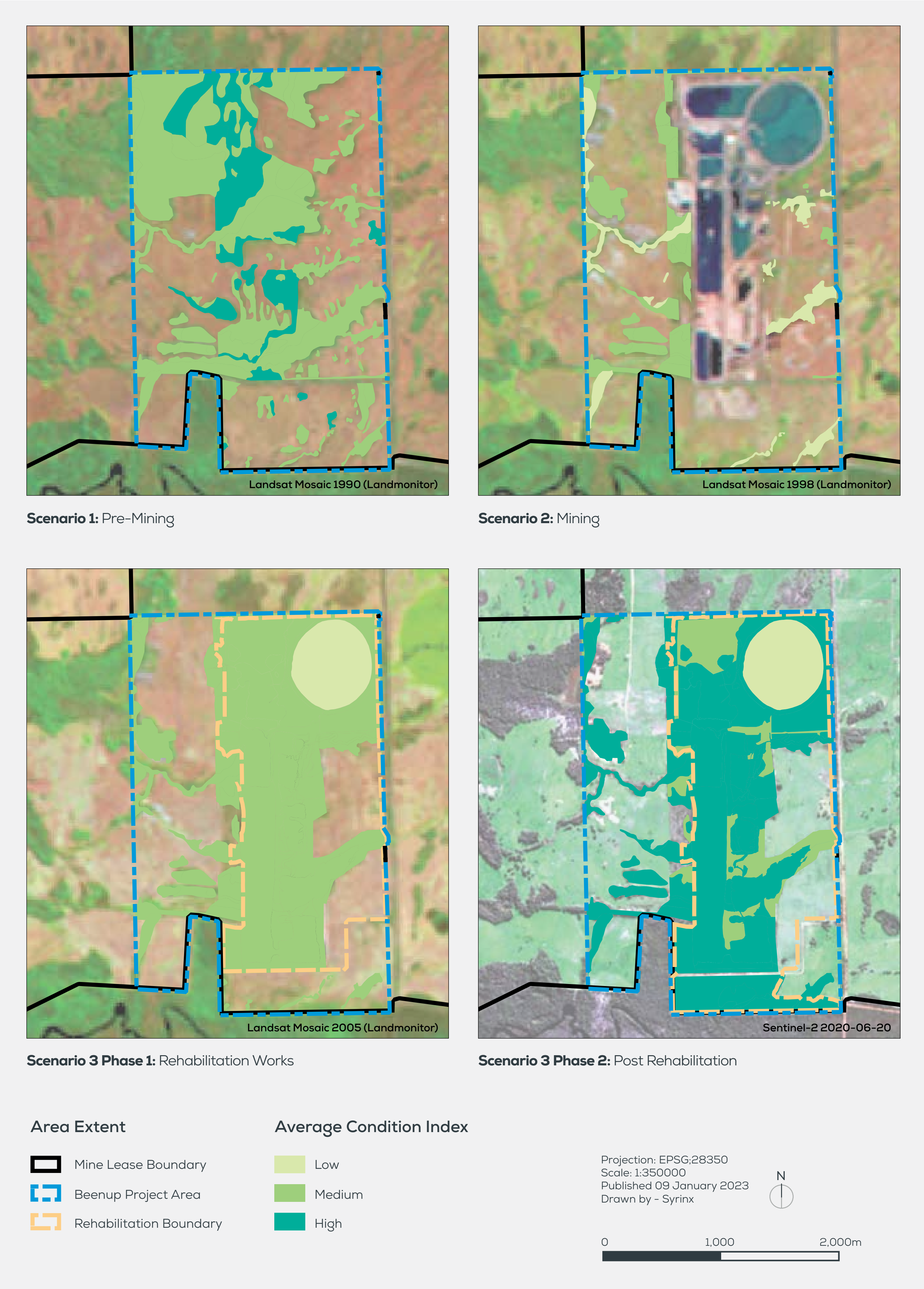

Figure 8. Changes in ecosystem assets' condition across the different NCA Scenarios

Matters of National Environmental Significance (MNES)

The MNES within the Beenup site include a) nationally threatened species and ecological communities; and b) internationally and nationally significant migratory species (Table 9).

Post-restoration, the number of both threatened fauna and flora species returned to site exceeded pre-mining numbers. All of the newly found fauna species were associated with the extensive creation of wetland ecosystems, which were not present in the pre- mining Scenario.

The entire community extent was estimated to occupy 276 – 404 ha in 2012. In 2013, after the Beenup mine was closed, 148 ha of this TEC (remnant) was transferred from BHP to the DBCA and is now secured in the conservation estate. An additional 70 ha of this community has been successfully restored during the Beenup restoration project.

Table 8. Beenup site ecosystem asset register - extended table.

	Land Classification				
	FAO Level 3	**IUCN Level 1: Realm**	**Level 2: Biome**	**ALUM V8 Primary Land Use Class**	**Ecosystem (Geomorphic) Units**
Natural	A12. Natural and Semi-Natural Vegetation	Terrestrial	T2 Temperate-Boreal Forests and Woodlands	1. Conservation and Natural environments	Dryland Plains
					Dunes
	A24. Natural and Semi-Natural Aquatic or Regularly Flooded Vegetation	Freshwater/ Terrestrial	TF1 Palustrine Wetlands	6. Water	Paluslopes
					Sumplands
					Palusplains
					Ironstone Palusplains
Modified / Semi-Natural	B27. Artificial Waterbodies	Terrestrial	A12. Natural and Semi-Natural Vegetation	1. Conservation and Natural Environments	MDSA
		Freshwater	F1 Rivers and Streams	6. Water	Drainage Channels
			F3 Artificial Wetlands	6. Water	Lakes/pools
Pasture	A12. Natural and Semi-Natural Vegetation	Terrestrial	T7 Intensive Land Use Systems	3. Production from Dryland Agriculture and Plantations	Pasture
					Plantation
Artificial	B15. Artificial Surfaces and Associated Areas	Terrestrial	T7 Intensive Land Use Systems	5. Intensive Uses	Artificial Surfaces and Associated Areas (Mine)

Table 9. Beenup site ecosystem assets - Matters of National Environmental Significance.

			Conservation codes	Scenario 1: Pre-Mining	Scenario 2 Mining	Scenario 3 Phase 1 Rehabilitation Works	Scenario 3 Phase 2 Post-Rehabilitation
Natural and Semi Natural Areas	**TECs**						
	Scott River Ironstone Association		E	✓	✓	✓	✓
	area (ha)			148	130	68	68
	Threatened Flora Species						
	Darwinia ferricola Keighery		E	✓		✓	✓
	Grevillea brachystylis ssp. *australis*	Short-styled Grevillea	V	✓		✓	✓
	Lambertia orbifolia ssp. *Scott River Plains*	Round-leafed Honeysuckle	E	✓		✓	✓
	Banksia nivea ssp. *uliginosa*	Swamp Honeypot	E			✓	✓
	Threatened Fauna Species						
	Calyptorhynchus baudinii	Baudin's Cockatoo	E	✓		✓	✓
	Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	V	✓		✓	✓
	Ardea modesta	Eastern Great Egret	MI				✓
	Tringa nebularia	Common Greensbank	MI			✓	✓
	Actitis hypoleucos	Common Sandpiper	MI				✓
	Calidris acuminata	Sharp-tailed Sandpiper	MI				✓

	Scenario 1 Pre-Mining		Scenario 2 Mining		Scenario 3 Phase 1 Rehabilitation Works		Scenario 3 Phase 2 Post-Rehabilitation	
	Ecosystem Assets - Extent & Condition at Scenario End Date							
	Extent (ha)	Condition	Extent (ha)	Condition	Extent (ha)	Condition	Extent (ha)	Condition
	23	HIGH	66	MEDIUM	65	HIGH	96	HIGH
	53	HIGH	84	HIGH	22	HIGH	23	HIGH
	59	HIGH	46	HIGH	88	HIGH	89	HIGH
	28	HIGH	15	MEDIUM	32	MEDIUM	33	HIGH
	132	HIGH	63	HIGH	35	HIGH	36	HIGH
	148	HIGH	130	HIGH	68	MEDIUM	68	HIGH
	-	-	-	-	40	LOW	40	LOW
	71	HIGH	61	MEDIUM	17	MEDIUM	17	HIGH
	-	-	-	-	78	MEDIUM	78	HIGH
	802	LOW	884	LOW	213	LOW	179	LOW
	3	LOW	2	LOW	1	LOW	-	-
	-	-	361	-	1	-	1	-

		Scenario 1 Pre-Mining	Scenario 2 Mining	Scenario 3 Phase 1 Rehabilitation Works	Scenario 3 Phase 2 Post-Rehabilitation
TEC (ha)	ha	148	130	68	68
Threatened Flora Species	no. of species	3	0	4	4
Threatened Fauna Species	no. of species	2	0	3	6

MNES Categories	
E	Endangered (E)
V	Vulnerable (V)
MI	Migratory species

The threatened ecological community (TEC) present at the Beenup site is the Scott River Ironstone Association, which is classified as endangered. This ecological community comprises seasonally inundated shrubland or heathland occurring on patches of shallow soils over massive ironstone formations and is highly restricted to the Scott Coastal Plain in south-west Western Australia (WA). Twenty plant species have their distribution centred on these ironstone areas, with a further three restricted to this habitat.

Most of this TEC has been historically cleared for agriculture. When the Beenup site was operational (Scenario 2), only five areas of this threatened community were in secure conservation reserves.

EXAMPLE MONETARY ACCOUNTS

8

These example monetary accounts show how natural capital assets and ecosystem services can be represented within a balance sheet and environmental profit and loss statement format.

This section contains the following:

1. Environmental Profit and Loss statements for the defined NCA Scenarios.
2. Natural capital Balance Sheet for each of the land use scenarios.
3. Environmental Profit and Loss statement and corresponding natural capital Balance Sheet for FY2020/21.
4. Breakdown of natural capital asset value.

Valuation of Non-Ecosystem Environmental Assets

Land and mineral resources comprise the two non-ecosystem natural capital assets.

Land is shown in the accounts as changes to the extent (physical stock) between the defined NCA Scenarios, and the monetary value as the market value of land per hectare (based on actual purchase and sell price in most cases, or market value where data was not available using real estate values for the region).

The challenge in developing these example accounts for the Beenup site (and most mining accounts) is how and where to show the value of the non-renewable mineral resource. This is a topical subject at present due to the impact the failure to account for depletion of resources (and the higher level of complexity in extracting and processing them) has had on sustainability and productivity growth (Dasgupta 2021; CIMA 2019; Valero *et al.*, 2018; Hoang, 2018).

In determining an approach for Beenup, consideration of when it is appropriate to include the mineral resource was firstly decided given the changing land use scenarios: Scenario 1 Pre-Mining - the resource was proven but approvals not yet granted to mine; Scenario 2 - the resource was developed and exported; and Scenario 3 (Phases 1 and 2) - the resource was considered uneconomic but the mining rights remain. To accord with the definition of natural capital assets needing to be economic, the mineral resource is monetised on the Balance Sheet in Scenario 1, and in the Environmental Profit and Loss statement in Scenario 2 when there was an obvious flow of benefit from extraction and sale of the resource. The change in the physical asset stock is shown across the four Scenarios on the natural capital Balance Sheet, but because the resource is considered uneconomic by the end of Scenario 2, no value was ascribed to the resources remaining in-ground.

Environmental Profit and Loss (EP&L) Statements for Defined NCA Scenarios

Summary EP&L Statement - Beenup Pilot Case Study

	Scenario 3 Phase 2 Post-Rehabilitation EP&L for the period July 2005 - June 2020		
	Business (AUD$)	**Society (AUD$)**	**Total (AUD$)**
Total Natural Capital Benefits	-	16,794,270	16,794,270
Total Natural Capital Costs	(9,679,238)	-	(9,679,238)
NET BALANCE	**(9,679,238)**	**16,794,270**	**7,115,032**

Mineral resources were valued using a coarse estimation method with a range of assumptions. This should not be construed as representing accurate figures nor a method to be copied, but rather is shown as an example to further the debate on how best to treat mineral resources in NCA. The intent here was to preserve a positive value of the natural capital, defining the natural capital asset value of the mineral resource using the extracted resource value.

The value was determined using the gross revenue estimated as the production volume multiplied by the average $/t price on the market for the period (note, this is not intended to imply this is the price BHP received for the resource), less an assumed extraction operating cost for the two year period, less a proportion of the consumption of capital (amortised over the 25 year initial expected life of the resource, and defining the resource as equivalent to the commercially exploitable reserve), less a depletion percentage (to reflect the ~4% reduction in the mineral resources).

Note, all costs are assumed (no actual data).
The Beenup mine did not operate for the period initially intended due to operational difficulties, and hence the actual cost (losses) associated with extraction of minerals at Beenup were written off in the financial accounts during the period of operations; ascribing these losses to the natural asset would show the resource as having a negative value. Although the mineral asset was small in the case of Beenup due to the premature closure of the mine, for other mining NCA assessments, inclusion of the mineral resources may cloud the importance of ecosystem assets due to the sheer quantum of the gap in the market and non-market valuation of these asset groups. This is a challenge needing further resolution.

Valuation of Ecosystem Assets

A range of valuation techniques were applied for monetising the ecosystem stocks and services for this case study and are detailed in separate tables (see the Notes to Example Monetary Account section). There is considerable uncertainty with all monetary valuation methods for natural capital assessments, however there are now very well-established methods that can be applied. One of the benefits of the Beenup site retrospective accounts was that actual data was available for assigning some valuation figures, in particular replacement costs.

These example accounts show how the various non-market and market valuation methods might be applied to other applications of natural capital accounts in the mining sector.

To avoid double counting of values, the value of the main ecosystem services (e.g., carbon, wetlands, habitats) exclude the interrelated values; that is:

- Carbon is excluded from ecosystem condition accounts.
- The ecosystem services that are valued when estimating the value of wetlands and habitats do not include carbon sequestration.
- The ecosystem services that are valued when estimating the value of wetlands and habitats are mutually exclusive.

More detailed methods are provided in the Notes to Example Monetary Accounts section within this document.

20-21 Accounts

The balance sheet for the 20-21 account was done using a net present value (NPV) method where the future flows and value of natural capital assets are forecast over a 20 year forward period. Understanding future value of these assets should be used to inform decision making based on likely market changes and risk estimates.

	Scenario 3 Phase 1 Rehabilitation Works EP&L for the period July 1999 - June 2005			**Scenario 2 Mining** EP&L for the period July 1991- June 1999			**Scenario 1 Pre-Mining** EP&L for the period July 1982- June 1991		
	Business (AUD$)	**Society (AUD$)**	**Total (AUD$)**	**Business (AUD$)**	**Society (AUD$)**	**Total (AUD$)**	**Business (AUD$)**	**Society (AUD$)**	**Total (AUD$)**
	4,956,000	7,325,119	12,281,119	80,000,000	5,847,086	85,847,086	20,000,000	17,171,178	37,171,178
	(26,313,211)	(7,875,762)	(34,188,973)	(66,787,041)	(22,444,629)	(89,231,670)	(12,462,275)	-	(12,462,275)
	(21,357,211)	**(550,643)**	**(21,907,854)**	**13,212,959**	**(16,597,544)**	**(3,384,584)**	**7,537,725**	**17,171,178**	**24,708,903**

	Services	Notes [1]	(physical account) measure	(physical account) metric
Environmental Assets - Other				
Land (as provision of space)	**Land change**	PL 1	area	ha
Mineral and Energy Resources	**Mineral sands**	PL 2		
	Mineral sands extracted		volume/amount extracted	tonnes
	Depletion of resource	PL2	volume/amount extracted	tonnes
	Expenses - environmental assets (other)	PL 3		
Environmental Assets - Ecosystems				
Pasture and Native Ecosystems	**Grazed biomass**			
	Increase in fodder to support grazing	PL 4	area supporting grazing	ha
	Carbon	PL 5		
	Carbon sequestration - Pasture		quantity of above and below ground sequestered carbon	t CO_2 e
	Carbon sequestration - Natural Ecosystems			
	Adjustments to carbon due to land area changes	PL 5		t CO_2 e
	Water			
	Water quality regulation	PL 6	mass of nutrients removed	tonnes
			mass of sediment removed	tonnes
	Water flow regulation	PL 7	volume discharged (environmental flows)	ML
	Water supply	PL 8	volume supplied to third party	ML
	Natural products			
	Native seed supply	PL 9	seed harvested	tonnes
	Beekeeping and production of honey		quantity commercially produced	tonnes
	Commercial wildflower harvesting		area supporting wildflowers	ha
	Habitat provision			
	Provision of high quality habitat to support/sustains matters of national conservation significance	PL 10	maintenance of MNES	no. of MNES restricted to the Warren subregion
	Habitat value adjustment - gains/(losses) in flows			
	Education, Scientific & Research	PL 11		
	Technical visits		number of visits	no.
TOTAL				
NET NATURAL CAPITAL PROFIT/(LOSS)				

1. Notes to the EP&L Accounts are provided in a separate section within this report
2. Physical Accounts show the change (gains/losses) in the quantity of the assets in the given period
3. Monetary Accounts show the change (gains/losses) in the value of the assets in the given period

Scenario 3 Phase 2 Post-Rehabilitation EP&L for the period July 2005 - June 2020						Scenario 3 Phase 1 Rehabilitation Works EP&L for the period July 1999 - June 2005					
Physical Account [2]		Monetary Flow Account [3]				Physical Account		Monetary Flow Account			
Flows		Benefits		Costs		Flows		Benefits		Costs	
		Realisable or potentially realisable benefits of physical flows		Costs associated with generation of physical flows				Realisable or potentially realisable benefits of physical flows		Costs associated with generation of physical flows	
Flows to business	Flows to society	Benefits to business (AUD$)	Benefits to society (AUD$)	Costs to business (AUD$)	Costs to society (AUD$)	Flows to business	Flows to society	Benefits to business (AUD$)	Benefits to society (AUD$)	Costs to business (AUD$)	Costs to society (AUD$)
-	-	-	-	-	-	*-1,052*	-	3,156,000	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
		-	-	(7,660,286)	-			-	-	(20,797,317)	-
-	*179*	-	473,722	(611,804)	-	-	*214*	-	225,984	(710,887)	-
-	*1,616*	-	30,700	-	-	-	*580*	-	11,016	-	-
-	*106,939*	-	2,031,849	-	-	-	*36,836*	-	699,891	-	-
-	*16,493*	-	313,360	-	-	-	*-304,116*	-	-	-	(5,778,212)
-	*109*	-	9,291,598	-	-	-	*44*	-	3,716,639	(1,680,000)	-
-	*1,099*	-	-	-	-	-	*440*	-	-	-	-
-	*17,430*	-	1,742,996	(61,180)	-	-	*14,348*	-	1,434,829	(1,200,000)	-
-	-	-	-	-	-	-	*8,150*	-	815,000	(1,114,020)	-
-	-	-	-	-	-	*200*	-	1,800,000	-	(465,443)	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	*5*	-	1,050,000	(1,223,607)	-	-	*5*	-	420,000	(310,000)	-
		-	1,848,333	-	-			-	-	-	(2,097,550)
-	*366*	-	11,712	(122,361)	-	-	*55*	-	1,760	(35,544)	-
		-	**16,794,270**	**9,679,238**	**-**			**4,956,000**	**7,325,119**	**(26,313,211)**	**(7,875,762)**
				7,115,032						**(21,907,854)**	

	Services	Notes [1]	(physical account) measure	(physical account) metric
Environmental Assets - Other				
Land (as provision of space)	**Land change**	PL 1	area	ha
Mineral and Energy Resources	**Mineral sands**	PL 2		
	Mineral sands extracted		volume/amount extracted	tonnes
	Depletion of resource	PL2	volume/amount extracted	tonnes
	Expenses - environmental assets (other)	PL 3		
Environmental Assets - Ecosystems				
Pasture and Native Ecosystems	**Grazed biomass**			
	Increase in fodder to support grazing	PL 4	area supporting grazing	ha
	Carbon	PL 5		
	Carbon sequestration - Pasture		quantity of above and below ground sequestered carbon	t CO_2 e
	Carbon sequestration - Natural Ecosystems			
	Adjustments to carbon due to land area changes	PL 5		t CO_2 e
	Water			
	Water quality regulation	PL 6	mass of nutrients removed	tonnes
			mass of sediment removed	tonnes
	Water flow regulation	PL 7	volume discharged (environmental flows)	ML
	Water supply	PL 8	volume supplied to third party	ML
	Natural products			
	Native seed supply	PL 9	seed harvested	tonnes
	Beekeeping and production of honey		quantity commercially produced	tonnes
	Commercial wildflower harvesting		area supporting wildflowers	ha
	Habitat provision			
	Provision of high quality habitat to support/sustains matters of national conservation significance	PL 10	maintenance of MNES	no. of MNES restricted to the Warren subregion
	Habitat value adjustment - gains/(losses) in flows			
	Education, Scientific & Research	PL 11		
	Technical visits		number of visits	no.
TOTAL				
NET NATURAL CAPITAL PROFIT/(LOSS)				

1. Notes to the EP&L Accounts are provided in a separate section within this report
2. Physical Accounts show the change (gains/losses) in the quantity of the assets in the given period
3. Monetary Accounts show the change (gains/losses) in the value of the assets in the given period

Scenario 2 Mining EP&L for the period July 1991- June 1999						Scenario 1 Pre-Mining EP&L for the period July 1982- June 1991					
Physical Account [2]		Monetary Flow Account [3]				Physical Account		Monetary Flow Account			
Flows		Benefits		Costs		Flows		Benefits		Costs	
		Realisable or potentially realisable benefits of physical flows		Costs associated with generation of physical flows				Realisable or potentially realisable benefits of physical flows		Costs associated with generation of physical flows	
Flows to business	Flows to society	Benefits to business (AUD$)	Benefits to society (AUD$)	Costs to business (AUD$)	Costs to society (AUD$)	Flows to business	Flows to society	Benefits to business (AUD$)	Benefits to society (AUD$)	Costs to business (AUD$)	Costs to society (AUD$)
393	-	-	-	(1,178,190)	-	*1,319*	-	-	-	(3,957,000)	-
-	*-400,000*	80,000,000	-	(60,000,000)	-	-	-	20,000,000	-	-	-
-	-	-	-	-	(20,000,000)	-	-	-	-	-	-
		-	-	(2,408,851)	-			-	-	(8,505,275)	-
-	*886*	-	1,247,615	-	-	-	*805*	-	1,275,120	-	-
-	*2,380*	-	45,222	-	-	-	*2,575*	-	48,917	-	-
-	*69,107*	-	1,313,029	-	-	-	*93,497*	-	1,776,443	-	-
-	*-41,784*	-	-	-	(793,892)	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	*31,292*	-	3,129,220	(3,200,000)	-	-	*26,660*	-	2,665,953	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	*1*	-	112,000	-	-	-	*4*	-	504,000	-	-
		-	-	-	(1,650,737)			-	10,900,745	-	-
-	-	-	-	-	-	-	-	-	-	-	-
		80,000,000	**5,847,086**	**(66,787,041)**	**(22,444,629)**			**20,000,000**	**17,171,178**	**(12,462,275)**	**-**
				(3,384,584)						**24,708,903**	

Balance Sheets for Defined NCA Scenarios

Indicators	Scenario 3 Phase 2 2020 Statement Value of assets (AUD$)	Scenario 3 Phase 1 2005 Statement Value of assets (AUD$)	Scenario 2 1999 Statement Value of assets (AUD$)	Scenario 1 1991 Previous Statement Value of assets (AUD$)	Scenario 1 Opening Account 1982 Statement Value of assets (AUD$)
Natural Capital Assets					
Land assets	1,980,000	1,980,000	5,136,000	3,957,000	3,957,000
Mineral resource assets	-	-	-	20,000,000	-
Other	-	8,934,211	20,000,000	-	-
Habitat	9,000,791	7,152,459	9,250,008	11,225,496	11,225,495
Carbon storage	20,921,473	18,545,564	23,612,868	23,048,510	21,248,510
Water and Wetlands	11,101,413	2,099,448	2,595,173	2,665,953	296,217
Gross Natural Capital Asset Value	**43,003,677**	**38,711,682**	**60,594,049**	**60,896,959**	**36,727,222**
Natural Capital Liabilities					
Liabilities	(284,128)	(3,107,163)	(3,081,677)	-	-
Gross Natural Capital Liabilities Value	**(284,128)**	**(3,107,163)**	**(3,081,677)**	**-**	**-**
NET NATURAL CAPITAL ASSET VALUE	**42,719,549**	**35,604,519**	**57,512,372**	**60,896,959**	**36,727,222**

Extended Balance Sheet - Beenup Pilot Case Study

	Assets	Notes	(physical account) measure	(physical account) metric
OPENING ACCOUNT				
Environmental Assets - Other				
Land (as provision of space)	**Land**	BS 1	area	ha
Mineral & Energy Resources	**Mineral sands reserves**	BS 2	volume/amount	tonnes
	Cash from sale of mineral resource	BS 2		
Cash & Cash Equivalents	Gains/losses due to land area changes	BS 3		
TOTAL ENVIRONMENTAL ASSETS				
Environmental Assets - Ecosystems				
Pasture	**Carbon**			
	above ground storage (biomass)	BS 4	volume/amount stored	t CO_2e
	below ground storage (soils)		volume/amount stored	t CO_2e
	Habitat			
	ecosystem condition	BS 5	area of ecosystem condition	ha of CI (condition index)
				Low
Native Ecosystems	**Carbon**			
	above ground storage (biomass)	BS 4	volume/ amount stored	t CO_2e
	below ground storage (soils)		volume/ amount stored	t CO_2e
	Water and Wetlands			
	water storages and flow regulation	BS 6	volumes	ML (t m-3)
	wetlands supporting water quality improvement		wetland area supporting water quality improvement	ha
	Natural products			
	native seed reserves	BS 7	area supporting seed production	ha
	other (commercial wildflowers, beekeeping etc)		area supporting production of other natural products	ha
	Habitat			
	ecosystem condition	BS 5	area of ecosystem condition	ha of CI (condition index)
				High
				Medium
				Low
TOTAL ECOSYSTEM ASSETS				
TOTAL NATURAL CAPITAL ASSET VALUE				

	Liabilities	Notes
Maintenance provisions		
Loans and other provisions		
TOTAL LIABILITIES		
NET NATURAL CAPITAL ASSET VALUE (CLOSING ACCOUNT)		

	Scenario 3 Phase 2 Post-Rehabilitation		Scenario 3 Phase 1 Rehabilitation Works		Scenario 2 Mining		Scenario 1 Pre-Mining	
	Physical Account	Monetary Account	Physical Account	Monetary Account	Physical Account	Monetary Account	Physical Account	Monetary Account
	Stock	Value of asset (AUD$)	Stock	Value of asset (AUD$)	Stock	Value of asset (AUD$)	Stock	Value of asset (AUD$)
	-	**35,604,519**	**-**	**57,512,372**	**-**	**60,896,959**	**-**	**36,727,222**
	660	1,980,000	*660*	1,980,000	*1,712*	5,136,000	*1,319*	3,957,000
	-	-	-	-	*14,600,000*	-	*15,000,000*	20,000,000
	-	-	-	-	-	20,000,000	-	-
	-	-	-	8,934,211	-	-	-	-
	-	**1,980,000**	**-**	**10,914,211**	**-**	**25,136,000**	**-**	**23,957,000**
	-	-	-	-	-	-	-	-
	68,597	1,303,338	*93,337*	1,773,394	*368,199*	6,995,776	*332,577*	6,318,955
	179	270,290	*214*	322,453	*886*	1,334,715	*805*	1,212,570
	477,631	9,074,989	*415,636*	7,897,086	*408,514*	7,761,760	*393,575*	7,477,916
	554,902	10,543,146	*467,110*	8,875,084	*466,070*	8,855,332	*486,928*	9,251,639
	17,723	1,681,815	*22,791*	1,135,809	*31,292*	2,595,173	*26,660*	2,665,953
	128	9,419,598	*127*	963,639	-	-	-	-
	362	-	*327*	-	*465*	-	*514*	-
	-	-	-	-	-	-	-	-
	440		*97*		*366*		*514*	
	-	8,730,501	*307*	6,830,006	*9*	7,915,293	-	10,012,926
	40		*40*		*91*		-	
	-	**41,023,677**	**-**	**27,797,471**	**-**	**35,458,049**	**-**	**36,939,959**
	-	**43,003,677**	**-**	**38,711,682**	**-**	**60,594,049**	**-**	**60,896,959**
	-	(284,128)	-	-	-	-	-	-
	-	-	-	(3,107,163)	-	(3,081,677)	-	-
	-	**(284,128)**	**-**	**(3,107,163)**	**-**	**(3,081,677)**	**-**	**-**
		42,719,549		**35,604,519**		**57,512,372**		**60,896,959**

EP&L Statement and Natural Capital Balance Sheet for FY2020/21

FY2020/21 EP&L Statement - Beenup Pilot Case Study

	Services	Notes	(physical account) measure	(physical account) metric
Environmental Assets - Other				
Land (as provision of space)	**Land change**	PL 1	area	ha
Mineral and Energy Resources	**Mineral sands**	PL 2		
	Mineral sands		volume/amount extracted	tonnes
	Depletion of resource			tonnes
	Expenses - environmental assets (other)	PL 3		
Environmental Assets - Ecosystems				
Pasture and Native Ecosystems	**Grazed biomass**			
	Increase in fodder to support grazing	PL 4	area supporting grazing	ha
	Carbon	PL 5		
	Carbon sequestration - Pasture		quantity of above and below ground sequestered carbon	t CO_2 e
	Carbon sequestration - Natural Ecosystems			
	Water			
	Water quality regulation	PL 6	mass of nutrients removed	tonnes
			mass of sediment removed	tonnes
	Water flow regulation	PL 7	volume discharged (environmental flows)	ML
	Water supply	PL 8	volume supplied to third party	ML
	Natural products			
	Native seed supply	PL 9	seed harvested	tonnes
	Beekeeping and production of honey		quantity commercially produced	tonnes
	Commercial wildflower harvesting		area supporting wildflowers	ha
	Habitat provision			
	Provision of high quality habitat to support/sustains matters of national conservation significance	PL 10	maintenance of MNES	no. of MNES restricted to the Warren subregion
	Habitat value adjustment - gains/(losses) in flows			
	Education, Scientific & Research	PL 11		
	Technical visits		number of visits	no.
				TOTAL
TOTAL NATURAL CAPITAL BENEFITS				
TOTAL NATURAL CAPITAL COSTS				
NET NATURAL CAPITAL PROFIT /LOSS				
NET BALANCE				

EP&L for the period July 2020 - June 2021

Physical Account		Monetary Flow Account			
Flows		Benefits		Costs	
		Realisable or potentially realisable benefits of physical flows		Costs associated with generation of physical flows	
Flows to business	Flows to society	Benefits to business (AUD$)	Benefits to society (AUD$)	Costs to business (AUD$)	Costs to society (AUD$)
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	*179*	-	31,581	(29,368)	-
-	*108*	-	2,047	-	-
-	*6,062*	-	115,169	(23,494)	-
-	*17*	-	1,467,322	(117,471)	-
-	*131*	-	-	-	-
-	*1,510*	-	150,984	(58,735)	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	*5*	-	70,000	(58,735)	-
-	-	-	-	-	-
-	*60*	-	1,920	-	-
-		**-**	**1,839,023**	**(287,803)**	**-**
			Business		**Society**
-	**-**	**-**	**-**	**-**	**1,839,023**
-	**-**	**-**	**(287,803)**	**-**	**-**
-	**-**	**-**	**(287,803)**	**-**	**1,839,023**
					1,551,220

FY2020/21 Balance Sheet - Beenup Pilot Case Study

Assets		Notes	(physical account) measure
Environmental Assets - Other (Abiotic Resource)			
Land (as provision of space)	**Land**	BS 1	area
Mineral & Energy Resources	**Mineral sands**	BS 2	volume/amount
TOTAL ENVIRONMENTAL ASSETS			
Cash & cash equivalents	Gains/losses from environmental assets (sale of minerals, land)	BS 3	
Environmental Assets - Ecosystems			
Pasture	**Carbon**		
	above ground storage (biomass)	BS 4	volume/amount stored
	below ground storage (soils)		volume/amount stored
	Habitat		
	ecosystem condition	BS 5	area of ecosystem condition
Native Ecosystems	**Carbon**	BS 4	
	above ground storage (biomass)		volume/amount stored
	below ground storage (soils)		volume/amount stored
	Water and Wetlands	BS 6	
	water storages and flow regulation		volumes
	wetlands supporting water quality improvement		wetland area supporting water quality improvement
	Natural products		
	native seed reserves	BS 7	area supporting seed production
	other (commercial wildflowers, beekeeping etc)		area supporting production of other natural products
	Habitat		
	ecosystem condition	BS 5	area of ecosystem condition
TOTAL ECOSYSTEM ASSETS			
TOTAL NATURAL CAPITAL ASSET VALUE			

Liabilities	Notes
Maintenance provisions	BS 8
Loans and other provisions	BS 8
TOTAL LIABILITIES	
NET NATURAL CAPITAL ASSET VALUE	

(physical account) metric	FY 20-21 (20 year NPV) Physical Account Stock	NPV Monetary Account Value of asset (AUD$)
ha	*660*	1,980,000
tonnes	-	-
	-	**1,980,000**
	-	1,980,000
t CO_2e	-	-
t CO_2e	*68,704*	1,728,283
ha of CI (condition index)		
Low	*179*	201,849
t CO_2e	*480,000*	
t CO_2e	*558,595*	27,224,144
ML (t m-3)	*1,510*	
ha	*128*	7,821,691
ha	*362*	-
ha	-	-
ha of CI (condition index)		
High	*440*	
Medium	*0*	
Low	*40*	5,091,244
	-	**42,067,211**
	-	**44,047,211**
	-	(144,640)
	-	-
	-	**(144,640)**
		43,902,571

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Breakdown of Monetary Accounts

Net Natural Capital Value

The net values shown in the Balance Sheet for each of the four Scenarios are strongly influenced by the different land areas under BHP control in each period; for example, in Scenario 1 the land extent was 1319 ha compared with Scenario 3 Phase 2 which was 660 ha. To assist in articulating the changes in time more comparatively, this section represents the monetary value of the natural capital assets on a per hectare basis. To assist in following the change in natural capital value between the agricultural land use (baseline at 1982) and restored land at 2020, an opening account is shown for Scenario 1 which shows the (then) privately held land and associated natural capital values, before BHP began acquiring land and adding the mineral resource value to the balance sheet as shown in Scenario 1. No liabilities are assumed for this opening account.

When compared this way, the data shows that the net natural asset value post-restoration, is higher than the baseline (agricultural land use) as well as pre-mining (Scenario 1) and mining (Scenario 2) (Figure 9). Liabilities are very low in the FY2020/21 account given there is minimal management required in this post-rehabilitation phase.

Gross Ecosystem Value

To indicate proportionally where this value lies, Figure 10 shows the difference between the gross value of native ecosystems and the gross value of pasture on a per hectare basis for the different NCA Scenarios (i.e., excluding other environmental assets – mineral resources and land and excluding liabilities).

This shows that native ecosystems account for 80 - 90% of the total gross natural capital value.

Further breakdown of the gross value of the native ecosystem values are shown in Table 10 and Figure 11. In Scenario 1 and Scenario 2, most ecosystems are remnants with established vegetation, and hence carbon stocks above and below ground are high. In Scenario 3 Phase 1, most vegetation is new (rehabilitated), so biomass carbon stocks (above ground) are lower compared to remnants. In Scenario 3 Phase 2, biomass carbon stocks are higher than before mining and wetlands make a significant contribution to overall natural capital value. Importantly, biomass carbon is progressively increasing with vegetation maturation and increase in soil and sediment stocks, especially in wetlands.

Summary of Net Natural Capital Value (AUD$/ha)

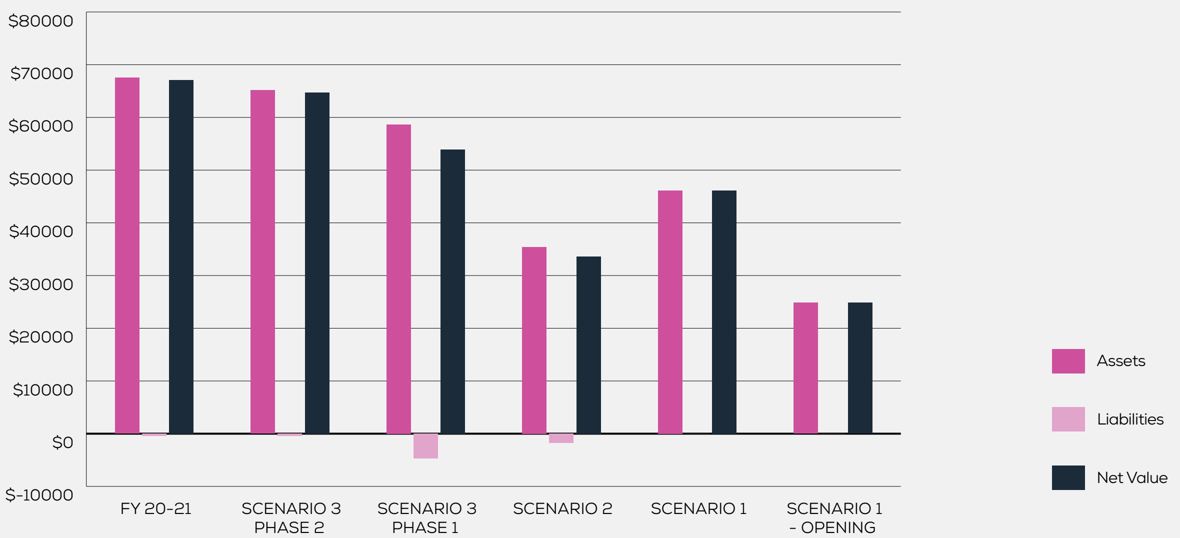

Figure 9. Summary of the net natural capital value for each of the NCA Scenarios (AUD$/ha)

Table 10. Breakdown of the contribution of carbon, water and wetlands and habitat to gross natural asset value (AUD$/ha)

Ecosystem Asset Value (AUD$/ha)	Scenario 3 Phase 2 AUD$	Scenario 3 Phase 1 AUD$	Scenario 2 AUD$	Scenario 1 AUD$
Carbon	40,841	37,661	35,736	32,548
Water & Wetland	23,111	4,714	5,581	5,187
Habitat	18,175	15,336	17,022	19,480
TOTAL	**82,127**	**57,711**	**58,339**	**57,215**

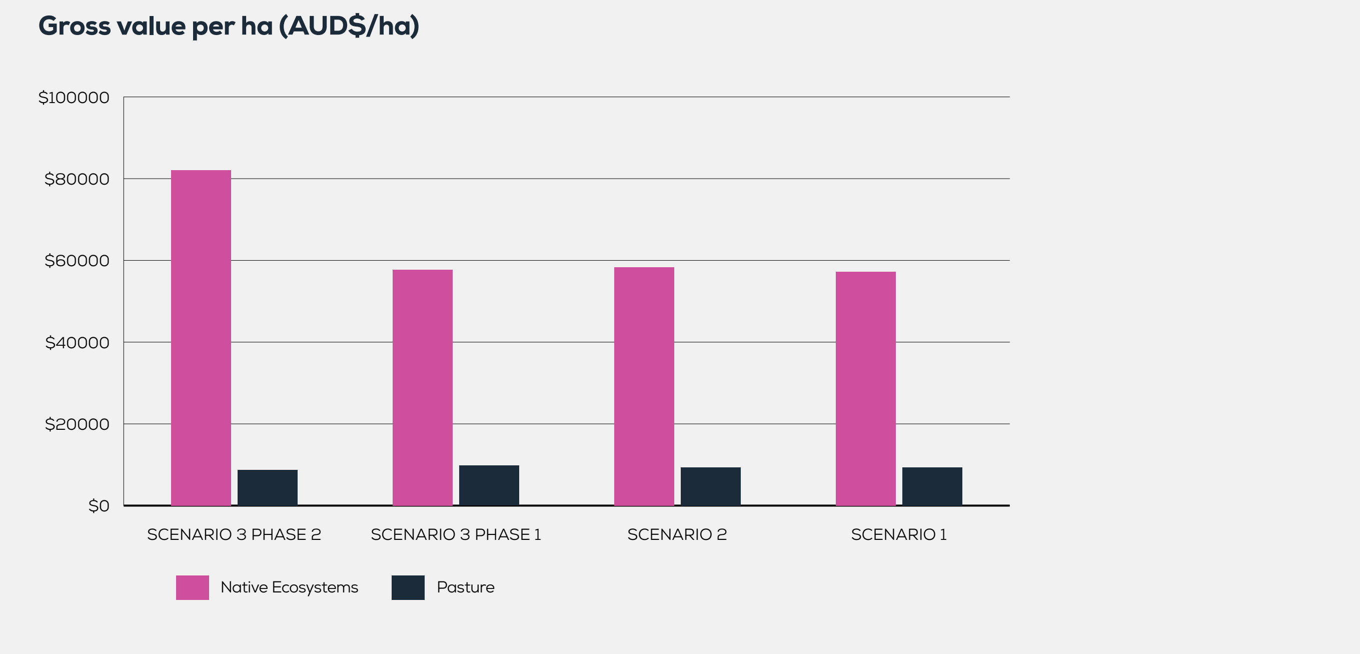

Figure 10. Total gross value of native and pasture ecosystems across the NCA Scenarios (AUD$/ha)

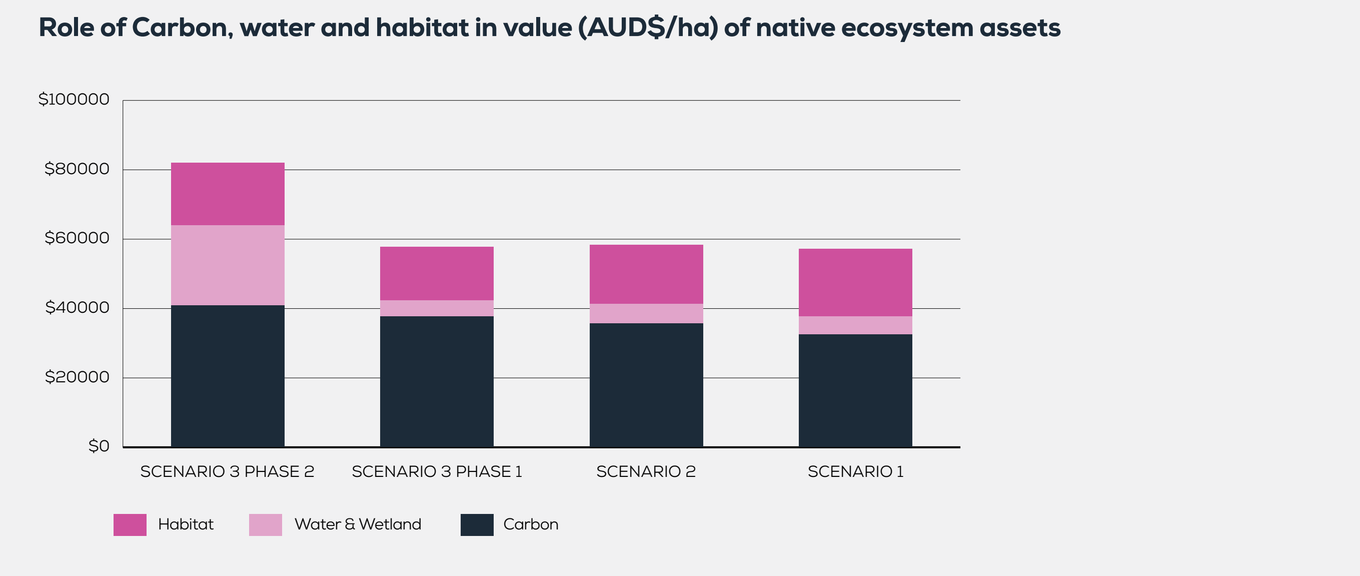

Figure 11. Gross value of water, carbon and habitat (AUD$/ha) in native ecosystems for each of the NCA Scenarios

Summary

In summary, the Beenup site demonstrates the possibility of achieving a 'net positive' outcome with respect to natural capital asset value after mining through restoration as follows:

- The total natural capital asset value per hectare (as estimated) exceeds the pre-mining values (Figure 9).
- The creation of natural habitat and wetlands during the rehabilitation phase is the key to increasing gross natural capital value post-mining (Scenario 3 Phases 1 and 2) (Figure 10 and Figure 11).
- Carbon stocks compare well with pre-mining levels, and these are still increasing in line with vegetation growth and maturation, and have good prospects for improving over time.

NATURAL CAPITAL ACCOUNTING NOTES

9

Notes to Example Physical Accounts

Land Tenure

The Land Tenure maps and areas detail the ownership within the mine lease boundary. The base dataset was LGATE-001, with the historical lot numbers and extent updated based on the information provided by the Annual Environmental Reports and personal communication with BHP.

For the purposes of this pilot case study only, all land purchased or leased by BHP (even if it was subsequently leased backed to farmers) was considered as being within BHP's control.

During Scenario 2, there were partial leases held on the following lots: 4255 (Lot 1), 4255 (Lot 2) and 4260. The Lot 1 (4255) area was assumed to be the extent within the project disturbance boundary, while the southern portion of Lot 2 (4255) was matched to the provided area of the lease (23 ha). The spatial extent of the lease on 4260 was estimated from a digitised map.

Ecosystem Units – Land And Ecosystem Classifications

The development of the ecosystem asset register was done using the following classification system:

- **Land use:** Australian Land Use and Management (ALUM) Classification Version 8 (October 2016) (ABARES, 2016) – provides a nationally consistent method for collection and presentation of land use information. This classification has already been adopted by BHP, WABSI and the wider mining sector.

  https://www.agriculture.gov.au/abares/aclump/land-use/alum-classification/alum-classes

- **Land cover:** Land Cover Classification System (LCCS) developed by FAO (Food and Agriculture Classification of the United Nations) – provides an internationally accepted and consistent framework for the classification and mapping of land cover. Environmental variables available within this classification system representing the LCCS Level 3 taxonomy (eight categories representing semi-natural and/or cultivated/managed vegetation or natural or artificial bare or water bodies were adopted).

  https://www.fao.org/3/x0596e/x0596e00.htm

- **Land tenure:** we adopted the Australian Bureau of Agricultural and Resource Economics and Sciences (ABERES) classification, which is also used in national NCA accounting for Australia.

  https://www.agriculture.gov.au/abares

- **Ecosystems:** the IUCN Global Ecosystem Typology 2.0 (IUCN GET) classification was adopted for ecosystems. This is a globally applicable hierarchical ecosystem classification system used in the SEEA-EA (UN System of Environmental and Economic Accounting – Ecosystem Accounts). The three upper levels that classify ecosystems based on their functional characteristics were applied in the Beenup NCA process – Level 1: Realm, Level 2: Biome and Level 3: Ecosystem Functional Groups. The system was somewhat modified to reflect the actual functional units Australia uses for wetland classification, and the National Vegetation Information System (NVIS) Level 4 for vegetation associations.

  https://portals.iucn.org/library/sites/library/files/documents/2020-037-En.pdf

- **Geomorphic units:** these were the main guiding units used to design the restoration methods at the Beenup site and are the umbrella units that vegetation communities are mapped within. Similar approaches are used by BHP and the Department of Primary Industries and Regional Development (DPRID) for the Pilbara, hence is a common mapping unit used in the mining sector.
- **National Vegetation Information System (NVIS) Level 4:** provides information on the extent and distribution of vegetation types in Australian landscapes and is used in the national approach to ecosystem mapping. While the NVIS system has some issues in application, it is already used within the mining industry.

  https://www.dcceew.gov.au/environment/land/native-vegetation/national-vegetation-information-system

The **ecosystem** is the level of assessment (analytical unit) adopted for NCA accounts.

The IUCN GET classification has been reasonably well adapted to the level of the Biome in this pilot case study, which essentially distinguishes wetland and dryland areas, climatic zones and very broad vegetation structural groupings. Beyond this level, the system is hard to make work at a regional or site scale and does not align with the national approach to ecosystem mapping, which uses the National Vegetation Information System (NVIS).

The NVIS will likely be favoured by DCCEEW for national NCA assessments in Australia, simply because of the ease in applying existing spatial datasets to track change. While the NVIS system has some issues in application, it is more or less adopted within the mining industry (most baseline surveys are done to the detailed level (Level 6, Sub Association); rehabilitated and restored areas (including the Beenup site) are usually dealt with at higher levels (Level 4, Sub Formation). Geomorphic units are also distinguished since these were the main guiding units used to design the restoration methods and is the umbrella unit that vegetation communities were mapped within. Similar approaches are used by BHP and the DPRID for the Pilbara, hence is a common mapping unit used in the mining sector in Australia.

Level 2 of the IUCN GET classification system and Level 4 of the NVIS is therefore considered an appropriate vegetation classification level for Beenup but also most other mines.

As part of this Beenup pilot case study, a new T8 category was developed and used to include the rehabilitated MDSA and waste dumps and similar artificial structures typical of other mines (not captured by existing classes). Additionally, further Biome Ecosystem Groups, TF 1.8, 1.9, 1.10 were used, which are designed to capture the diversity of wetland types (not captured by existing classes) and align with the global geomorphic wetland classification system.

The final units of assessment are shown in Table 11.

Table 11. Ecosystem classification

	Realm	Terrestrial	Terrestrial
IUCN GET	Biome	T2 Temperate-boreal forests and woodlands	T2 Temperate-boreal forests and woodlands
	Ecosystem Group	T2.6 Temperate pyric sclerophyll forests and woodlands	T2.6 Temperate pyric sclerophyll forests and woodlands
	Geomorphic Units	Dryland Plains	Dunes
NVIS level 4	Vegetation Communities	Open forest to woodland of *Eucalyptus marginata – Corymbia calophylla* (1.1)	Low open woodland of *Banksia attenuata, Banksia ilicifolia* and *Eucalyptus marginata* (2.1)
		Open forest to woodland of *Eucalyptus marginata – Corymbia calophylla* with *Banksia grandis* and *Banksia ilicifolia* (1.2)	Low woodland to low open forest of *Agonis flexuosa, Banksia ilicifolia* and *Eucalyptus marginata* (2.2)
		Woodland of *Eucalyptus diversicolor* (1.7)	
		Open forest of *Eucalyptus marginata – Corymbia calophylla* (1.8)	

	Realm	Freshwater/Terrestrial	Freshwater/Terrestrial
IUCN GET	Biome	TF1 Palustrine Wetlands	TF1 Palustrine Wetlands
	Ecosystem Group	TF1.8* Seasonal freshwater basins	TF1.9* Seasonal freshwater plains
	Geomorphic Units	Sumplands	Palusplains
NVIS level 4	Vegetation Communities	Low open woodland of *Melaleuca preissiana* (2.3)	Open heath of *Banksia occidentalis* (3.1)
		Low woodland to low open forest of *Melaleuca preissiana* and *Agonis juniperina* (2.4)	Open heath of mixed Myrtaceae species over sedgelands (3.4)
		Rushland of *Leptocarpus* spp. with pockets of open heath of Proteaceae and Myrtaceae spp. (4.2)	Tall rushlands/sedgelands of *Leptocarpus, Chordifex* and *Schoenus* spp. with pockets of closed heath of *Myrtaceae* spp. (4.1)

*The T8 category is new and proposed to include the rehabilitated MDSA and waste dumps and similar manmade structures typical of other mines (not captured by existing classes)

TF 1.8, 1.9, 1.10* are proposed to capture the diversity of wetland types (not captured by existing classes) and align with the global geomorphic wetland classification system.

Terrestrial	Terrestrial	Terrestrial	Freshwater/Terrestrial
T8 Anthropogenic terrestrial systems*	T7 Intensive land use systems	T7 Intensive land use systems	TF1 Palustrine Wetlands
T8.1 Locally native vegetation cover	T7.2 Sown pastures and fields	T7.2 Sown pastures and fields	TF1.10* Seasonal freshwater slopes
Artificial (MDSA)	Modified (Irrigated Pasture)	Modified (Pasture)	Paluslopes
Mixed low shrubs and heath	Cleared	Cleared	Open forest to woodland of *Eucalyptus marginata, Corymbia calophylla* and *Eucalyptus patens* (1.3)
			Open forest to woodland of *Eucalyptus marginata, Corymbia calophylla* and *Melaleuca preissiana* (1.5)
			Open forest of *Eucalyptus marginata, Corymbia calophylla* and *Agonis flexuosa* (1.6)
			Rushlands of *Anarthria* spp. with regular emergent trees of *Melaleuca preissiana, Eucalyptus marginata* and *Nuytsia floribunda* (4.6)

Freshwater/Terrestrial	Freshwater	Freshwater
TF1 Palustrine Wetlands	F1 Rivers and Streams	F3 Artificial Wetlands
TF1.9* Seasonal freshwater plains	F1.5 Seasonal lowland rivers (streams)	F3.2 Constructed lacustrine wetlands – Beaches and permanent lakes
Ironstone Palusplains (Assessed 18 July 1996 as Endangered)	Channels	Lakes/pools (including beaches)
Closed heath to scrub of mixed Proteaceae - Myrtaceae species (3.2)	Open forest of *Eucalyptus marginata - Eucalyptus patens* with *Banksia littoralis.* (1.4)	Sedgeland with fringing open heath of Proteaceae and Myrtaceae spp.
Open heath of mixed Proteaceae - Myrtaceae species over rushlands (3.3)	Low open woodland of *Melaleuca preissiana - Agonis spp* (2.5)	Open forest to woodland of *Corymbia calophylla- Agonis flexuosa* over *Olearia axillaris* open shrubland*
Low rushland/sedgelands of Cyperaceae - Restionaceae species with pockets of low open heath of Proteaceae and Myrtaceae spp.(4.3)	Sedgelands of *Juncus pallidus* (4.4)	

Matters Of National Environmental Significance (MNES)

The matters of national environmental significance within the Beenup site include a) nationally threatened species and ecological communities; and b) migratory species.

Threatened Ecological Communities (TEC) are defined as MNES under the Australian Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (DotEE, 2018) https://www.dcceew.gov.au/environment/biodiversity/threatened/communities/about. TECs can be listed under one of three conservation categories; critically endangered (CR), endangered (EN), and vulnerable (V), as defined in Table 12.:

The full list of MNES assets occurring with the Beenup owned/leased land is presented in Table 12.

The Threatened Ecological Community (TEC) present within the project boundary is the Scott River Ironstone Association, listed as Endangered nationally (date effective 23-May-2013) (http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=123).
The community is restricted to ironstone soils on the Scott Coastal Plain, between the Blackwood Plateau and the southern coast of WA, east of Augusta. It is commonly described as being comprised of heaths, shrublands and thickets and is variously dominated by *Melaleuca preissiana, Hakea tuberculata, Kunzea micrantha* or *Melaleuca incana* ssp. *gingilup*, depending on the degree of waterlogging. The understorey is generally dominated by *Loxocarya magna*. Most occurrences have very diverse annual flora of *Stylidium* spp., *Centrolepis* spp., *Schoenus* spp., *Aphelia* spp. and other herbs. The community also contains a number of endemic and restricted taxa such as *Darwinia ferricola, Grevillea manglesioides* ssp. *ferricola* (P3), *Lambertia orbifolia* ssp. Scott River Plains and *Melaleuca incana* ssp. *gingilup*.

Threatened flora species present at the Beenup site are predominately associated with the Scott River Ironstone Association TEC. While during the mining phase (Scenario 2) no threatened flora species were recorded, post-mining rehabilitation scenarios (Scenario 3 Phases 1 & 2) are comparable with the pre-mining baseline, with an addition of one species: the Scott River Ironstone TEC associated species – *Banksia nivea* ssp. *uliginosa*.

Threatened fauna include two cockatoo species and four species of migratory birds. Prior to mining and reflecting the 'woodland' ecosystems present at the time, only two cockatoo species were recorded. Post-rehabilitation (Scenario 3 Phase 2), an additional four migratory bird species were recorded, associated with the freshwater ecosystem restored and 'created' as part of the Beenup restoration project. The rotifer *Trichocerca* cf. *iophoessa carinata* recorded during post-mining surveys is considered rare. Its collection from the Beenup wetlands constitutes the second record of this species from Australia. Prior to pre-mining surveys, it had only been recorded from Argyle. The second rotifer species recorded during post-mining surveys, *Eosphora anthadis*, is also rare, and has been recorded within Australia on three occasions prior to its collection from the Beenup site; one in Western Australia, one in New South Wales and one in Tasmania.

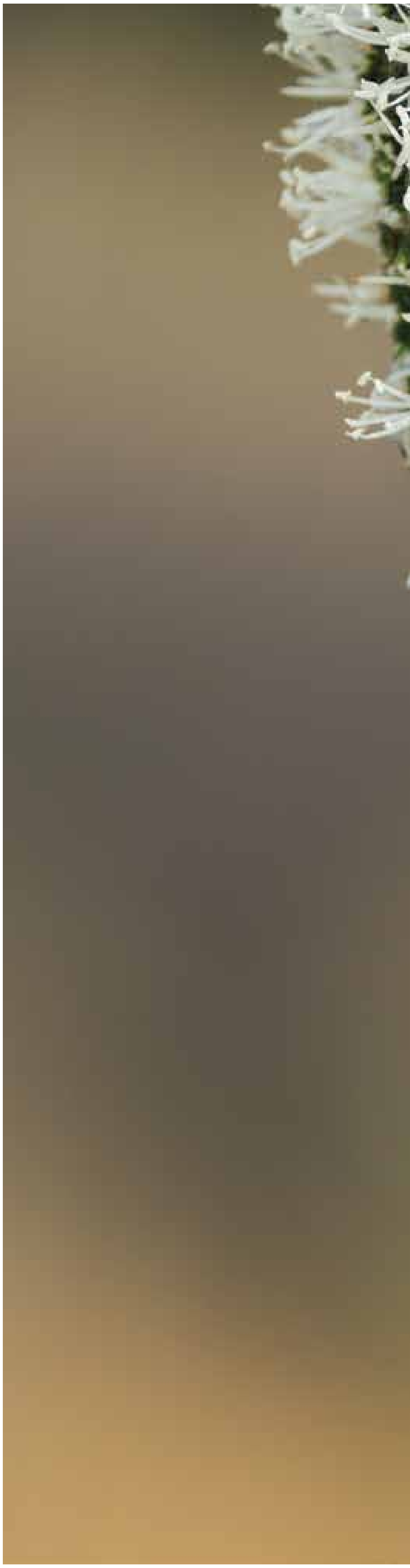

Table 12. Matters of National Environmental Significance occurring in each of the NCA Scenarios – extended table

Scenarios	TECs			Threatened and Priority Flora
		Conservation Code	Area (ha)	Species
Scenario 1 Pre-Mining	Scott River Ironstone Association	E	148	*Darwinia ferricola Keighery*
				Lambertia orbifolia ssp. *Scott River Plains*
				Grevillea brachystylis ssp. *australis*
				Boronia exilis (ms)
				Calothamnus lateralis var *crassus*
				Banksia nivea ssp. *uliginosa*
				Loxocarya magna
				Chordifex gracilior
				Grevillea papillosa
				Leucopogon gilbertii
				Adenanthos detmoldii
				Aotus carinata
				Verticordia lehmannii
				total no. of Threatened species
				total no. of Priority species
Scenario 2 Mining	Scott River Ironstone Association	E	130	-
Scenario 3 Phase 1 Rehabilitation Works	Scott River Ironstone Association	E	68	*Darwinia ferricola Keighery*
				Lambertia orbifolia ssp. *Scott River Plains*
				Grevillea brachystylis ssp. *australis*
				Banksia nivea ssp. *uliginosa*
				Synaphea nexosa
				Calothamnus lateralis var *crassus*
				Boronia anceps
				Gastrolobium formosum (syn: Jansonia formosa)
				Loxocarya magna
				Stylidium leeuwinense
				Aotus cordifolia
				Chordifex gracilior
				total no. of Threatened species
				total no. of Priority species
Scenario 3 Phase 2 Post-Rehabilitation	Scott River Ironstone Association	E	68	*Darwinia ferricola Keighery*
				Lambertia orbifolia ssp. *Scott River Plains*
				Grevillea brachystylis ssp. *australis*
				Banksia nivea ssp. *uliginosa*
				Synaphea nexosa
				Boronia anceps
				Calothamnus lateralis var. *crassus*
				Chordifex gracilior
				Gastrolobium formosum
				Grevillea papillosa
				Loxocarya magna
				Aotus carinata
				Astartea onycis
				Stylidium leeuwinense
				total no. of Threatened species
				total no. of Priority species

Conservation Codes

CE Critically endangered species
E Endangered species
V Vulnerable species
MI Migratory species
OS Other specially protected species

P Priority species
Priority 1 (P1): Poorly-known species
Priority 2 (P2): Poorly-known species
Priority 3 (P3): Poorly-known species
Priority 4 (P4): Rare, Near Threatened and other species in need of monitoring

Conservation codes current at the end of each time period for each Scenario.

Fauna Species of Conservation Significance

Conservation Codes	Species		Conservation Codes
E	*Calyptorhynchus baudinii*	Baudin's Cockatoo	E
E	*Calyptorhynchus banksii naso*	Forest Red-tailed Black-Cockatoo	V
V	*Falco peregrinus*	Peregrine Falcon	OS
P2			
P3			
P3			
P3			
P3			
P3			
P3			
P4			
P4			
P4			
3	**total no. of birds**	**3**	
10	**total no. of mammals**	**0**	
	total no. of microinvertebrates	**0**	
	-		
V	*Calyptorhynchus baudinii*	Baudin's Cockatoo	E
E	*Calyptorhynchus banksii naso*	Forest Red-tailed Black-Cockatoo	V
E	*Falco peregrinus*	Peregrine Falcon	OS
E	*Tringa nebularia*	Common Greensbank	MI
P1			
P2			
P3			
P3			
P3			
P3			
P3			
P3			
4	**total no. of birds**	**4**	
8	**total no. of mammals**	**0**	
	total no. of microinvertebrates	**0**	
V	*Calyptorhynchus baudinii*	Baudin's Cockatoo	E
E	*Calyptorhynchus banksii naso*	Forest Red-tailed Black-Cockatoo	V
E	*Falco alba peregrinus*	Peregrine Falcon	OS
E	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	P4
P1	*Ardea modesta*	Eastern Great Egret	MI
P3	*Tringa nebularia*	Common Greensbank	MI
P3	*Actitis hypoleucos*	Common Sandpiper	MI
P3	*Calidris acuminata*	Sharp-tailed Sandpiper	MI
P3	*Isoodon obesulus fusciventer*	Southern Brown Bandicoot or Quenda	P4
P3	*Trichocerca cf. lophoessa carinata*	rotifera	
P3	*Eosphora anthadi*	rotifera	
P4			
P4			
P4			
4	**total no. of birds**	**8**	
10	**total no. of mammals**	**1**	
	total no. of microinvertebrates	**2**	

Ecosystem Extent

For each of the analysed Scenarios, the ecosystem extent presented in the Tables and Figures represents the closing account extent for the given assets and for the given timeframe (i.e., it is the ecosystem extent recorded at the end of the given Scenario).

The existing surveys were used to construct a baseline ecosystem extent map for the pre-mining scenario (Scenario 1), which was then modified for the other Scenarios using information from satellite imagery and annual environmental reports for the Beenup project.

Ecosystem Condition

For each of the analysed Scenarios, the ecosystem condition (Table 7, Table 8) represents the closing account condition values for the given timeframe (i.e., it is the ecosystem condition recorded at the end of the given Scenario).

The summary approach is as follows:

- A scale of HIGH, MEDIUM and LOW condition values was adopted using a multi-step approach that firstly determined the ecosystem condition variables, then ecosystem indicators and finally ecosystem indices for the four Scenarios; this general approach is outlined in Keith *et al.* 2020 (a conceptual framework and practical structure for implementing ecosystem condition accounts) and in SEEA-EA.
- Ecosystem condition indicators are rescaled versions of ecosystem condition variables; they are derived when condition variables are set against (divided by) reference level values. These were thematically aggregated within the five Ecosystem Condition States adopted from the SEEA-EA framework (chemical, structural, compositional, functional and landscape).
- In developing indicator (and index) accounts, the pre-mining scenario (Scenario 1) was adopted as the reference condition, unless more regional reference data was available (as was the case for water quality, aquatic fauna and weed cover).
- In line with the standard approach, the index value for any ecosystem variable was calculated by multiplying indictor values with the specific weight assigned. For example, if the Native species richness variable was 0.5, the reference value 1, and weight for that characteristic was 0.5, then the indicator value was 0.5*1 = 0.5, and index value (0.5/1)*0.5=0.25. The selection of a weighting system was done depending on the relative importance of each indicator to the assessed overall condition of the ecosystem. In determining the overall index value, all five Condition States were given an equal weight of 1/5=0.2.
- The stylised values (Low, Medium, High) related to the selected ranges (total index range 0-1), to derive the final aggregated condition values as shown below.

Condition/quality scale			
High	0.75	-	1
Medium	0.50	-	0.75
Low	0	-	0.50

This approach allows for an easy cross integration with the Society for Ecological Restoration (SER) International Standards Rating system (Gann *et al.*, 2019), with possible rating conversion as indicated below:

SER	Beenup study
1	0-0.2
2	0.2-0.4
3	0.4-0.6
4	0.6-0.8
5	0.8-1

Ecosystem connectivity

Ecosystem Connectivity is one of the five Ecosystem Condition States used in deriving the overall ecosystem condition.

The vegetation fragmentation for the four ecosystem extent scenarios were created by first combining ecosystem units in joint regions into single polygons for an accurate measurement of area for each patch. The new ecosystem regions were then split into three different size categories (Norton *et al.*, 2010):

- Small ecosystem patch (< 10 ha)
- Medium ecosystem patch (10 ≤ 50 ha)
- Large ecosystem patch (> 50 ha)

A set of rules was then developed and applied to assess whether a patch was connected or fragmentated. This information fed into the ecosystem condition.

The number of fragmentated ecosystem units for the entire region as well as the Ecosystem Accounting Area, (Beenup Project Area) is shown in Table 13 and Figure 12.

Table 13. Ecosystem Patches for the Mine Lease Boundary and Beenup Project Area

Mine Lease Boundary

	Vegetation	Count			Fragmented Area (ha)				Perimeter (km)		
Scenarios	Area (ha)	Small	Medium	Total	Total	% of Area	Average Patch Size (ha)	Median Patch Size (ha)	Total	Average	Median
Scenario 1	1278	85	2	87	153	12	1.76	0.55	47	0.54	0.34
Scenario 2	771	50	3	53	176	23	3.32	0.79	42	0.79	0.41
Scenario 3P1	1035	26	3	29	95	9	3.27	0.99	21	0.71	0.47
Scenario 3P2	1085	18	2	20	73	7	3.64	2.43	16	0.79	0.74

Beenup Project Area

	Vegetation	Count			Fragmented Area (ha)				Perimeter (km)		
Scenarios	Area (ha)	Small	Medium	Total	Total	% of Area	Average Patch Size (ha)	Median Patch Size (ha)	Total	Average	Median
Scenario 1	332	49	0	49	43	13	0.88	0.32	20	0.41	0.28
Scenario 2	98	22	1	23	40	41	1.74	0.32	16	0.68	0.31
Scenario 3P1	389	6	0	6	9	2	1.56	0.66	3	0.54	0.37
Scenario 3P2	429	3	0	3	9	2	2.88	3.64	2	0.82	0.88

Water Quality and Flow Regulation

Wetlands were included as a specific ecosystem asset given their role in water quality improvement and environmental flow regulation services. This asset is not covered in the ecosystem condition accounts hence has not been double counted.

Water budget and flows

The water budget at the Beenup site was developed by calculating inputs, outputs and changes in water storages on-site.

The general approach taken for determining surface flows was based on the methodology from the previous modelling undertaken for the Beenup mining lease area (BHP, 2022), which was updated with the aerially scaled dataset using local rainfall data, and areas across the different scenarios.

Three sub-catchments (Beenup 1, 2 and 3) were found to represent water sub-catchments BHP owned or leased or was influenced by, and therefore this is the area used in the water budget accounts. These sub-catchments were digitised from the original BHP modelling.

The streamflow outside of the observational record was estimated by comparing the data to precipitation and determining a coefficient to convert yearly precipitation into an outflow. It was assumed that there is no streamflow into the region and the entire sub-catchments was accounted for.

For groundwater flow analysis, it was assumed that natural groundwater flows (both laterally from flow within groundwater aquifers and seepage in and spring flow out) were balanced. The only additional source of groundwater considered was re-infiltration from changes in surface water or use in irrigation. Surface Water Storage was estimated based on area/depth of MDSA, Extension and Dredge Ponds, with the change estimated at the theoretical max capacity. Following the rehabilitation, the exact depths of the lakes are unknown, with estimates made based on the BHP Beenup Annual Environmental Reports.

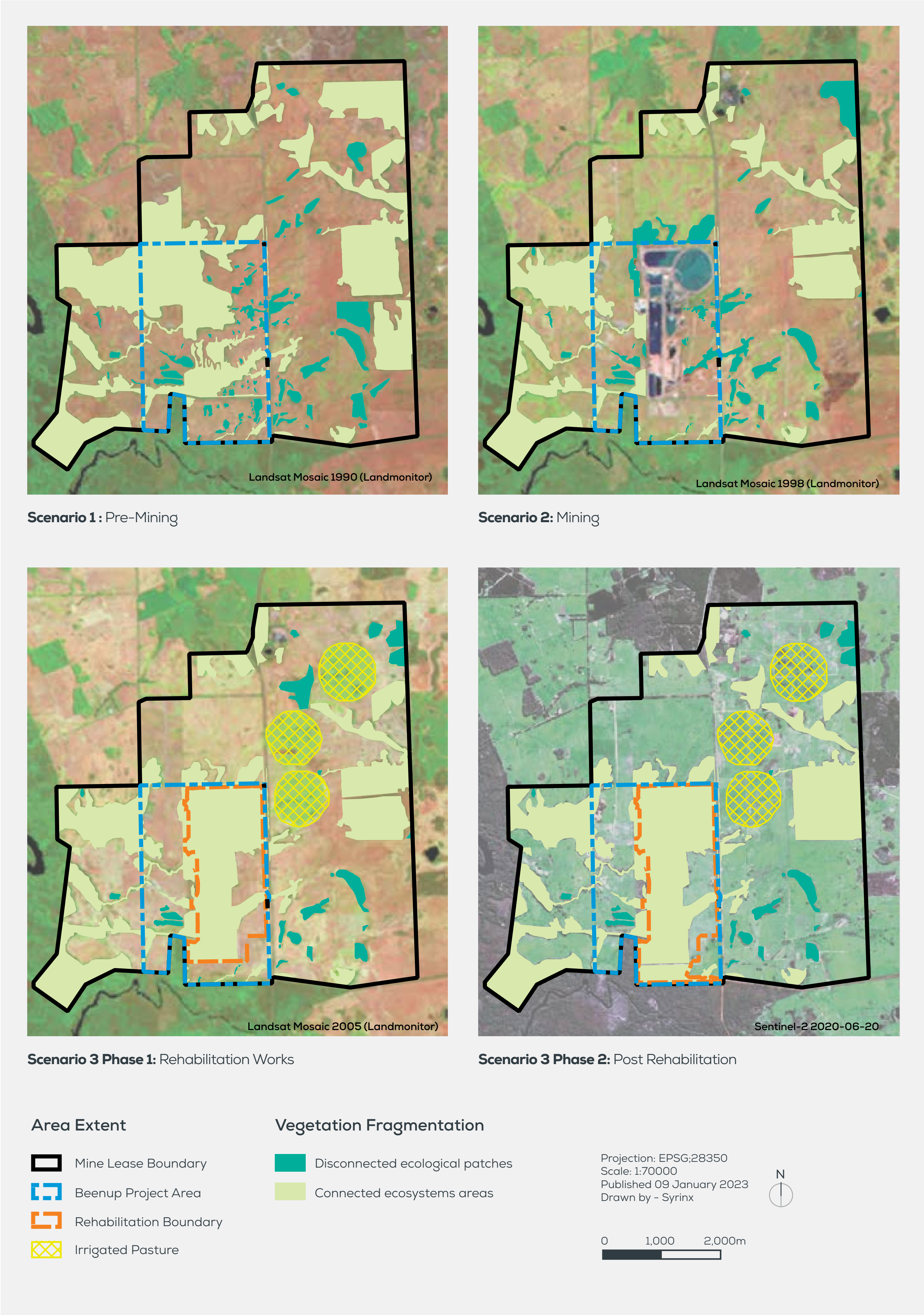

Figure 12. Vegetation fragmentation and ecosystem connectivity across each NCA Scenario.

Importantly, the lack of consistent and continuous measurements of rainfall and streamflow on site introduced error into the calculations. In this pilot case study, sensitivity analysis indicated the standard error for rainfall was 13% and streamflow 50%. Conservative numbers were used for this study, which may underestimate flows and nutrient removal rates. Identifying key points in the water basin to monitor rainfall and streamflow is critically important for applicability of data in NCA studies. Numerical modelling could support measurements but without the base measurement's validations would be difficult.

Water quality

Nutrient loads across the Beenup Project Area were derived for Scenario 1 Pre-Mining, Scenario 3 Phase 2: Post-rehabilitation and FY2020/21. Two other Scenarios (Scenario 2 Mining and Scenario 3 Phase 1: Rehabilitation works) were excluded due to a combination of data scarcity, in particular in relation to streamflow through diversions, and in acknowledgement that over these periods the mine site met government regulations in regard to environmental condition and rehabilitation targets.

Nutrient loads for Scenario 1 were calculated using the monthly streamflow through a sub-catchment combined with a nutrient concentration data (average) representative of slow or fast flows. For Scenario 3 Phase 2, monthly streamflow into and out of the wetlands were combined with nutrient concentrations from the three monitoring stations (M003, M008, M007).

The nutrient modelling results (Table 14) demonstrate the capacity of Beenup wetlands to remove large amounts of nutrients. Between 287 to 492 kg of nitrate (corresponding to ~ 14-24 tons of total nitrogen) were removed annually in Scenario 3 Phase 2, while in FY 2020/21 the net removed was 220 kg, which is close to the maximum seen across the period investigated.

It should be noted that the water quality data (concentrations) were primarily point measurements, which did not accurately provide the picture of the maximum, minimum or mean concentrations through time. This is important as the seasonal nature of the Beenup region likely varies the nutrient concentrations through time.

This uncertainty in nutrient concentrations made sensitivity analysis on the data difficult. Numerical modelling could support this by estimating peaks in nutrients, however the quality of the model would be limited by the available data for validation. Consideration of how to approach water quality in a consistent and methodical way is required in subsequent NCA studies, which can be used to guide what measurements are required on site.

Carbon

Carbon stocks were not covered in the ecosystem condition accounts, hence are accounted for separately.

Carbon stocks and annual carbon (C) sequestration rates were calculated from historic data on soil carbon and actual tree density and age, which were then combined to derive biomass carbon and average soil carbon for Scenarios 1, 2 and 3 Phase 1. Actual soil carbon and above-ground biomass carbon data was obtained during additional investigations in May 2022 on site.

Table 14. Nutrients and TSS in and out from the Beenup site for Scenario 3 Phase 2 and FY2020/21

	Parameter	Scenario 3P2	FY 20-21
M003 - Inflow Beenup 1 Total loads (kg)	TSS: Total suspended solids	1,200,380	137,936
	P: Total phosphorous	80,354	6,311
	NO_3N: Nitrate as Nitrogen	2,764	196
M008 - Inflow Beenup 2 Total loads (kg)	TSS: Total suspended solids	48,400	5,405
	P: Total phosphorous	1,099	60
	NO_3N: Nitrate as Nitrogen	841	84
M007 - Outflow Total loads (kg)	TSS: Total suspended solids	149,954	12,656
	P: Total phosphorous	2,466	185
	NO_3N: Nitrate as Nitrogen	3,007	60
Total removed (kg)	TSS: Total suspended solids	1,098,825	130,685
	P: Total phosphorous	78,987	6,187
	NO_3N: Nitrate as Nitrogen	598	220

Notes to Example Monetary Accounts

Environmental Profit and Loss Statement – Notes

The following EP&L statements were prepared for the Beenup pilot case study:

30 June 2021 P&L – EP&L statement for FY2020/21

30 June 2020 P&L – EP&L statement for Scenario 3 Phase 2 (Post-rehabilitation period of 15 years)

30 June 2005 P&L – EP&L statement for Scenario 3 Phase 1 (Rehabilitation works period of 6 years)

30 June 1999 P&L – EP&L statement for Scenario 2 (Mining period of 8 years)

31 June 1991 P&L – EP&L statement for Scenario 1 (Pre-mining period of 8 years)

The EP&L statements include Ecosystem Assets, and Other Environmental Assets (land and mineral resources) as defined by SEEA-EA.

The following ecosystem services were selected as material to the Beenup site and included in the EP&L statements:

Other Environmental Assets

- Change in land (as a provision of space)
- Extracted mineral sands (abiotic resource)

Ecosystem Assets

- Grazed biomass (pasture)
- Sequestered carbon
- Water - flow and quality regulation, and supply
- Natural products - NOTE, while this ecosystem service is included in the EP&L statement, at Beenup, this is not monetised except for Scenario 3 Phase 1 where seeds were collected and used for the rehabilitation works
- Habitat provision - provision of high-quality habitat to support/sustain MNES
- Education, Scientific & Research services

Note, the few hectares of pine plantation were incorporated into the pasture class for the monetary accounts; these are grazed and the land areas considered too small to be material to this NCA.

The 2021 EP&L statement considers profit and loss recorded in one financial year (2020/21).

All other EP&L statements include cumulative profit/loss for the given Scenario time period. For example, for Scenario 3 Phase 2, which spans across 15 years (July 2005 to June 2020), the relevant EP&L statement (June 2020 statement) includes 15 years' worth of ecosystem provisions. This alternative EP&L accounting approach was adopted to reflect the multi-year NCA Scenarios.

EP&L statements show the physical and monetary flows in natural capital for the period covered by each of the Scenarios. Flows for each period were calculated using actual data as available within each period and using assumptions on annual averages to derive the total flows.

Unlike assets, the flows are attributed to society, except where these were actual transactions attributable to the BHP business. The latter includes land for all Scenarios, and seeds in Scenario 3 Phase 1, which were collected, propagated and supplied back to BHP for the mine restoration.

Monetary valuations are estimates for benefits and represent potential value only, except for land and seed values. The latter were actual transactions, with the value of land treated as equal to costs (unimproved value). Costs are actuals for Scenario 3 Phase 1 and Scenario 3 Phase 2, reflecting the actual utilisation of the relevant closure provision (BHP source data) and estimates for Scenario 1 and Scenario 2 except for land (actuals). No cost data (other than land) was available for the Scenario 1 Pre-Mining hence a nominal sum was ascribed to reflect land acquisition costs and environmental studies to support environmental approvals. For Scenario 2, cost data was actual for land, and derived for the sale of minerals using the approximate volume of ilmenite produced over the period, multiplied by the actual price of ilmenite at that time point, less a proportion of costs and depletion. Environmental costs for Scenario 2 are an estimate – most of the costs in this phase were production costs not material to these accounts. It should be noted that at the end of Scenario 2, the mine had accrued ~AUD$200 million of losses; this EP&L statement only captures an approximate story around natural capital movements.

Specific Notes

PL 1 For **Land** (Other Environmental Assets) – changes in the extent of land owned or leased by BHP was included in the EP&L statement. An average of AUD$3000 per/ha was used, which is an unimproved land value near to the actuals paid for different land parcels (Table 13).

PL 2 **Mineral sands** – this service was included using the actual production realised (400,000 tonnes) and an estimated net profit (assumed net of extraction costs with costs proportioned over the 25-year life of the resource) and using the market sell price of ilmenite). In the financial accounts, the real cost of minerals extracted was shown as a write-off of the investment and EP&L. The mineral resource is shown on the balance sheet at the end of Scenario 1 (nom $20m) when the resource was proven. In the EP&L, Scenario 2 shows revenue AUD$80m, cash costs of AUD$60m and depletion of the full AUD$20m, which resulting in a net nil 'profit' in the period but cash of AUD$20m. The Scenario 2 balance sheet shows the cash of AUD$20m but AUD$nil for the resource as it is fully depleted.

PL 3 Expenses are shown as cost allocations for environmental activities not associated directly with natural capital, but with other matters such as environmental geotechnical assessments, as well as loss in value of carbon and habitat due to the sale of land or clearing of land.

PL 4 **Grazed biomass** – grazed biomass is normally presented as t/ha since this is a flow. Available data was limited to AUD$/ha of pasture; hence the 'flow' is shown indirectly as the changes in area supporting grazing between Scenarios. Valuation excluded any change in the value of pasture through time (although this would have been the case).

PL 5 **Carbon sequestration** – annual C sequestration rates, shown as t CO_2-eq, were calculated from historic data on soil carbon and actual tree density and age, which were then combined to derive biomass carbon and average soil carbon for Scenarios 1, 2 and 3 Phase 1. Actual soil carbon and above-ground biomass carbon data was obtained during additional investigations in May 2022 on site, and these were used for Scenario 3 Phase 2 and the FY2020-2021 EP&L, and to check historic rate assumptions. Final carbon flow values were multiplied by the individual Scenario duration period (number of years), prior to multiplying with the set AUD$ rate. For pasture only, soil carbon sequestration was included. The changes in carbon stocks are assumed to have occurred at the beginning of each scenario period, i.e., sale or acquisition of lands are assumed to occur all in the opening year. In fact, this was not the case and values would differ if annual data was able to be tracked. Negative values are a consequence of land sales (reduction in extent) and condition changes, mainly associated with the operational footprint where both soil carbon and above-ground biomass carbon stocks were cleared, and flows are commencing from young to maturing vegetation through the rehabilitation phases.

PL 6 **Water quality regulation** – historical data was used to calculate total mass removal of nutrients (nitrogen and phosphorus) and total suspended solids (calculated from available data) for individual Scenarios within the Beenup site sub-catchments. Combined total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) values (tonnes removed) are included in physical accounts. As nutrients are commonly removed together with TSS, to prevent double accounting, only TN and TP mass removal was used to calculate AUD$ value i.e., the sum of TN and TP tonnes were multiplied with the AUD$ rate (AUD$85,342/tonne, derived as a replacement value cost – see Table 13). The estimates of nutrients removed in each Scenario have been derived from incomplete datasets (flows are mostly derived not measured, and hence are subject to error), however, this is a key ecosystem service that the Beenup site generates, and more refined assessments of flows may be warranted in later stages.

PL 7 **Water flow regulation** – is shown as baseflow (ML) values discharging from the site for individual Scenarios. The water budget was estimated by calculating water inputs, water outputs and changes in storage. The rainfall/evaporation at the Beenup site was directly measured between 1993 and 2011 (missing 2001). Nearby meteorological stations at Cape Leeuwin and Scott River – Brennan's Ford were used as data sources spanning the missing years (2001 and 2012 – 2021). A combined dataset of these stations which closely matched the magnitude of the Beenup local data was used for the time periods not covered by the Beenup local data, as both the magnitude and correlation were the best fit. Surface water flows were determined using the methodology of the previous modelling undertaken for the Beenup mine lease area updated with new areas across the different Scenarios as well as using new observational data. The streamflow outside of the observational record is estimated by comparing the data to rainfall and determining a coefficient to convert yearly rainfall into an outflow, and assuming that there is no streamflow into the region as the entire sub-catchments are accounted for in the catchment model.

PL 8 **Water supply** – this service is relevant only to Scenario 3 Phase 2, during which period treated dredge water (required to be removed from the site) was provided to third party (farmers) for pasture irrigation. Data is actual figures from Beenup Annual Environmental Reports.

PL 9 **Natural products** – seed supply is included as a monetised ecosystem service in Scenario 3 Phase 1, where seeds were collected and used for the rehabilitation works. Other natural products are shown as potential habitat area that could support these activities for which commercial interest has been shown on site, and which are seen as future potential services of value.

PL 10 **Habitat provision** - high quality habitat that supports/sustains MNES was included as a means of enabling the valuation of habitat as contributing to a biodiversity service, without double accounting for values already captured (carbon, water purification etc). In future, this may be dealt with by the new biodiversity credit scheme method once developed, however for now this enables a nominal value based on the cost of maintaining the TEC ironstone habitat each year and supporting DBCA with translocation and reporting activities.

PL 11 **Visitors** – actual numbers used recorded annually in Beenup Annual Environmental Reports aggregated for each of the individual Scenarios.

Balance Sheets - Notes

For each Scenario, the balance sheet includes stocks at the end of the Scenario; that is 30 June of the last Scenario year.

Assets

For *Natural ecosystems* – all individual geomorphic units were aggregated and considered jointly in the balance sheets. The following assets were included:

- Carbon – total carbon stored below ground (soils) and above ground (biomass).
- Water and wetlands – area supporting water storages, water flow regulation and water quality improvement.
- Natural products – area supporting seed production (physical stocks only shown).
- Natural habitat – area of ecosystem with a certain condition index (as defined through ecosystem condition assessment process).

For *Pasture*, only below ground (soil) carbon and habitat (condition) were included as stocks in the balance sheets.

PV/NPV Method

Balance sheets for all of the Scenarios were done using the present value (PV) method, given these are historic accounts and actual price and cost data was available to build these accounts. For the FY2020/21 balance sheet, the net present value (NPV) method was used to capture value using additions to physical flows year-by-year, unit value adjustments for market services (carbon) and a discounted rate over the forward 20-year period.
As described in SEEA-EA, the use of an NPV approach describes how the value of an ecosystem asset is related to its capacity to supply ecosystem services and how this capacity is expected to change in the future. A discount rate of 3.5% was used, which aligns with SEE-EA suggested rates. The NPV incorporated price escalations for carbon in accordance with independent projections (Bloomburg NEF, 2022). Other NCA accounts opt for a lower discount rate but assume no price escalations, which has a similar outcome. A 10% annual escalation in the price of carbon was assumed for the first 10 years of the analysis.
This is considered conservative given current independent projections for carbon prices (e.g., Bloomburg NEF, 2022). The 10% escalation equates to an average of AUD$54/t CO_2-eq over the forward 20-year period, 20% less than Bloomburg NEF forecasts. Under a partial or hybrid net zero scenario where a proportion of greenhouse gas emissions are offset, not reduced, carbon prices are projected to be AUD$50 t CO_2-eq in 2030 escalating to AUD$120 t CO_2-eq in 2050 (Bloomburg NEF, 2022). Carbon prices may vary considerably regionally and over time. No change to the current ecosystem services was assumed and annual flow increments of services were assumed to be the same throughout the period, and no improvements to habitat condition included.

Values and Costs

All costs were assigned to the BHP business, with the value of assets not assigned to the BHP business or society. This is a potentially realisable value of the natural capital stock held by the business if all natural capital values were recognised in the market (noting at present only land and carbon have market values and the carbon stocks in relation to the Beenup site are not currently eligible as carbon credits/offsets that could be sold by BHP).

Specific Notes

BS 1 For Land (other environmental assets) – only land owned or leased by BHP was included in the balance sheet as an unimproved value. For ease of accounting, leased land was assumed to have equal value to owned land, and accumulated lease payments included as part of the lease liability.

BS 2 The titanium mineral sands asset was included in the pre-mining (Scenario 1) and mining (Scenario 2) balance sheet and EP&L statements. When BHP held rights to these reserves and the resource was mined (when mining rights were relinquished, the mineral resources revert back to the Crown and these reserves are written off in the balance sheet). The projected net realisable resource was estimated as 600,000 t/yr (actual production estimate) over an anticipated 25 years of mine life. In the year of production, the ilmenite price was AUD$200 per tonne (Department of Minerals and Energy (1997) *Statistics Digest*. Government of Western Australia). The mineral resource is shown on the balance sheet at the end of Scenario 1 (nom $20m) when the resource was proven. In the EP&L, Scenario 2 shows revenue AUD$80m, cash costs of AUD$60m and depletion of the full AUD$20m, resulting in a net nil 'profit' in the period but cash of AUD$20m. The Scenario 2 balance sheet shows the cash of AUD$20m but $nil for the resource as it is fully depleted.

BS 3 The closure provision and related closure asset have been excluded from the Balance Sheet within these natural capital accounts which differs from their treatment in a set of financial statements for financial reporting purposes. The costs of closure and rehabilitation activities have been presented in the P&L only as it better represents the true costs and benefits to natural capital over time.

Cash and cash equivalents – Beenup has been funded by the BHP Group throughout its life cycle. For financial reporting purposes, the cash flow funding would be presented as equity injections from the Group with no associated repayment obligation based on the terms of the funding arrangement in place. For the purpose of these natural capital accounts, the funding of the site has been excluded.

BS 4 Carbon stocks as t CO_2-eq, were calculated for soils in pasture and native ecosystems, and for above ground biomass for native ecosystems. Pasture biomass carbon (above ground) was not calculated at this stage as it is only a minor component of total carbon stock. Soil carbon stocks were calculated from historic data from site with actual soil carbon data obtained during additional investigations in May 2022 used for Scenario 3 Phase 2 and the FY2020/21 accounts. Above ground carbon biomass was estimated for Scenarios 1 and 2 using actual tree density and age from pre-mine surveys. For Scenario 3 Phase 1 and Scenario 3 Phase 2, actual tree DBH (diameter at breast height) obtained on site in May 2022 was combined with density data and wood density for same or similar species to generate carbon stocks. Gains/losses to carbon reserves and to habitat condition occur as a result of land changes (extent), as well as activities (clearing for mining, restoration of mined lands). The balance sheet shows the physical changes, however the revenue from sale of habitat and the carbon and other stock associated with sold land has been estimated and is not a true reflection of actual revenues. In the case of the transfer of the TEC (153 ha) to the conservation estate, which occurred in Scenario 3 Phase 1, the value of this asset (above land value) is shown as a cash asset for this period only.

BS 5 Habitat values were derived using the condition index data for each geomorphic unit, aggregated for each Scenario, multiplied by the replacement values ascribed to different conditions and as shown in Table 13. Pasture habitat value was calculated using a reduced AUD$/ha rate (compared to native ecosystems) to reflect the low above ground habitat value of pasture and lower replacement costs. Note habitat value is not necessarily reflective of pasture value, but a relative comparison against natural reference ecosystems.

BS 6 Wetlands were included as an asset specific to water provisioning services – water flow regulation, water quality improvement and water supply. Wetlands included the following geomorphic units: Lakes/pools, sumplands and interconnecting drainage channels. Only drainage channels were present in the pre-mining (Scenario 1) and drainage diversions in the mining (Scenario 2) periods, hence were excluded from the stock. Valuation of the contribution of wetlands to these water services was difficult, hence a very coarse approach based on sum of flows and a nominal wetland value of AUD$1000/ha/year was applied (Table 15).

BS 7 Natural products (native seeds) – the valuation of this asset took an approach based on the contribution of the land (habitat) as a raw material input to produce seed (or wildflowers or other natural product). Given the same habitat (area) can support several natural products (e.g., commercial wildflowers, and native flowers for beekeeping), care should be taken to avoid double accounting. The total AUD$/ha value needs to properly reflect all the different natural products supported by the same habitat area. For Beenup NCA, as only native seed stocks were considered, the AUD$/ha rate only reflects this one natural product.

BS 8 Liabilities – two types of liabilities are included:
a) Costs of maintaining natural capital assets; and
b) Loans and other provisions.

Costs of maintaining natural capital assets provisions include provisions for expenses associated with the maintenance of natural assets (fencing, repairs etc).

Loans and other provisions cover land purchase and lease, and non-closure funded environmental costs during pre-mining (Scenario 1) and mining phases (Scenario 2).

Table 15. Valuation methods and unit price for EP&L statements

		Indicators	Units of Measure	Unit Price	AUD$
Environmental Assets - Other					
	Land (as provision of space)	Area	ha	AUD$/ha	3,000
Environmental Assets - Ecosystems					
Pasture and Native Ecosystems	Grazed biomass (Pasture)	Area supporting grazing (beef)	ha	AUD$/ha	176
	Carbon	Carbon sequestration	t CO_2-eq	AUD$/t CO_2-eq	19
	Water quality regulation	Mass of nutrients (TN and TP)	tonnes	AUD$/tonne	85,342
		Mass of sediment (TSS) removed	tonnes	AUD$/tonne	
	Water flow regulation (baseflow)	Volume discharged	ML	AUD$/ML (environmental flow valuation)	100
	Water supply (irrigation)	Volume supplied	ML	AUD$/ML	100
	Natural products - Seed Supply	Seed supply (area supporting seed supply)	ha	AUD$/ha	6,750
	Habitat provision	Maintenance of MNES	no. of MNES restricted to the Warren subregion	AUD$/no. of MNES	14,000
	Education, scientific & research	Technical visitors	no. of visits	AUD$/visit	32

Valuation Method	Notes
1 - Market Value Method	Calculated using productivity data from AgVivo (2014) study, and pricing from meat industry market report for 2021. (Taylor, 2014)
1 - Market Value Method	As at end June 2021 ($19 per tonne - Clean Energy Regulator, Quarterly Market Report, June Quarter 2021), and on https://accus.com.au/. As at 8th June 2022 it is $36.
2 -Replacement Cost Method	Annual benefit per tonne from Hardy Inlet WQIP, which is $85,342/t for TN and $178,510/t for TP. Cost adopted is for N removal using natural ecosystem management intervention. (White, 2012)
	Nominal - no data. Sediment build up is a critical issue for the mouth of the Blackwood River, however the value of retention is partially covered by P retention, so while TSS removed (tonnes) was included in physical flows, it was not monetised as an additional service (i.e. only TN and TP were included in the monetisation).
3 - Benefit Transfer Method	Benefit transfer value to irrigated pasture would be ~$500 per ML (Thomas, 2010), which is not a good proxy for environmental flows. Water trading for surface water median price was $22.5/ML for 2021. (http://www.bom.gov.au/water/dashboards/#/water-markets), however does not reflect environmental values. Victoria, AUS has an ecosystem service value of flows at $~150/ML (McCormick and Showers, 2019). Have adopted a nominal value of $100/ML.
3 - Benefit Transfer Method	Benefit transfer value to irrigated pasture would be ~$500 per ML. This was reduced to $100 to better align with water flow regulation service. (Thomas, 2010)
4 - Exchange Value Method	Assumes 0.75 t/ha and $450/kg (median 2021 WA) sell price. Value of the raw material likely to be 10% or less than sell price; 2% used as an indicative value. Flows only realised in Scenario 3 Phase 1. (Lobb, 2021)
5 - Contingent valuation method based	Contingent valuation method based on actual spend on recovery plans and maintenance of lands set aside for conserving MNES, which is ~$14,000 per MNES. Derived as an equal apportioning of the national annual spend ($122 mill) divided by the number of MNES (1890 as at 2021), divided by the number of habitat patches covered by recovery plans for each species. For Beenup, the cost is conservatively assigned only to those TECs and species restricted to the Warren IBRA subregion, with 5 habitat sites assumed (DBCA Recovery Plans for *Lambertia orbifolia* ssp. *Scott River Plains, Banksia nivea ssp uliginosa, Darwinia ferricola, Grevillea brachystylis* ssp. *australis*, and the Scott River Ironstone Association TEC). (Wintle, BA, Cadenhead, NCR, Morgain, RA, *et al.* 2019).
6 - Travel Method	Travel method - all visitors local. Assume 1 bus trip ex Busselton, bus hire with driver at $1000/day = $22/pp, plus $10 food/day =$32/pp/visit; 15 people ex Molloy as 4 vehicles ex Augusta (70 km x $1.30 x 4) is $24/pp, plus $10 food/day = $34/pp/visit. Adopt lower value, $32/pp/visit. Compares well with other studies. This may be an underestimate for some visitor groups where the purpose is research, with multiplier effects through the economy, not just user experience. Actual cost of trip for group ex Busselton. Similar to published literature values. (Heagney *et al.* 2019)

Table 16. Valuation methods and unit price for balance sheets.

		Indicators	Units of Measure	Unit	
Environmental Assets - Other					
	Land (as provision of space)	Area	ha	AUD$/ha	$3,000
Environmental Assets - Ecosystems					
	Carbon	Carbon storage	t CO_2-eq	AUD$/t CO_2-eq	$19
	Habitat provision - Natural Ecosystems	Net Value	ha of CI (condition index)	AUD$/ha	
			Medium CI	Average	$15,063
			High CI	Premium (% above)	20%
					$18,076
			Low CI	Moderating factor (% reduction)	50%
					$7,531
	Additions to CI for presence of MNES				
		TECs	presence (in GU)	Premium - threatened ecological communities	$3,013
		Threatened species	presence of one or more (in GU)	Premium - threatened species	$753
	Habitat provision - Pasture		ha of CI (condition index)		
			Low CI	Moderating factor (% reduction)	80%
					$1,506
	Wetland provisioning services	Wetland area	ha	AUD$/ha	$1000 plus sum of flow value
	Water stored	Volume stored		AUD$/ML	$100

Valuation Method	Notes
1 - Market Value Method	As at end June 2021 ($19 per tonne) - Clean Energy Regulator, 2021, and on https://accus.com.au/. As at 8th June 2022 it was $36/t.
7 - Replacement Cost Method	
8 - Hedonic Pricing	Assumes median condition, since cost is averaged across the site. Replacement cost method, using actual per ha cost averaged over the restoration area (excluding pasture).
	% increase applied for high condition Nominal only
	% reduction applied for low condition ecosystems and MDSA (given this site is native vegetation cover only, not full restoration). Nominal only
8- Hedonic Pricing	Given a premium of 20% of replacement cost, or ~$3000/ha for TECs. This aligns with typical State based offset purchase costs which are a similar per hectare premium above standard land costs. Presence of threatened ecological communities (in this case Ironstone Palusplain) and the threatened flora species supported by the restored habitat). These are by definition, not considered replaceable. Increased value of these can be measured by increases in the individual numbers of threatened species, an increase in the number of populations of threatened species, and/or an increase in the extent of habitat supporting threatened species. Each of these measures can be used to demonstrate that the habitat is succeeding in supporting such species and that the trajectory in terms of conservation 'success' is positive. The ultimate measure of success is that the TEC and/or species are delisted as vulnerable. Premium for supporting vulnerable species of 5%.
7 - Replacement Cost Method	For pasture , habitat value (for LOW CI) was reduced by 80% to reflect the very low above ground habitat value of pasture and lower replacement costs.
3 - Benefit Transfer Method	Wetlands were included as an asset specific to water provisioning services - water flow regulation, water quality improvement and water supply. Wetlands include Lakes/pools and Sumplands and interconnecting drainage channels. Valuation of the contribution of wetlands to these water services was difficult, hence a very coarse approach based on sum of annual flows calculated from site data and a nominal wetland value equal to $1000/ha was applied.
3 - Benefit Transfer Method	Water provision for aquatic species and climate regulation. Nominal figure of $100/ML used.

Notes to Tables 15 and 16

1. Market value method applied using the market rate for products (beef, carbon) as at June 2021.
2. Replacement cost method used as a proxy for the removal of nutrients and sediments from the Blackwood Catchment due to retention in the Beenup wetlands These are median values taken from the Department of Water calculations for the catchment (DoW 2012, Hardy Inlet WQIP.)
3. Benefit Transfer Method (Adjusted Unit Value Transfer) used as proxy for environmental water flow services (baseflows only). Data from Victoria (McCormick and Showers (2019). https://www.environment.vic.gov.au/__data/assets/pdf_file/0034/459574/Ecosystem-services-from-forests-in-Victoria-Assessment-of-Regional-Forest-Agreement-regions.pdf), adjusted by 30%.
4. Exchange Value Method was applied to seed stocks. While there is a market, Beenup is not currently providing this service (included on Balance Sheet as an asset only).
5. Contingent valuation method based on actual spend on recovery plans and maintenance of lands set aside for conserving MNES.
6. Travel cost method applied for technical visits to site. Very limited tours of Beenup have occurred since completion of the site, mainly due to it being closed to public access, COVID and limited awareness/promotion of the site. Tours are however almost solely education tourism and research based, the latter which have multiplier effects through the economy. Common visitors include TAFEs, the DBCA, Bush Heritage, Birds Australia, Busselton Naturaliste Group, LandCare groups and Conference delegates. Failing any better method at this point in time, the travel cost method was used as a means of capturing value. using the market rate for products (beef, carbon) as at June 2021.
7. Replacement cost method used as a proxy for biodiversity value. It has been applied only to ecosystem condition. This is so as to avoid double accounting of those ecosystem services that are measured directly by other methods, and to ensure the valuation applies to the assets (stock), irrespective of performance (flows or ecosystem services) (i.e. the method is agnostic in terms of ecosystem flows, however does apply premiums to account for condition and specific values (see below). In the case of Beenup, actual restoration costs are available which were used, removing costs associated with remediation of the mine itself (i.e. all earthworks, clean-up costs, associated costs to do with meeting environmental obligations of closure, hence only includes costs associated with ecological restoration as follows: design, research and trials, seed collection and treatment, revegetation, weed control, monitoring, supplementary planting.
8. Hedonic Pricing method used to apply a premium to high conservation assets (threatened ecological communities (TECs) and species. The premium for the TEC species applied accounts for the cost of assisted translocation of these species to this (and similar) sites. Since there are no known remnant ironstone palusplain areas within the region that are not cleared, it has been assumed that the replacement value of this particular geomorphic unit should also include a land VALUE premium. As such, the premium is the sum of the ordinary replacement costs for restoration, plus the sum of the land purchase price to acquire the equivalent land elsewhere. As a proxy, the premium paid (typically) above land value for environmental offsets under the WA EPA offset scheme has been used (nom $3-4k per ha).

Abbreviations and Acronyms

Acronym	Full Name
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ALUM	Australian Land Use and Management
BCG	Beenup Consultative Group
CICES	Common International Classification of Ecosystem Services
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CNCA	Corporate Natural Capital Accounting
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DPRID	Department of Primary Industries and Regional Development
DWER	Department of Water and Environmental Regulation
EAA	Ecosystem Accounting Area
EP&L	Environmental profit and loss
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ES	Ecosystem services
ESG	Environmental, social, and governance
EMP	Environmental Management Programme
ERMP	Environmental Review and Management Programme
FAO	Food and Agriculture Organisation of the United Nations
FY	Financial Year
GHG	Greenhouse gas
GIS	Geographic information systems
IUCN	International Union for the Conservation of Nature
IUCN GET	IUCN Global Ecosystem Typology
LCCS	Land Cover Classification System
MDSA	Mine Development Storage Area
MNES	Matters of National Environmental Significance
NC	Natural Capital

Glossary

The SEEA CF and SEEA EA provide a comprehensive glossary of terms, and we have adopted the same definitions wherever possible.

Term	Glossary - Description / meaning	Source
Assets	A resource: (a) controlled by an entity as a result of past events; and (b) from which future economic benefits are expected to flow to the entity.	Australian Accounting Standards Board, Australian Accounting Standards Conceptual Framework, Para 4.3.
	A store of value representing a benefit or series of benefits accruing to an economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another.	SEEA
Asset account	Records, in physical or monetary terms, the opening and closing stocks of the relevant asset and then the various additions and reductions in stock, including regeneration and depletion.	SEEA
Account structure	There are two main types of account structures that are used in NCA – flow accounts and asset accounts, both of which may be compiled in physical and monetary terms.	SEEA
Balance sheet	A statement, drawn up in respect of a particular point in time, of the values of assets owned and of the liabilities owed by an institutional unit or group of units. Note in this document both the natural capital balance sheet and the financial balance sheet are referred to.	System of National Accounts 2008 (2008 SNA) (United Nations *et al.*, 2010)
Benefits	The goods and services that are ultimately used and enjoyed by people and society, referring here to natural capital related benefits.	SEEA
Bioregion	Bioregions are large, geographically distinct areas of land with common characteristics such as geology, landform patterns, climate, ecological features and plant and animal communities.	DCCEEW
Choice model	The choice model makes use of social surveys to elicit individuals' expressions of their choices among alternative options that are defined by different levels of attributes of ecosystem services and the associated payment that would be required.	Legesse *et al.*, 2022
Conservation estate	A general term that refers to any land that has legislative protection for the purpose of conservation.	
Dependencies	In this context, aspects of ecosystem services that an organisation relies on to function. Dependencies include ecosystems' ability to regulate water flow, water quality, and hazards like fires and floods; provide a suitable habitat for pollinators (who in turn provide a service directly to economies), and sequester carbon (in terrestrial, freshwater and marine realms).	SBTN (2022) Working Definitions [unpublished], TNFD
	Natural capital dependency refers to a business's reliance on or use of natural capital.	NCC (Natural Capital Coalition), 2016. Natural capital protocol.
Discount rate	A rate of interest used to adjust the value of a stream of future flows of revenue, costs or income to account for time preferences and attitudes to risk.	SEEA
Ecosystem accounting area	The geographical territory for which an ecosystem account is compiled.	SEEA
Ecosystem assets	Contiguous spaces of a specific ecosystem type characterised by a distinct set of biotic and abiotic components and their interactions.	SEEA
	A type of environmental asset that relate to diverse ecosystems, where an "ecosystem" is a dynamic complex of plants, animals and microorganisms, interacting with each other and their non-living environment. Ecosystem assets (as well as environmental assets) are considered assets on the basis of their biophysical existence and are not dependent on establishing flows of benefits or ownership.	TNFD
Ecosystem condition	The quality of an ecosystem measured in terms of its abiotic and biotic characteristics.	SEEA
Ecosystem condition account	Account that presents the overall quality of an ecosystem asset and captures, in a set of key indicators, the state or functioning of the ecosystem in relation to both its naturalness and its potential to supply ecosystem services.	SEEA
Ecosystem enhancement	An increase in the value of an ecosystem asset over an accounting period that is associated with an improvement in the condition of the ecosystem asset during that accounting period.	SEEA

Term	Glossary - Description / meaning	Source
Ecosystem extent	The size (area) of an ecosystem asset.	SEEA
Ecosystem extent account	Account that presents information on the extent of different ecosystem types (e.g. forests, wetlands, agricultural areas) in terms of area.	SEEA
Ecosystem services	The benefits people obtain from ecosystems	SEEA/IUCN/ Millennium Ecosystem Assessment
	The benefits provided to humans through the transformations of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of essential goods and services e.g. clean air, water, and food.	Constanza *et al.*, 1997
Ecosystem services account	Account that presents the measures of supply of ecosystem services and their corresponding users and beneficiaries, classified by broad national accounting categories or other groupings of economic units.	SEEA
Ecosystem services flow	In ecosystem accounting, ecosystem services are recorded as flows between ecosystem assets and economic units (people and society).	SEEA
	Flows are ecosystem services supplied by ecosystem assets and used by users during an accounting period.	
Environmental assets	The naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity. They include ecosystem assets and other environmental assets (land, renewable energy resources, cultivated biological resources, water resources, mineral and energy resources and atmospheric systems).	SEEA
Environmental Profit and Loss account	In this case study, the EP&L represents the change in value of the socio-economic benefits from ecosystem services, less costs and separate from the inputs of other factors of production. This is a departure from international frameworks (e.g. SEEA) in which the EP&L is a company's monetary valuation and analysis of its environmental impacts including its business operations and its supply chain from cradle-to-gate.	This report and SEEA
Financial accounts	This refers to the standard financial statements produced within organisations, i.e., the final account in the full sequence of accounts that records transactions between the business and the market.	The Organisation for Economic Co-operation and Development
Group valuation method	The group valuation method applies the principles of deliberative democracy and the assumption that decision-making relating to the public good should rely on open public debate rather than an aggregation of individual preferences.	Legesse *et al.*, 2022
Impacts	Changes in the state of nature, which may result in changes to the capacity of nature to provide social and economic functions. Impacts can be positive or negative. They can be the result of an organisation's or another party's actions and can be direct, indirect or cumulative.	SBTN (2022) Working Definitions [unpublished], CDSB (2021) Framework application guidance for biodiversity-related disclosures.
	A natural capital impact is the negative or positive effect of business activity on natural capital.	NCC (Natural Capital Coalition), 2016. Natural capital protocol.
	Changes in the state (quality or quantity) of natural capital, which may result in changes to the capacity of nature to provide social and economic functions. Impacts may be positive or negative and direct, indirect or cumulative.	TNFD
Intangible assets	An identifiable non-monetary asset without physical substance. An intangible asset is recognised if: (a) it is probable that the expected future economic benefits that are attributable to the asset will flow to the entity; and (b) the cost of the asset can be measured reliably.	Australian Accounting Standards Board , Australian Accounting Standard AASB 138 Intangible Assets
IUCN Global Ecosystem Typology	A global typological framework that applies an ecosystem process-based approach to ecosystem classification for all ecosystems around the world. The SEEA ecosystem type reference classification reflects the IUCN GET.	
Land use	Reflects both (a) the activities undertaken and (b) the institutional arrangements put in place for a given area for the purposes of economic production, or the maintenance and restoration of environmental functions.	SEEA Central Framework,
Liability	A present obligation of the entity arising from past events, the settlement of which is expected to result in an outflow from the entity of resources embodying economic benefits.	Australian Accounting Standards Board, Australian Accounting Standard AASB 137 Provisions, Contingent Liabilities and Contingent Assets

Term	Glossary - Description / meaning	Source
Matters of National Environmental Significance	The matters of national environmental significance (MNES), identified under the EPBC Act, are: • world heritage properties • national heritage places • wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed) • nationally threatened species and ecological communities • migratory species • Commonwealth marine areas • the Great Barrier Reef Marine Park • nuclear actions (including uranium mining) • a water resource, in relation to coal seam gas development and large coal mining development.	DCCEEW
Materiality	An impact or dependency on natural capital is material if consideration of its value, as part of the set of information used for decision making, has the potential to alter that decision.	NCC (Natural Capital Coalition), 2016. Natural capital protocol.
Materiality assessment	The process that involves identifying what is (or is potentially) material in relation to the natural capital assessment's objective and application.	NCC (Natural Capital Coalition), 2016. Natural capital protocol.
Monetary (ecosystem) asset account	This account records the monetary value of opening and closing stocks of all ecosystem assets within an ecosystem accounting area and additions and reduction to those stocks. The monetary value is assigned based on various valuation methods.	SEEA
Natural Capital	The stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people.	NCC (Natural Capital Coalition), 2016. Natural capital protocol.
Natural Capital Accounting	An umbrella term covering efforts to use an accounting framework to provide a systematic way to measure and report on stocks and flows of natural capital. Its underlying premise is that since the environment is important to society and the economy, it should be recognised as an asset that must be maintained and managed, and its contributions (services) be better integrated into commonly used frameworks like the System of National Accounts.	SEEA
Natural Capital Assessment	The systematic assessment of an organisations impacts and dependencies on natural capital, and the risks and opportunities associated with those impacts and dependencies.	SEEA
Nature Positive	A high-level goal and concept describing a future state of nature (e.g. biodiversity, ecosystem services and natural capital) which is greater than the current state.	TNFD
Nature-related Opportunities	Activities that create positive outcomes for organisations and nature by avoiding or reducing impact on nature, or contributing to its restoration.	TNFD
Nature-related risks	Potential threats posed to an organisation linked to its, and other organisations', dependency and impact upon nature. These risks can manifest as financial impacts.	TNFD
Net Present Value	The value of an asset determined by estimating the stream of income expected to be earned in the future and then discounting the future income back to the present accounting period.	SEEA
Non-market benefits	Benefits of goods and services that are not valued or traded in current markets. Examples of non-market impacts include changes in amenity, liveability, recreation, brand and animal welfare.	
Present Value	A current estimate of the present discounted value of the future net cash flows in the normal course of business.	
Proprietary pricing	Internally determined pricing rather than market pricing	
Provision	In the accounting sense means a liability of uncertain timing or amount. In this case study is used to refer to maintenance provisions for ecosystem services.	Australian Accounting Standards Board, Australian Accounting Standard AASB 137 Provisions, Contingent Liabilities and Contingent Assets
Flows	Environmental stocks and flows are considered holistically. The economic value and quantity of stocks of assets (e.g., natural resources) change over time and these changes are reflected and recorded as flows.	SEEA
Physical flows	Physical flows are reflected in the movement and use of materials, water and energy. The three types of physical flows are natural inputs, products and residuals.	SEEA

Term	Glossary - Description / meaning	Source
Physical flow accounts	Records the flows in quantities of elements, substances and materials.	SEEA
Reference condition	The condition against which past, present and future ecosystem condition is compared to in order to measure relative change over time	SEEA
Remnant vegetation	The native vegetation that still exists or, if the natural vegetation has been altered, is still representative of the structure and floristics of the natural vegetation.	
Restoration (ecological)	The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.	The Society for Ecological Restoration (SER), 2004
Restoration economy	Refers to the employment, capital, resources, and economic activity that emerge from investments in ecological restoration, or "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed."	The Society for Ecological Restoration (SER), 2004
System of Environmental Economic Accounting	The accepted international standard for environmental-economic accounting, providing a framework for organizing and presenting statistics on the environment and its relationship with the economy. It brings together economic and environmental information in an internationally agreed set of standard concepts, definitions, classifications, accounting rules and tables to produce internationally comparable statistics.	SEEA
System of Environmental Economic Accounting– Ecosystem Accounting	A framework for integrating measures of ecosystems and the flows of services from them with measures of economic and other human activity. The accounting approach recognises that these individual resources function in combination within a broader system and within a given spatial area.	SEEA
Social capital	Societies' relationships, shared values and institutions.	Social & Human Capital Coalition, 2018. The Social & Human Capital Protocol.
Threatened Ecological Community	An ecological community becomes threatened when it is at risk of extinction. That is, the natural composition and function of the ecological community have been significantly depleted across its full range. In Australia three categories exist for listing threatened ecological communities (TECs) under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act): critically endangered, endangered and vulnerable.	DCCEEW
Value chain boundary	The part or parts of the business value chain to be included in a natural capital assessment. An assessment of the full lifecycle of a product would encompass all three parts. • Upstream (cradle-to-gate): covers the activities of suppliers, including purchased energy. • Direct operations (gate-to-gate): covers activities over which the business has direct operational control, including majority-owned subsidiaries. • Downstream (gate-to-grave): covers activities linked to the purchase, use, reuse, recovery, recycling, and final disposal of the business' products and services.	NCC (Natural Capital Coalition), 2016. Natural capital protocol.

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