Australian Government
Department of Industry, Innovation and Science

Office of the Chief Economist

Economic Assessment of Mineral Resources within the Woomera Prohibited Area

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In collaboration with Geoscience Australia

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Executive Summary

As part of the Australian Government's review of the Woomera Prohibited Area (WPA) Coexistence Framework, the Office of the Chief Economist within the Department of Industry, Innovation and Science has undertaken an economic assessment of mineral resources within the WPA.

The total Net Present Value of known resources in the WPA is estimated to be around $5.9 billion. The possible future mines in the WPA are estimated to have a Net Present Value between $6.4 billion and $19 billion, based on the conservative and optimistic scenarios provided by Geoscience Australia, and the individual future possible mine Net Present Values presented in Table A below.

Table A: Net Present Values of 'known' mineral resources and possible future mines

'Known' mineral resources		Possible future mine developments	
Deposit	**Net present value ($ million)**	**Future possible mines**	**Net Present Value ($ million)**
Challenger	238	Challenger	354
Prominent Hill	2,110	Prominent Hill	
Cairn Hill	181	— No Uranium	4,347
Peculiar Knob	77	— Conservative Uranium	5,235
Giffen Well	1,761	— Optimistic Uranium	5,628
Hawks Nest	1,188	Peculiar Knob	119
Commonwealth Hill	19	Giffen Well	626
Lake Phillipson	98	Honeymoon	64
Penrhyn	216	Jacinth-Ambrosia	1,362
Total	**5,889**	Four Mile and Beverley	290

Notes: Values are in real 2018 Australian dollars.

In terms of economic impacts, summarised in Table B, large mineral developments, such as that modelled in the Prominent Hill future potential mine, have the potential to have large employment and value add effects. The economic impacts of the other future potential mines have relatively smaller effects, but would still have the potential to materially increase employment and economic activity.

Table B: Annual average economic impact of future possible mine developments

Future possible mine	Direct employment (no.)	Secondary employment (no.)	Value add ($ million)	Royalties ($ million)
Challenger	250	150	110	3
Prominent Hill				
— No Uranium	1,350	840	620	42
— Conservative Uranium	1,370	1,150	840	50
— Optimistic Uranium	1,380	1,250	920	53
Peculiar Knob	150	70	8	3
Giffen	550	120	14	13
Honeymoon	150	230	170	3.5
Jacinth-Ambrosia [a]	na	na	na	15
Four Mile and Beverley	150	280	200	3.5

Notes: **a** Secondary employment and value add cannot be estimated for Jacinth-Ambrosia due to data limitations.

Contents

Introduction

The Australian Government is conducting a review of the Woomera Prohibited Area (WPA) Coexistence Framework ('the Review'). The WPA, located in central South Australia, is an area of strategic importance to the Australian Government, with the military testing range representing a key asset in Australia's defence capability development.[1] The WPA is also of interest to a range of other users, including Aboriginal groups, pastoralists, tourists and the resources sector. The existing coexistence framework, established in 2014, seeks to balance the interests of all users in the WPA. The 2018 WPA Review aims to build on the existing framework.

As part of the review, the Office of the Chief Economist (OCE) in the Department of Industry, Innovation and Science, has conducted an economic assessment of mineral resources in the WPA. In addition to the currently identified mineral resources in the WPA, there is the potential for the discovery and development of additional resources in the future.

The economic assessments of current 'known' Economic Demonstrated Resources and possible future mine developments are underpinned by Geoscience Australia's resource estimation methodology and data. Geoscience Australia has also produced a separate report[2] to inform the Review, to provide an updated understanding of the geology, resources and exploration activity in the WPA.

The economic assessment in this report quantifies and discusses:

- the value of 'known' mineral resources (Economic Demonstrated Resources) of the WPA
- the value of possible future mine developments, including conservative and optimistic valuations
- the direct and indirect economic impacts associated with possible future mine developments.

There are a wide range of factors and considerations that could affect the value or commercial viability of mining projects, investment decisions, and the economic impacts associated with mine development. The accompanying commentary in this report is fundamental to gaining an understanding of the assumptions and broader context underpinning the empirical analysis. Important considerations are highlighted in break-out boxes (like the one below) throughout the report.

Throughout this report:

- the phrase 'mineral resources in the Woomera Prohibited Area' refers to the subset of mineral resources for which Geoscience Australia have provided data and information for (See Appendix C)
- for employment and population data, the WPA and surrounding region has been defined as any postcodes within driving distance of the WPA (about 100km). This includes the postcodes of 5701, 5713, 5717, 5719, 5720, 5722, 5723, 5725; and the suburbs of Nullarbor and SA Remainder.

1 Department of Defence (2018) About the Woomera Prohibited Area, http://www.defence.gov.au/woomera/about.htm

2 Geoscience Australia. 2018. Mineral and petroleum resources and potential of the Woomera Prohibited Area, 2018. Professional Opinion 2018/08. Geoscience Australia, Canberra. http://dx.doi.org/10.11636/9781925848311

Background

South Australian mining industry snapshot

The mining industry is an important contributor to South Australia's economy (Table 1). In 2016–17, the sector accounted for 32 per cent of merchandise exports, 3.7 per cent of Gross State Product (GSP), and 1.2 per cent of employment. In addition, the mining industry paid $1.1 billion in wages and salaries and $7.3 billion in royalties, rents and lease payments.

Table 1: Key mining statistics, 2016–17

Mining industry	South Australia	Australia
Gross value added	$3.8 billion	$130 billion
Share of GSP or GDP	3.7%	8.0%
Export values [a]	$3.7 billion	$204 billion
Share of merchandise exports	32%	68%
Employment [b]	8,000	157,000
Share of total employment	1.2%	1.4%
Wages and salaries	$1.1 billion	$23 billion
Share of wages and salaries	3.6%	4.2%
Income [c]	$7.3 billion	$215 billion
Share of total income	4.1%	7.0%

Notes: **a** Resources and energy commodity exports; **b** Employment at end of June 2017; **c** Includes income from rent, leasing and hiring, and royalties.

Source: ABS (2018) Australian Industry, cat. no. 8155.0, table 6; ABS (2018) Australian National Accounts: State Accounts, cat. No. 5220.0, tables 5 and 10; Department of Industry, Innovation and Science (2018) June 2018 Resources and Energy Quarterly

In 2017, South Australia produced $5.1 billion of resource and energy commodities (Table 2). Copper accounted for the largest share of production by value, at 39 per cent. Other major commodities produced by South Australia include oil and gas, iron ore, gold and uranium.

Table 2: Gross value of mineral and petroleum commodity production in South Australia, 2017

Commodity	Unit	Quantity	Value ($ million)	Share (Per cent)
Copper	kt	262	2,009	39.2
Gold	kg	8,416	474	9.3
Silver	kg	44	32	0.6
Iron ore	mt	10.5	714	14
Uranium (U_3O_8)	t	4,675	335	6.5
Oil and gas	na	na	1,061	21
Other	na	na	495	9.7
Total	na	na	5,120	100

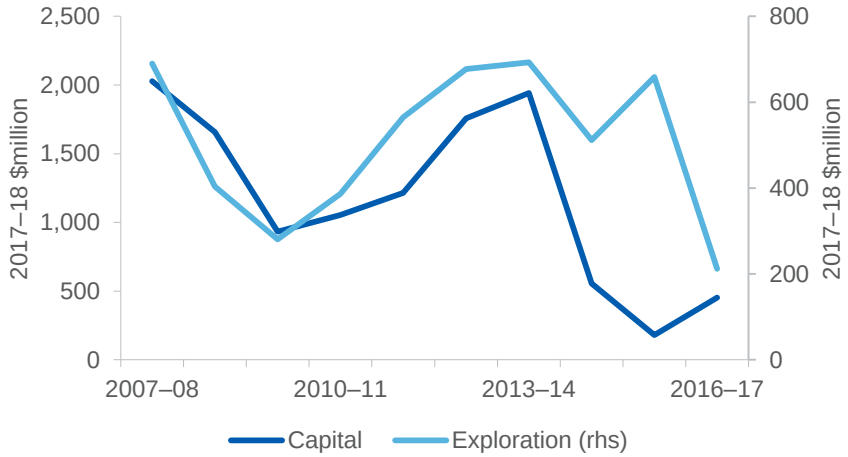
Notes: Oil and gas includes condensate, crude oil, LPG and natural gas. Other includes gemstones, industrial minerals and construction minerals.

Source: Department of Premier and Cabinet (2018) South Australian mineral resource production statistics, South Australia.

Trends in South Australia's mining industry

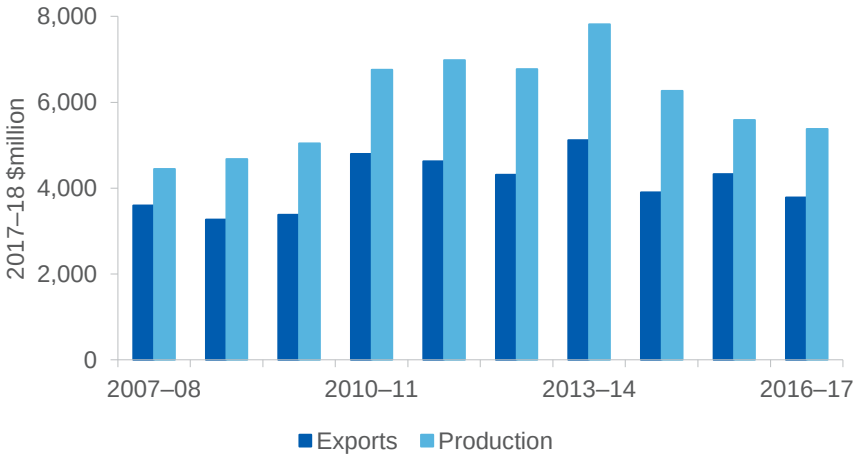
Over the last decade, trends in South Australia's mining industry (defined as mining and petroleum extraction) have closely followed those observed in the rest of Australia. In both, strong commodity prices drove a wave of exploration and capital expenditure, which rose sharply from around 2009–10 and stimulated output growth (Figures 1 and 2). The subsequent period of rapid supply growth from Australia and other mining countries contributed to declining resource and energy commodity prices from around 2013 onwards. These declines have reduced the value of South Australia's mining output, and dampened exploration and investment activity, which all remain below their 2013–14 peak. Nevertheless, there are positive signs in South Australia's mining industry, reflected in the recent uptick in capital expenditure, supported by stronger commodity prices and South Australian government policies aimed at promoting growth (for example, *South Australia's Copper Strategy* and *South Australia's Magnetite Strategy*).[3]

Figure 1: Value of exploration and capital expenditure in the South Australian minerals industry



Source: SARIG (2018) Mineral and petroleum indicators, https://map.sarig.sa.gov.au/

Figure 2: Value of resources and energy exports and production in South Australia



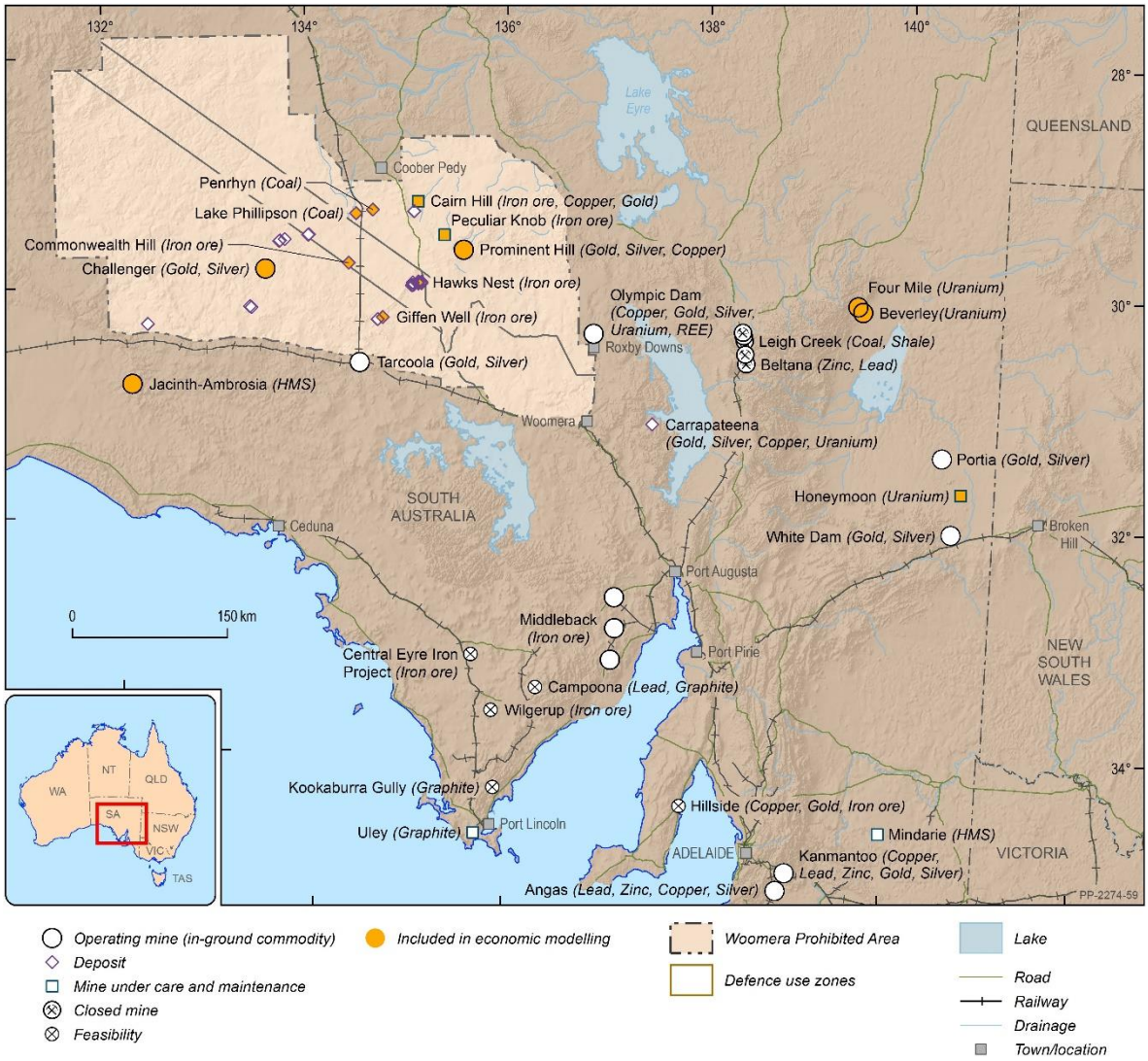
Source: SARIG (2018) Mineral and petroleum indicators, https://map.sarig.sa.gov.au/

3 Department for Energy and Mining (2018) Initiatives, http://minerals.statedevelopment.sa.gov.au/about_us/initiatives

Major mining operations and projects

Map 1 shows the major operational mines in and around the WPA, and mineral deposits within the WPA. Lower commodity prices have affected the economic viability of mining operations and projects, with several operations currently on care and maintenance. There are some projects currently in the pipeline in South Australia, but none of these are in or near the WPA (Table 3).

Map 1: Operational mines in and around the WPA, and mineral deposits within the WPA



Note: Mines are labelled with their in-ground resources; Mines and deposits symbolised as 'Included in modelling' refer to those deposits used as either geological or economic analogues in the possible future mines modelling process.

Source: Geoscience Australia (2018)

Table 3: South Australia's major operating and approved mines

Operation or project	Commodity	Status	Company
Beverley	Uranium	Operating	Heathgate Resources
Cairn Hill [a]	Iron ore (magnetite), Copper, Gold	Operating (Production currently on hold)	Cu-River Mining Australia
Challenger [a]	Gold	Operating	WPG Resources
Four Mile	Uranium	Operating	Quasar Resources
Jacinth-Ambrosia	Heavy mineral sands	Operating	Iluka Resources
Portia	Gold	Operating	Benagerie Gold (subsidiary of Havilah Resources)
Tarcoola Gold	Gold, Silver	Operating	Tarcoola Gold
White Dam	Gold	Operating	Exco Resources
Kanmantoo	Copper, Gold, Silver	Operating	Hillgrove Resources
Middleback Ranges	Iron ore (hematite, magnetite)	Operating	OneSteel Manufacturing (part of the SIMEC Mining Group)
Olympic Dam [a]	Copper, Uranium, Gold, Silver	Operating	BHP
Prominent Hill [a]	Copper, Gold, Silver	Operating	OZ Minerals
Angas	Zinc, Lead, Silver, Gold, Copper	Care and maintenance	Terramin Australia
Beltana	Zinc	Care and maintenance	Perilya
Honeymoon	Uranium	Care and maintenance	Boss Resources Limited
Mindarie	Heavy mineral sands	Care and maintenance	Murray Zircon
Peculiar Knob [a]	Hematite	Care and maintenance	Southern Iron (subject to deed of company arrangement)
Uley	Graphite	Care and maintenance	Quantum Graphite Operations (now under administration)
Carrapateena	Copper, Gold, Silver	Under construction	OZ Minerals
Campoona	Graphite	Feasibility: Mining lease granted, PEPR pending [b]	Pirie Resources (subsidiary of Archer Exploration)
Central Eyre Iron Project	Iron ore (magnetite)	Feasibility: Mining lease granted, PEPR pending [b]	Iron Road
Hillside	Copper, Gold	Feasibility: Mining lease granted, PEPR pending [b]	Rex Minerals
Kookaburra Gully	Graphite	Feasibility: Mining lease granted, PEPR pending [b]	Australian Graphite
Wilgerup	Iron ore (hematite)	Feasibility: Mining lease granted, PEPR approved [b]	Centrex Metals
Leigh Creek	Coal	Rehabilitation	Alinta Energy Services

Notes: **a** Located in or near the WPA. **b** PEPR is 'program for environment protection and rehabilitation'.

Source: Department of State Development, South Australia's major operating/approved mines resource estimates and production statistics, South Australia.

Social and economic snapshot of the WPA and its surrounds

In 2016, there were almost 6,700 people living in the region surrounding the WPA[4], with the majority of the population located in the town centres of Roxby Downs and Coober Pedy[5]. The region has a relatively low unemployment rate of 4.6 per cent; which is below the State (7.5 per cent) and national (6.9 per cent) averages. Since the 2016 Census, both regional and State unemployment rates have shown a downward trend according to the ABS Labour Force Survey. Participation in the labour force is also much higher for the region than for the State in general (participation rate of 74 per cent compared to the State average of 57 per cent).

Mining is the major employer in the region, with 1,380 people, or almost 42 per cent, working in the mining industry (Table 4). Within the mining industry, Copper ore mining accounts for over half of the employed persons. Other major employers in the region include accommodation and food services, education and training, retail trade and construction. Most of the other industries are reliant on the mining industry, both indirectly and directly.

Table 4: Employment in the region surrounding the WPA

Industry	Employment (no.)	Share of total employment (per cent)
Mining	1,380	41.9
Copper ore mining	***700***	***51.1***
Other mining [a]	***330***	***23.4***
Other metal ore mining	***240***	***17.6***
Gold ore mining	***110***	***7.9***
Accommodation and food services	240	7.4
Education and training	220	6.8
Retail trade	210	6.5
Construction	210	6.4
Other [b]	1,020	31.1
Total	**3,280**	**100**

Notes: **a** 'Other mining' includes all other ANZSIC classes in the Mining division not mentioned above, including all not further defined categories. **b** 'Other' includes all other ANZSIC divisions not mentioned above.

Source: ABS 2016 Census of Housing and Population

The WPA region is an important employer for South Australia. Of the 1,380 employed in mining in the region, 92 per cent of workers travel from within South Australia. Of these, almost 57 per cent live locally, with a majority of the rest being Fly-In Fly-Out (or Drive-In Drive-out) workers from the Barossa Valley and Adelaide.

Almost 7.7 per cent of the region identify themselves as Indigenous, which is four times higher than the State average of 2.0 per cent. Labour market outcomes for Indigenous people living in this region are comparatively better than the wider Indigenous population. The unemployment rate is 12.1 per cent and the participation rate at 50.5 per cent; this compares favourably with the South Australian averages (20 per cent and 40 per cent, respectively) and Australian averages (18 and 44 per cent, respectively).

4 Defined as any postcodes within driving distance of the WPA (around 100km). This includes the postcodes of 5701, 5713, 5717, 5719, 5720, 5722, 5723, 5725; and the suburbs of Nullarbor and SA Remainder.

5 ABS (2016) Census of Housing and Population.

Methodology

The economic assessment contained in this report quantifies:

- the value of 'known' mineral resources (Economic Demonstrated Resources) within the WPA
- the value of possible future mine developments, including conservative and optimistic valuations
- the direct and indirect economic impacts associated with possible future mine developments.

The report also provides a discussion of the key factors and considerations that could affect the value or commercial viability of mining projects, investment decisions, and the extent of economic impacts of mining developments in the WPA. This information is crucial to gaining an understanding of the broader context underpinning the economic assessments.

The economic assessment in this report is underpinned by Geoscience Australia's resource estimation methodology and data. Appendix B provides a summary of the data provided by Geoscience Australia and key geological terms used in this report.

'Known' mineral resources

Economic Demonstrated Resources have been used as an indicator of the 'known' mineral resources in the WPA. These are resources that are well understood geologically, and have been regarded as economically feasible to extract or produce with reasonable certainty. Economic Demonstrated Resources are considered to provide a reasonable and objective estimate of what is likely to be available for mining in the long term. Economic Demonstrated Resources data in the WPA have been provided by Geoscience Australia and are current as at 31 December 2016.

The Economic Demonstrated Resources have been assessed on a deposit-by-deposit basis, so that the assumptions and inputs underpinning the analysis accurately reflect the characteristics of the individual deposits. The analysis assumes that all deposits are being mined in 2018 and will continue to operate until resource depletion. Other assumptions made specific to each potential deposit include:

- total costs, including operating costs and consumption of fixed capital
- annual production, by commodity
- revenue, based on long term price forecasts.

Possible future mine developments

Modelling of the economic impacts of possible future mine developments in the WPA has been undertaken in the present Review, using two scenarios involving the discovery and subsequent development of new undiscovered mineral resources. Only deposit types with a high likelihood of discovery and with potentially high-value grade-tonnage characteristics for major mineral commodities and key critical commodities have been considered in the two scenarios.

In order to evaluate the possible future mine development scenarios, the assumption must be made that the 'analogue deposits' used in the evaluation are of a character (global resource size, grade, depth of overburden, etc.) that might reasonably be expected to be discovered in the WPA in the future. Wherever possible, the analogue deposits used in the possible future mine scenarios are based on actual deposits within the WPA (e.g. Prominent Hill); see Geoscience Australia's report to the WPA 2018 Review for in-depth discussion on this. The analogue deposits chosen are shown in Table 5, and the commodities included in these analogue deposits include: copper, gold, uranium, iron, silver, titanium and zirconium.

Conservative scenario

The first, conservative, scenario assumes the discovery and development of the combined economic impact of a single additional deposit of the size and characteristics (global resource size, grade, depth of overburden, etc.) as listed in Table 5. The number of each of the analogue deposits included in the conservative scenario has been determined subjectively based on Geoscience Australia's understanding of geology, known mineral resources distribution and undiscovered resource potential in the WPA. In particular, the total mapped areas of moderate- to high-potential within the WPA have been considered for each of the major and critical commodities, and a judgement has been made on the likely maximum number of deposits that could be discovered and developed within the WPA in the short to long term. See Geoscience Australia's report to view the commodity by commodity future potential maps.

Optimistic scenario

A second, optimistic, scenario assumes that *multiple* additional analogue deposits as listed in Table 5 are discovered and developed. As in the conservative scenario, the number of each of the analogue deposits has been determined subjectively based on Geoscience Australia's understanding of geology, known mineral resources distribution, and undiscovered resource potential in the WPA.

In the optimistic scenario (and as with conservative scenario), **Prominent Hill**, **Challenger**, **Giffen Well**, and **Peculiar Knob** have been used as the analogue deposits for possible future gold, copper, silver and iron ore developments.

Three each of the **Prominent Hill**, **Challenger** and **Giffen Well**, and two **Peculiar Knob**-sized possible future developments have been included in the modelling. However, for uranium the discovery and development of a single **Prominent Hill**-sized deposit which has **Olympic Dam** uranium grades; plus, a single sandstone-hosted uranium deposit equivalent to the **Four Mile** plus **Beverley** uranium deposit has been assumed. The latter two deposits are significantly larger than the **Honeymoon** deposit used in the conservative scenario, and are considered to be of a type and size that could be reasonably expected to occur within the WPA, based on the known geology.

The **Jacinth-Ambrosia** heavy mineral sands deposit has been used as the analogue for a future titanium-zirconium mine**. Jacinth-Ambrosia** is situated in the same geological setting as the significantly smaller **Barton West** deposit within the WPA, and is located just 60 km south of the WPA. As such, based on Geoscience Australia's understanding of the geology, known mineral resources distribution, and undiscovered resource potential in the WPA, it is reasonable to assume that a deposit of **Jacinth-Ambrosia**'s size and grade could be discovered and developed within the WPA.

Table 5: Analogue deposits used to conservatively and optimistically model future mine developments in the WPA

Commodity	Conservative Scenario	Optimistic Scenario
Gold	1 Prominent Hill 1 Challenger	3 Prominent Hills 3 Challengers
Copper	1 Prominent Hill	3 Prominent Hills
Silver	1 Prominent Hill 1 Challenger	3 Prominent Hills 3 Challengers
Iron	1 Giffen Well 1 Peculiar Knob[a]	3 Giffen Well 2 Peculiar Knob[a]
Uranium	1 Honeymoon 1 Prominent Hill (using Carrapateena grades)	1 Four Mile and Beverley 1 Prominent Hill (using Olympic Dam grades)
Titanium and zirconium (heavy mineral sands only)	na	1 Jacinth-Ambrosia

Notes: The scenario represent possible future mines that may be developed *in addition* to the currently operating mines in the WPA. **a** Peculiar Knob deposit is hematite only, **na** No Titanium and zirconium conservative scenario valued

Source: Geoscience Australia (2018)

All scenarios in Table 5 have been valued. The analysis assumes that discovery of the deposits are made in 2018. Other assumptions made specific to each potential deposit include:

- number of years from discovery of the deposit until production begins
- capital cost
- operating costs per annum
- production per annum
- revenue based on long term price forecasts
- mine life.

The assumptions made for the scenarios are also used to calculate future potential flow on impacts to the economy.

Valuing mineral resources

The value of ‘known’ mineral resources and possible future mine developments in the WPA are estimated using a Net Present Value approach.

Net Present Values

The use of Net Present Values to value mineral resources is recommended by the United Nations’ System of National Accounts (SNA) and System of Environmental-Economic Accounting[6]. This

6 United Nations (UN) (2014) System of Environmental-Economic Accounting 2012 — Central Framework, UN, New York, https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf

approach is adopted by most countries around the world, including Australia[7]. The application of the Net Present Value approach to valuing mineral resources in this report is underpinned by the guidance contained in the System of Environmental Economic Accounting Framework.

The Net Present Value approach involves projecting the expected future net income generated by the mineral resource, and then discounting this value by an appropriate rate over the life of the resource. Net Present Values are calculated using the equation below:

$$NPV = \sum_{t=0}^{T} \frac{(P-C)Q}{1+r^t}$$

The key variables are summarised in Table 6 and described in the following sections.

In compiling the supporting data and information, the following principles have been followed to ensure that the analysis is robust and that the underpinning assumptions provide a grounded reflection of current and expected capital costs, operating costs, market conditions and other considerations. Where possible, data and information have been sourced on a site-by-site basis (including for deposits, undeveloped projects or mines in operation or on 'care and maintenance'), from the latest available company reports (such as annual reports, scoping studies, feasibility studies, and ASX announcements), or from a private data provider (AME Group). Where there have been data constraints on specific deposits, projects or mines, the closest approximations have been used, based on advice from Geoscience Australia on sites with similar specifications in terms of geological similarity, location, size, depth and/or grades.

Table 6: Key variables, inputs and assumptions underpinning the Net Present Values

Variable	Details	Sources
NPV = Net Present Value	The present value of the mineral resource	Derived
P = Commodity prices	Price per unit of saleable production	Department of Industry, Innovation and Science AME Group Consensus Economics
C = Cost per unit	Cost per unit of production	Company reports AME Group
Q = Production	Quantity of the mineral resource produced in year t	Company reports AME Group
T = Resource life	Resource life = Size of mineral resource/ Production rate	Derived Size of mineral resource provided by Geoscience Australia
r = Discount rate	7 per cent, with 3 per cent and 10 per cent used for sensitivity analysis	Office of Best Practise Regulation
t = year	Each year of production	

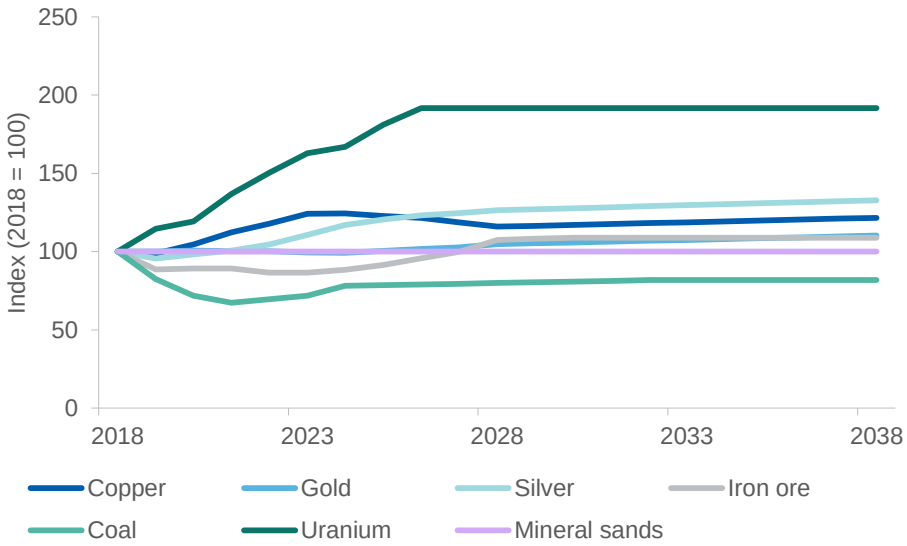
Commodity prices and exchange rates

To estimate the flow of revenue from mineral production, projections of future commodity prices are required. Price indices for each of the commodities considered in this report are shown in Figure 3. Projections are constructed for benchmark commodity prices (i.e. London Metal Bullion Association

7 The Australian Bureau of Statistics (ABS) uses the Net Present Value approach to provide estimates of the value of mineral resources in the Australian System of National Accounts (cat. no. 5204.0, table 62)

(LMBA) spot prices for gold and silver, London Metal Exchange (LME) spot prices for base metals, the iron ore 62 per cent fines Free on Board Australia price, and the thermal coal Newcastle 6000kcal spot price). Projections are also constructed for alternative commodity price series to best reflect the revenue that would be generated given the quality of the saleable product from the resource. For example, the black coal deposits in the WPA have an energy content of 20 to 24 GJ/t (4,777 to 5,732 kcal/kg), so a discount based on historical differences was applied to the benchmark Newcastle 6000kcal spot price to reflect the lower energy content. Similarly, a discount/premium was applied to the benchmark iron ore price to reflect lower/high iron content of the saleable product for each iron ore deposit.

Figure 3: Commodity price projections



Notes: All series are based on benchmark prices. The mineral sands series is an index comprised of projected zircon, rutile and ilmenite prices.

Source: Department of Industry, Innovation and Science (2018), AME Group (2018), Consensus Economics (2018)

In the short to medium term, price projections are compiled using forecasts from the June 2018 edition of the *Resources and Energy Quarterly* for the period to 2020, and the March 2018 edition of the *Resources and Energy Quarterly* for the period from 2021 to 2023. The forecasts in the *Resources and Energy Quarterly*[8] are based on an assessment of market fundamentals, economic conditions and changes to government policies with the potential to impact on supply or demand. The publication has been produced for 30 years, and contains the Office of the Chief Economist's forecasts for the value, volume and price of Australia's major resources and energy commodity exports.

Beyond 2023, price projections are drawn from the AME Group, as published in the June 2018 edition of the *Strategic Study*[9] reports. AME Group's long-term price projections are based on the long-term costs of production, the required return on capital to justify new investment, economic development cycles and structural economic changes in the long term. Where AME commodity price projections are unavailable, the average of Consensus Economics' long-term forecasts are used, as published in the

8 Department of Industry, Innovation and Science (2018) Resources and Energy Quarterly, Office of the Chief Economist, Canberra, https://industry.gov.au/req

9 AME Group (2018) June 2018 Strategic Studies.

June 2018 edition of the Consensus Economics forecasts.[10] Where production continues beyond the published forecasts of AME and Consensus Economics, a continuation of the price pattern is assumed.

Commodity price assumptions are made in US dollars, and exchange rate assumptions are required to establish the Australian dollar value of production. For the period to 2020, the Australian dollar to United States dollar exchange rate is assumed to follow the assumptions published in the June 2018 edition of the *Resources and Energy Quarterly* of US$/A$ 0.78. For the period from 2020 onwards, the exchange rate is assumed to average US$/A$ 0.80.

Costs

To determine whether a project is economically viable, the financial (i.e. capital costs and depreciation) and operating costs of the site must be considered. Where available, cost data and other information is used from company reports (including annual reports, scoping studies, feasibility studies, and ASX announcements) or based on data provided by AME Group. Where there are data constraints, costs are approximated based on sites with similar specifications in terms of location, size, depth and/or quality.

Production and resource life

Annual production volumes are based on company reports or data provided by AME Group. In any year, the resource life in terms of years to depletion is equal to the size of the resource (Economic Demonstrated Resources or global resource) at that time divided by the future expected annual production rate. Economic Demonstrated Resources and global resource sizes were provided by Geoscience Australia.

Discount rate

The discount rate is applied to cash flows to determine the present value of future cash flows. This is used to account for the opportunity cost of investment and for the time value of money, that is, the preference for current consumption over consumption in the future. The discount rate used in the analysis to determine the Net Present Value of the mineral resources is 7 per cent. A sensitivity analysis is conducted with 3 and 10 per cent discount rates, consistent with OBPR.[11]

The Net Present Value approach is subject to considerable uncertainty and, as a result, possible revision in the future as more data and information comes to light.

Commodity prices can be volatile, and the projections used in this report are subject to a wide range of risks and uncertainties. As such, the impacts of a 10 per cent increase/decrease in commodity prices on the estimated value of mineral resources are considered in a sensitivity analysis in Appendix C.

There is also uncertainty regarding technological developments or further exploration activity which will occur during the life of the mine, which could reduce operation costs or increase the life of the mine. The uncertainty surrounding the estimates of Net Present Values means that the results should be viewed with some caution, and considered alongside the accompanying commentary and geological assessment from Geoscience Australia.

10 Consensus Economics (2018) June 2018 energy and metals consensus forecasts, London.

11 Prime Minister and Cabinet (2016) Cost benefit analysis guidance note, Canberra.

Economic impacts

The economic impact of possible future mine developments are estimated in this report. The analysis does not consider the economic impact of 'known' resources, and assumes the discovery and development of mineral deposits of similar size and characteristics to each of the deposits considered in the scenarios. The annual economic impacts associated with the development of each of the deposits are estimated in terms of direct and indirect employment, royalties paid to the South Australian government, and value add to the economy.

Input-Output tables

Mining operations can generate substantial economic activity in both upstream and downstream industries. Input-Output (I-O) analysis is used to estimate the effect of mining developments on indirect employment and value add to the economy, based on tables from the ABS[12]. I-O analysis considers the impact that an initial stimulus can have on an economy through successive spending rounds, by taking into account the relationships between various sectors of the economy in the short-term.

The key advantage of using I-O analysis relates to its simplicity and transparency. However, as the analysis assumes fixed relationships, the results tend to overstate impacts on employment and economic activity. As a result, estimates of economic impacts in this report should be considered an upper-bound estimate. More complex modelling, such Computable General Equilibrium (CGE) models are required to overcome the limitations of I-O analysis, however, these models take far longer to generate, and have their own limitations and challenges.

12 ABS 5209.0.55.001 Australian National Accounts: Input-Output Tables – 2015-16

Results

Assessment of 'known' mineral resources

The total Net Present Value of known resources in the WPA is estimated to be around $5.9 billion, based on Economic Demonstrated Resources data provided by Geoscience Australia. Table 7 provides a summary of the estimated Net Present Value by deposit.

Table 7: Value of Economic Demonstrated Resources by deposit in the WPA

Deposit	Status	Commodity	Economic Demonstrated Resources	Value ($ million)
Challenger	Operating mine	Gold Silver	6.5 t Au 0.5 t Ag	238
Prominent Hill	Operating mine	Silver Copper Gold	0.3 kt Ag 1054 kt Cu 0.1 kt Au	2,110
Cairn Hill	Operating mine (production on hold)	Iron (magnetite) Copper Gold	5,982 kt Fe 33 kt Cu 0.001 kt Au	181
Peculiar Knob	Care and maintenance	Iron ore (hematite)	24 Mt	77
Giffen Well	Deposit	Iron (magnetite)	133 Mt Fe	1,761
Hawks Nest	Deposit	Iron (magnetite)	54 Mt Fe	1,188
Commonwealth Hill	Deposit	Iron (magnetite)	5.4 Mt Fe	19
Lake Phillipson	Deposit	Black coal	320.7 Mt	98
Penrhyn	Deposit	Black coal	302.3 Mt	216
Total				**5,889**

Notes: Values are in real 2018 Australian dollars. Metal symbols in the last column indicate that the resource is measured in metal content terms. Economic Demonstrated Resources current as at 31 December 2016.

Source: Geoscience Australia (2018); Department of Industry, Innovation and Science (2018)

There are currently four deposits (**Prominent Hill**, **Challenger**, **Cairn Hill** and **Peculiar Knob**) which have been developed in the WPA.

Two of these are currently operating mines. **Prominent Hill** is a medium-sized copper-gold mine in the eastern region of the WPA, and has an estimated Net Present Value of $2.1 billion. **Challenger** is a medium-sized gold mine, and has an estimated Net Present Value of $238 million. Reserves (Economic Demonstrated Resources) are expected to maintain production until 2019, with the company seeking to upgrade resources to extend the mine life through further exploration, which could result in a higher Net Present Value in the future.

For simplicity, the analysis assumes that the remaining deposits (which either have been developed but are not currently operating, or have not been developed), are all operating in 2018 and will continue to operate until resource depletion.

Production at **Cairn Hill**, a magnetite iron ore mine which produces a 55 per cent Fe direct shipping ore production, was suspended in late 2017. **Cairn Hill** currently has an estimated Net Present Value of $181 million.

The **Peculiar Knob** mine was placed on care and maintenance in 2015, due to low iron ore prices and high-cost nature of its mining operations. The Net Present Value of the reserves are estimated to be $77 million, but the sensitivity analysis in Appendix C highlights that this operation is marginal — if commodity prices were 10 per cent lower than the base case, the Net Present Value of this operation would become negative.

A further five undeveloped deposits in the WPA contain Economic Demonstrated Resources. These have an estimated total Net Present Value of $3.3 billion. Three of these are magnetite iron ore deposits (**Giffen Well**, **Hawks Nest** and **Commonwealth Hill**), and two of these are black coal deposits (**Lake Phillipson** and **Penrhyn**).

Assessment of potential undiscovered mineral resources

The geological potential for additional deposits to be discovered and developed into producing mines within the WPA is estimated by Geoscience Australia. A number of analogue deposits are then used to estimate the value of the mines. Two overarching scenarios have been used to evaluate a conservative and an optimistic outcome (Table 5). Seven analogue deposits are used to represent the discovery and development of possible future mines in the WPA. Assumptions on costs and production are based on existing mines, and updated to reflect current operating conditions and geological information.

Challenger

The Challenger mine began operation within the WPA in 2002, producing gold concentrate on-sold for processing, and with a silver by-product. As a lower bound, Geoscience Australia estimates that there could be one additional Challenger-like deposit discovered and developed within the WPA. As an upper bound it is estimated that there could be three more Challenger-like deposits discovered and developed. Key assumptions for discovering and developing a single Challenger-like deposit are shown in Table 8.

Table 8: Challenger

Variable	Assumption [a]
Development time prior to commencing production	8 years
Capital cost	$50 million[b]
Average annual operating expenditure per year	$81 million[b]
Average production per annum gold	2.5 t
Average production per annum silver	0.1 t
Mine life	15 years

Notes: a. Assumptions based on AME cost data, company reports and Geoscience Australia's estimations of potential deposit size in WPA, b. 2018 dollar terms.

Prominent Hill

Prominent Hill began production in the WPA in 2009. The mine produces copper, with by-products of gold and silver. As a lower bound, Geoscience Australia estimates that there could be one additional Prominent Hill-like deposit discovered and developed within the WPA. As an upper bound, it is estimated that there could be three more Prominent Hill-like deposits within the WPA. In addition, there is potential for uranium by-product to be included in the future possible mine. A conservative and optimistic grade of uranium is used. Key assumptions for discovering and developing a single Prominent Hill-like deposit, including assumptions for conservative and optimistic uranium by-products are presented in Table 9.

Table 9: Prominent Hill

Variable	Assumption [a]
Development time prior to commencing production	9 years
Capital cost	$1,475 million[b]
Average annual operating expenditure per year	$302 million[b]
Additional annual operating expenditure per year with uranium	$45 million[b]
Average production per annum copper	101 kt
Average production per annum gold	31 t
Average production per annum silver	18 t
Average production per annum uranium - conservative	1.5 kt
Average production per annum uranium – optimistic	2.0 kt
Mine life	22 years

Notes: a. Assumptions based on AME cost data, company reports and Geoscience Australia's estimations of potential deposit size in WPA, b. 2018 dollar terms.

Peculiar Knob

The Peculiar Knob mine began mining in 2012, but was placed under care and maintenance in 2015, due to low iron ore prices at the time. As a lower bound, Geoscience Australia estimates that one Peculiar Knob-like deposit could be discovered and developed in the WPA. As an upper bound, potentially two Peculiar Knob-like deposits could be discovered and developed. Table 10 presents the key assumptions for a single Peculiar Knob mine.

Table 10: Peculiar Knob

Variable	Assumption [a]
Development time prior to commencing production	7 years
Capital cost	$200 million[b]
Average annual operating expenditure per year	$254 million[b]
Average production per annum iron	2.9 Mt
Mine life	15 years

Notes: a. Assumptions based on AME cost data, company reports and Geoscience Australia's estimations of potential deposit size in WPA, b 2018 dollar terms.

Giffen Well

Feasibility studies were completed for Giffen Well in 2013, and production was targeted for 2017. However, the project was not completed due to perceived risks of falling iron ore magnetite prices at the time. Assumptions used for discovering and developing a single Giffen Well-like deposit under current operating conditions are in Table 11. As a lower bound, Geoscience Australia estimates that one more Giffen Well-like deposit could be mined in the WPA. As an upper bound, it is estimated that three Giffen Well-like deposits mined in the WPA.

Table 11: Giffen Well

Variable	Assumption [a]
Development time prior to commencing production	9 years
Capital cost	$1,020 million[b]
Average annual operating expenditure per year	$347 million[b]
Average production per annum iron	4.7 Mt
Mine life	35 years

Notes: a. Assumptions based on company reports and Geoscience Australia's estimations of potential deposit size in WPA, b 2018 dollar terms.

Honeymoon

The existing Honeymoon mine is located approximately 80 km north-west of the town of Broken Hill near the South Australia and New South Wales border. After beginning production in 2011, the Honeymoon mine went into care and maintenance in 2013, primarily due to a decline in uranium prices. Feasibility studies have been conducted and plans are underway to restart the mine and expand capacity to improve the mine's viability. Assumptions for discovering and developing a Honeymoon-like deposit in the WPA are presented in Table 12. As part of a lower bound scenario, Geoscience Australia estimates that one Honeymoon-like deposit could be discovered and developed in the WPA.

Table 12: Honeymoon

Variable	Assumption [a]
Development time prior to commencing production	9 years
Capital cost	$250 million[b]
Average annual operating expenditure per year	$81 million[b]
Average production per annum uranium	1,120 t
Mine life	9 years

Notes: a. Assumptions based on Company reports, World Nuclear Association data and Geoscience Australia's estimations of potential deposit size in WPA, b. 2018 dollar terms.

Jacinth-Ambrosia

Jacinth-Ambrosia is a mining and concentrating operation in the Eucla Basin, 800 kilometres from Adelaide. The operation primarily produces zircon with by-products of rutile and ilmenite. As part of an upper bound scenario, Geoscience Australia estimates that a single Jacinth-Ambrosia deposit could be discovered and developed in the WPA. Assumptions for discovering and developing a single Jacinth-Ambrosia-like deposit in the WPA are presented in Table 13.

Table 13: Jacinth-Ambrosia

Variable	Assumption [a]
Development time prior to commencing production	6 years
Capital cost	$400 million[b]
Average annual operating expenditure per year	$209 million[b]
Average production per annum Zircon	231 kt
Average production per annum Rutile	24 kt
Average production per annum Ilmenite	102 kt
Mine life	22 years

Notes: a. Assumptions based on Company reports and Geoscience Australia's estimations of potential deposit size in WPA, b. 2018 dollar terms.

Four Mile and Beverley

Four Mile and Beverley are two uranium mines, located in close proximity to each other and approximately 550 kilometres north of Adelaide. The Beverley mine ceased production in 2014, while Four Mile is currently still in operation. As part of an upper bound scenario, Geoscience Australia estimates that a combined Four Mile and Beverley-like deposit could be discovered and developed in the WPA. Key assumptions for discovering and developing a single Four Mile and Beverley-like deposit are presented in Table 14.

Table 14: Four Mile and Beverley

Variable	Assumption [a]
Development time prior to commencing production	9 years
Capital cost	$250 million[b]
Average annual operating expenditure per year	$97 million[b]
Average production per annum Uranium	1,367 t
Mine life	22 years

Notes: a. Assumptions based on Company reports, World Nuclear Association data and Geoscience Australia's estimations of potential deposit size in WPA, b 2018 dollar terms.

Net Present Values of future potential mines

The Net Present Value of each future potential mine is shown in Table 15. Using the upper and lower bound scenarios provided by Geoscience Australia and the individual mine Net Present Values presented in Table 15, the possible future mines in the WPA are estimated to have a Net Present Value between $6.4 billion and $19 billion.

Table 15: Quantities and Net Present value of future possible mines

Future possible mines	Commodity	Assumed total production over mine life [a]	Net Present Value [b] $m 2018, discount rate 7 per cent
Challenger	Gold	37.1 t Au	354
	Silver	1.5 t Ag	
Prominent Hill	Copper	2,222 kt Cu	
	Gold	0.1 kt Au	4,347 [c]
	Silver	0.4 kt Ag	5,235 [d]
	Uranium Conservative	33.3 kt U	5,628 [e]
	Uranium Optimistic	44.4 kt U	
Peculiar Knob	Iron Ore	44 Mt	119
Giffen	Iron Ore	166 Mt Fe	626
Honeymoon	Uranium	10 kt U	64
Jacinth-Ambrosia	Zircon	5,075 kt	
	Rutile	541 kt	1,362
	Ilemnite	2,233 kt	
Four Mile and Beverley	Uranium	30 kt U	290

Notes: Metal symbols in the last column indicate that the resource is measured in metal content terms **a** Assumed total production over mine life is based on Global Resource estimates from Geoscience Australia (see Appendix B) and per annum capacity of individual mining operations, **b** Net Present Value for the total future possible mine; **c** Prominent Hill Net Present Value without added Uranium; **d** Prominent Hill Net Present Value with Conservative grades of Uranium; **e** Prominent Hill Net Present Value with Optimistic grades of Uranium.

Economic impacts

The economic impact of the hypothetical development of each mine project outlined in the above scenarios are explored. The analysis is based on the assumption that mineral deposits of similar size and characteristics to each project will be discovered and developed. Table 16 presents the results of the estimated economic effects of each mine project.

The projects have not been aggregated when measuring wider economic impacts. Aggregation of the projects into the lower and upper bound scenarios would require consideration of economy-wide effects of the projects occurring simultaneously.

Table 16: Annual average economic impact of future possible mine developments

Future possible mine	Value of output ($ million)	Cost of output ($ million)	Direct employment (no.)	Secondary employment (no.)	Value add ($ million)	Royalties ($ million)
Challenger	153	84	250	150	110	3
Prominent Hill						
— No Uranium	1,151	302	1,350	840	620	42
— Conservative Uranium	1,337	347	1,370	1,150	840	50
— Optimistic Uranium	1,399	347	1,380	1,250	920	53
Peculiar Knob	254	209	150	70	8	3
Giffen	529	347	550	120	14	13
Honeymoon	137	81	150	230	170	3.5
Jacinth-Ambrosia [a]	428	206	na	na	na	15
Four Mile and Beverley	167	97	150	280	200	3.5

Notes: **a** Secondary employment and value add cannot be estimated for Jacinth-Ambrosia due to data limitations.

Source: Department of Industry, Innovation and Science – Resources and Energy Quarterly (June 2018), Company reports.

Other considerations

Sensitivity analysis

Given that the assumed benefits of known resources and possible future mine scenarios occurs into the future, uncertainties are tested using sensitivity analysis. Two key variables are tested in the sensitivity analysis: the discount rate and commodity prices, with the results presented in Appendix C.

If commodity prices are 10 per cent lower than what has been used in the base case, the value of known mineral resources declines substantially, from $5.9 billion to $2.1 billion. In addition, the lower prices make iron ore projects **Peculiar Knob** and **Commonwealth Hill**, and coal projects **Lake Phillipson** and **Penrhyn** return negative Net Present Values. Similarly for possible future mines, **Peculiar Knob** gives negative returns under the lower price sensitivity analysis.

A higher discount rate for possible future mine scenarios delivers a material effect to the Net Present Value of the upper and lower bound scenarios. The range of values under the base case of a 7 per cent discount rate is between $6.4 billion and $19 billion. Under the higher discount of 10 per cent, the range of value is between $3.7 billion and $11 billion. Under the 3 per cent discount rate, the range of value is between $14 billion and $40 billion. Sensitivity to the discount rate can be expected, due to the high

upfront capital outlays and long lead-in time before revenues are generated, a characteristic of many mining projects.

Developing mineral resources

The analysis in this report assumes the discovery and development of mineral Economic Demonstrated Resources and future potential mines in the WPA. However, in reality, exploration and mining investment only occurs under appropriate conditions, with many factors affecting the decision to undertake exploration activities and commit funding to projects, including the regulatory environment, tax and royalty arrangements, community acceptance, technical risks and access to infrastructure.

Commodity prices and exchange rates can be subject to volatility, which increases the financial risks and affects the commercial viability of a project. For example iron ore projects **Peculiar Knob** and **Giffen Well** were halted after prices declined in 2013. While mining deposits of similar size and characteristics could be viable in the future, investment in such projects would depend on the perceived risks of the operating environment.

Another important consideration is the availability of capital and labour when viewing the aggregated future possible mine scenarios and Economic Demonstrated Resources. The Net Present Value calculation and aggregations assume that there are enough resources for multiple additional projects to be realised in the WPA. This should be considered when interpreting the potential values.

Economic impacts

The assessment of economic impacts in this report uses I-O analysis to derive estimates of the economic activity that would be generated as a result of the development of mining projects. There are a number of limitations associated with this method, described in the methodology. In particular, this method often results in the overstatement of the impacts on employment and economic activity, and as a result, estimates of economic impacts in this report should be considered an upper-bound estimate. More complex modelling, such Computable General Equilibrium models would be required to overcome the limitations of I-O analysis.

There are also other economic impacts associated with the development of mining projects that have not been quantified in this report. For example, mining project developments affect both the current and capital accounts of the balance of trade. In addition to increasing Australian exports, growth in the sector also increases imports, particularly during the construction. The involvement of foreign entities through direct and portfolio investments also affects the capital account, with investments recorded as an inflow and repatriation of profits and dividends recorded as an outflow. Mining companies can also provide broader benefits to the wider community, which have not been considered in this report, such as introducing new technologies and expertise, and the provision of infrastructure, particularly in remote areas.

Conclusion

The Net Present Value of Economic Demonstrated Resources in the WPA is estimated to be $5.9 billion. Possible future mines in the WPA are estimated to have a Net Present Value between $6.4 billion and $19 billion. From the Economic Demonstrated Resources calculations, the Iron deposits contribute the most value with an estimated Net Present Value of $3.2 billion. For future possible mines, the Net Present Value of copper, as part of a Prominent Hill-like deposit, is the highest value commodity with an estimated value between $3.5 billion and $11 billion.

In terms of economic impacts, large mineral developments, such as that modelled in the Prominent Hill-like future potential mine, have the potential to have large employment and value add effects. The economic impacts of the other future potential mines have relatively smaller effects, but would still have the potential to materially increase employment and economic activity. Annual direct employment across the future possible mines ranges from 150 to 1,350 people, with secondary employment between 70 and 1,250 people. Annual value add across the future possible mines ranges between $8 million to $920 million.

The analysis in this report assumes the discovery and development of mineral Economic Demonstrated Resources and future potential mines in the WPA. However, in reality, exploration and mining investment only occurs under appropriate conditions, with many factors affecting the decision to undertake exploration activities and commit funding to projects. These factors should be considered when interpreting the values.

Appendix A: Acronyms and units

Table A1: Acronyms

Acronym	Definition
ABS	Australian Bureau of Statistics
ASX	Australian Securities Exchange
CFR	Cost and Freight
CGE	Computable General Equilibrium
EDR	Economic Demonstrated Resource
FOB	Free on Board
GA	Geoscience Australia
GDP	Gross Domestic Product
GSP	Gross State Product
I-O	Input-Output
LBMA	London Bullion Market Association
LME	London Metals Exchange
NPV	Net Present Value
OBPR	Office of Best Practise Regulation
OCE	Office of the Chief Economist
PEPR	Program for Environment Protection and Rehabilitation
SEEA	System of Environmental-Economic Accounting
SNA	System of National Accounts
WPA	Woomera Prohibited Area

Table A2: Units and minerals

Units	Units	Minerals	Minerals
kcal	Kilocalories	Ag	Silver
Kg	Kilograms	Au	Gold
t	Tonnes	Cu	Copper
kt	Thousand tonnes	Fe	Iron
Mt	Million tonnes	U_3O_8	Uranium oxide

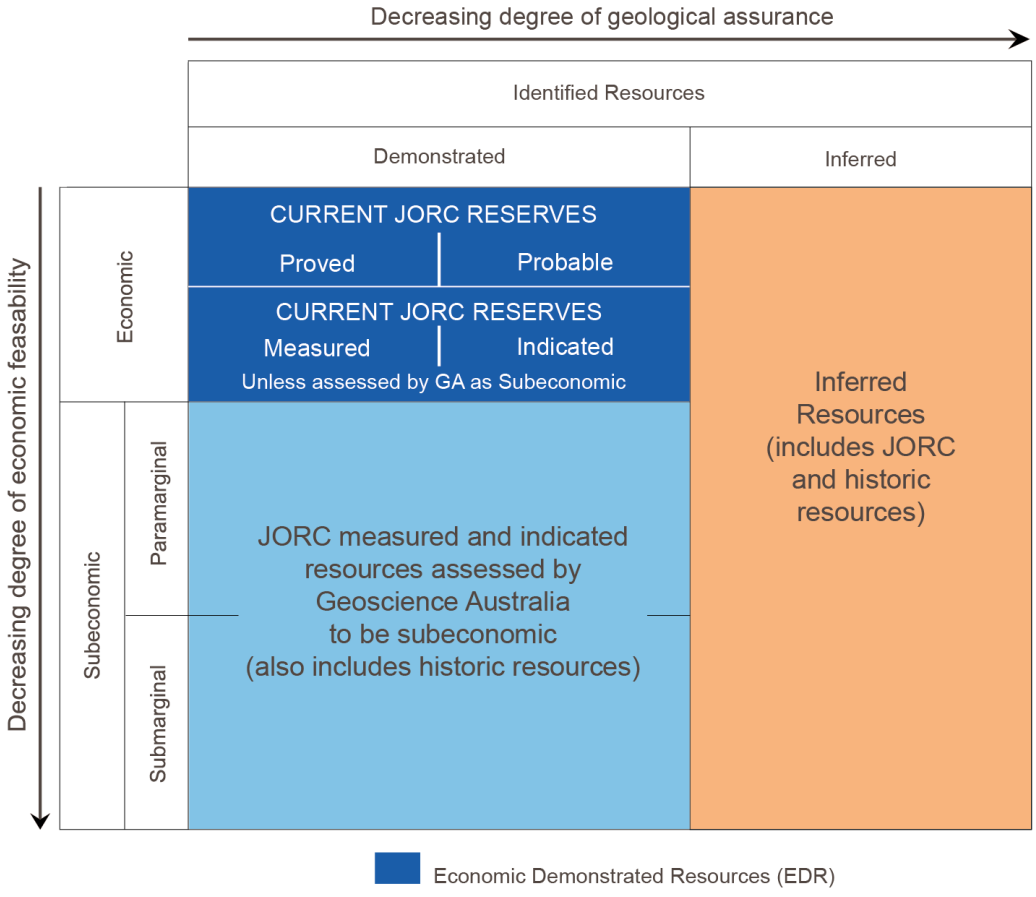
Appendix B: Geological terminology and data

Geological terminology

Table B3: Glossary of geological terminology

Term	Definition
Economic Demonstrated Resources	A collective term which includes the Joint Ore Reserve Committee (JORC) Code categories of: 'Measured Mineral Resources', 'Indicated Mineral Resources', 'Proved Ore Reserves' and 'Probable Ore Reserves'. These are resources that are well understood geologically, and have been regarded as economically feasible to extract or produce with reasonable certainty.
Inferred Resources	Resources for which quantitative estimates are based largely on broad knowledge of the geological character of the deposits and for which where are few, if any sample or measurements.
Total Resource	Total Resource = Economic Demonstrated Resource + Inferred Resource
Global Resource	Global Resource = Total Resource + Past Production

Figure B1: Geological classification of mineral resources



Notes: Some of the terminology in this diagram is detailed in the glossary of terms.

Source: Geoscience Australia (2018)

Geological data

Table B2: Deposits within the WPA for Economic Demonstrated Resources valuation

Deposit	Status	Commodity	Economic Demonstrated Resources
Challenger	Operating mine	Gold	6.5 t Au
		Silver	0.5 t Ag
Prominent Hill	Operating mine	Silver	0.3 kt Ag
		Copper	1054 kt Cu
		Gold	0.1 kt Au
Cairn Hill	Operating mine (production on hold)	Iron (magnetite)	5,982 kt Fe
		Copper	33 kt Cu
		Gold	0.001 kt Au
Peculiar Knob	Care and maintenance	Iron ore (hematite)	24 Mt
Giffen Well	Deposit	Iron (magnetite)	133 Mt Fe
Hawks Nest	Deposit	Iron (magnetite)	54 Mt Fe
Commonwealth Hill	Deposit	Iron (magnetite)	5.4 Mt Fe
Lake Phillipson	Deposit	Black coal	320.7 Mt
Penrhyn	Deposit	Black coal	302.3 Mt

Notes: Metal symbols in the last column indicate that the resource is measured in metal content terms. Economic Demonstrated Resources current as at 31 December 2016.

Source: Geoscience Australia (2018)

Table B3: Analogue deposits to be included in possible future mine developments scenarios

Future possible mines	Commodity	Total resource	Past production	Global resource
Challenger	Gold	8.2 t Au	32.8 t Au	41 t Au
	Silver	0.57 Ag	1.31 Ag	1.88 Ag
Prominent Hill	Copper	1,740 kt Cu	830 kt Cu	2,570 kt Cu
	Gold	0.11 kt Au	0.04 kt Au	0.15 kt Au
	Silver	0.46 kt Ag	0.21 kt Ag	0.67 kt Ag
	Uranium	27 kt U	12 kt U	40 kt U
	Conservative Uranium Optimistic	36 kt U	16.6 kt U	53 kt U
Peculiar Knob	Iron Ore (hematite)	34.3 Mt	10 Mt	45 Mt
Giffen	Iron Ore (magnetite)	213 Mt Fe	0	213 Mt Fe
Honeymoon	Uranium	9.8 kt U	0.31 kt U	10 kt U
Jacinth-Ambrosia	Rutile	0.53 Mt	0.015 Mt	0.5 Mt
	Zircon	5.5 Mt	0.152 Mt	5.6 Mt
	Ilemnite	9.8 Mt	0.274 Mt	10 Mt
Four Mile and Beverley	Uranium	31 kt U	3.1 kt U	34 kt U

Notes: Metal symbols in the last column indicate that the resource is measured in metal content terms. In almost all cases, the global resource for each analogue deposit (Economic Demonstrated Resources + Inferred Resource + cumulative production) has been used to model the total size of the future hypothetical resource. For Giffen Well, where no production has occurred, the sum of the Economic Demonstrated Resources and Inferred Resource has been used to model the total size of the future iron ore resource.

Source: Geoscience Australia (2018); Department of Industry, Innovation and Science (2018)

Appendix C: Sensitivity analysis

Given that the assumed benefits of known resources and possible future mines occurs into the future, sensitivity analysis has been used for two key variables: the discount rate and commodity prices.

Discount rate

Table C1 present the sensitivity to the discount rate. Upper and lower bound discount rates of 3 and 10 per cent are used, guided by recommendations from the Office of Best Practise Regulation[13].

Table C1: Sensitivity of Net Present Values to the discount rate

Deposit or future possible mine	Net Present Value ($million)		
	3 per cent Discount rate	7 per cent Discount rate (Base Case)	10 per cent Discount rate
Known resources			
Challenger	264	238	235
Prominent Hill	2,297	2,110	1,991
Cairn Hill	202	181	168
Peculiar Knob	82	77	74
Giffen Well	3,123	1,761	1,243
Hawks Nest	1,407	1,188	1,063
Commonwealth Hill	18	19	19
Lake Phillipson	56	98	129
Penrhyn	197	216	218
Total	**7,646**	**5,889**	**5,140**
Future possible mines			
Challenger	627	354	236
Prominent Hill			
- No Uranium	9,358	4,347	2,502
- Conservative Uranium	11,117	5,235	3,057
- Optimistic Uranium	11,893	5,628	3,305
Peculiar Knob	264	119	59
Giffen	1,403	626	302
Honeymoon	152	64	28
Jacinth-Ambrosia	2,568	1,362	873
Four Mile and Beverley	670	290	154

Notes: Values are in real 2018 Australian dollars.

Source: Department of Industry, Innovation and Science (2018)

13 Prime Minister and Cabinet (2016) Cost benefit analysis guidance note, Canberra.

Commodity prices

The sensitivity of the Net Present Value estimates to the forecast prices are shown in Table C2. The sensitivity analysis uses prices that are 10 per cent higher/lower than assumed in the 'base case' analysis.

Table C2 Sensitivity of Net Present Values to prices

Deposit or future possible mine	Net Present Value ($ million)		
	Forecast prices 10 per cent lower	Forecast prices (Base Case)	Forecast prices 10 per cent higher
Known resources			
Challenger	201	238	275
Prominent Hill	1,179	2,110	3,040
Cairn Hill	93	181	270
Peculiar Knob	-70	77	223
Giffen Well	1,053	1,761	2,470
Hawks Nest	728	1,188	1,649
Commonwealth Hill	-132	19	170
Lake Phillipson	-564	98	760
Penrhyn	-407	216	840
Total	**2,082**	**5,889**	**9,695**
Future possible mine			
Challenger	268	354	439
Prominent Hill			
- No Uranium	3,619	4,347	5,075
- Conservative Uranium	4,388	5,235	6,081
- Optimistic Uranium	4,743	5,628	6,514
Peculiar Knob	-33	119	270
Giffen Well	236	626	1,017
Honeymoon	12	64	116
Jacinth-Ambrosia	1,041	1,362	1,684
Four Mile and Beverley	183	290	397

Notes: Values are in real 2018 Australian dollars.

Source: Department of Industry, Innovation and Science (2018)