PROJECT ALTERNATIVES 4

4.1 INTRODUCTION

The BHP Billiton selection study has investigated numerous project alternatives for both major project components (e.g. the mining method) and smaller project options (e.g. location of landfill sites). This chapter presents the findings of the major 53 alternatives investigated across the major project components.

Table 4.1 lists the major project alternatives investigated, with the selected option shown in bold type. Sections 4.3 to 4.15 explain the reasons for the choices.

The justification for the expansion project is presented in Chapter 3, Project Justification, together with a discussion of not expanding the Olympic Dam operation (i.e. the 'do nothing' option), and the consequences of that.

Some selected options for the project components required further investigation to determine a preferred location (e.g. the desalination plant and landing facility). The sub-options investigated and the selected locations for these project components are also discussed in this chapter.

The BHP Billiton Group is always looking to optimise the performance of its operations and Olympic Dam is no exception. Section 4.16 of this chapter discusses some of the technologies currently being investigated for future use at Olympic Dam.

4.2 ASSESSMENT METHODS

The BHP Billiton Group has developed a proprietary risk management standard. The standard provides a consistent platform across the company's operations by which risks are rated and ranked.

The BHP Billiton Olympic Dam expansion team used the risk standard to assess the risks of the project alternatives:

- against predictions of health, safety, environmental, community and economic performance, including the implications for matters of national environmental significance protected under Part 3 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- to conform with the BHP Billiton Group and Olympic Dam policies and standards.

Sections 4.3 to 4.15 present the reasons for adopting the selected options and for rejecting the alternatives.

Primary water supply would be from a desalination plant, not from the Great Artesian Basin (GAB)

Table 4.1 Major project options investigated (selected option in bold type)

Project component	Options investigated
Mining method	**Continue existing underground method and expand operations by establishing a new open pit mine**
	Expand existing underground mining operation
Production rate	**Expand to 750,000 tpa of refined copper equivalent plus associated products**
	Expand to <750,000 tpa of refined copper equivalent plus associated products
	Expand to >750,000 tpa of refined copper equivalent plus associated products
Processing ore	**Upgrade existing metallurgical plant to full capacity, construct new concentrator and hydrometallurgical plant and export additional concentrate**
	Construct a new plant at Olympic Dam to process all of the recovered ore
	Upgrade existing metallurgical plant to full capacity and construct a new plant in Upper Spencer Gulf to process the additional concentrate
Location of port to export concentrate	**Port of Darwin**
	Port Adelaide
	Port Bonython
	Whyalla
Tailings storage method	**A paddock system as used in the existing operation with design modifications (e.g. thickening deposited tailings from the current 47% to 52–55% solids)**
	A paddock system with no design modifications
	Co-disposal of tailings with mine rock
	A central discharge system
	Co-locating the tailings and mine rock storage facilities
	Thickening tailings above 55% solids – applied to all options
	Neutralising the tailings – applied to all options
Primary water supply	**Coastal seawater desalination plant**
	Expand existing extraction from the Great Artesian Basin (GAB)
	New groundwater extraction from the Arckaringa Basin
	Adelaide treated wastewater (i.e. use primary sewage treatment plant water)
	Extraction from the River Murray
Location of coastal seawater desalination plant	**Point Lowly**
	Ceduna
	Port Augusta
	South of Port Pirie
	Whyalla
	South of Whyalla
Options for managing desalination plant return water	**Return to the sea**
	Land-based discharge
	Discharge to an inland salt lake
	Deep well injection
Primary electricity supply[1]	**From the national electricity market (i.e. the grid)**
	A purpose built on-site gas-fired power plant
	Dedicated low carbon emission energy sources – wind and/or solar
	Dedicated low carbon emission energy source – geothermal
Hiltaba Village (construction workforce accommodation)	**On Andamooka Road, 17 km east of Roxby Downs**
	Thirteen alternative locations to the north, south and east of Roxby Downs
Transporting materials	**Maximise bulk transport via rail with remaining materials transported by road**
	Continue existing all-by-road method
Location of landing facility	**Site 1 (Snapper Point south of O'Connell Court – about 10 km south of Port Augusta)**
	Site 2 – Shack Road, about 16 km south of Port Augusta
	Site 3 – Shack Road, about 18 km south of Port Augusta
	Site 4 – Shack Road, about 21 km south of Port Augusta
	Area 1 – Shack Road, about 2 to 8 km south of Port Augusta

Table 4.1 Major project options investigated (selected option in bold type) (cont'd)

Project component	Options investigated
Location of port to import sulphur and diesel	**Port Adelaide**
	Port Augusta
	Port Pirie
	Whyalla
	Port Bonython
	Interstate ports

[1] Nuclear power is not available in Australia and was therefore not assessed.

4.3 MINING METHOD

Chapter 3, Project Justification, broadly describes the commercial potential of a new open pit mine at Olympic Dam. This section examines the practicality of this option, on its own or in combination with the existing underground mine, as opposed to an expansion of Olympic Dam by underground mining only.

4.3.1 SELECTED OPTION

The selected option for the proposed Olympic Dam expansion is to continue underground mining and develop a new open pit mine. BHP Billiton has chosen this option because it generates the optimum return on investment. In addition:

- the open pit method enables bulk mining, which suits the lower-grade of ore in the southern part of the Olympic Dam ore body
- the existing underground mining method, which is more selective, suits the northern area of the ore body, with its higher-grade and more localised pockets of ore
- a greater proportion of the resource would be recovered with open pit mining – 98% of the mineral resource would potentially be recovered with the proposed open pit compared to 25% recovery with a more selective underground method (see Figure 4.1)
- the BHP Billiton Group is very familiar with and experienced in the proven method and technologies required to develop an open pit mine of this scale.

In relation to the EPBC Act, open pit mining at Olympic Dam has the potential to impact naturally extinct, but re-introduced threatened species in the southern section of Arid Recovery (see Chapter 15, Terrestrial Ecology, Section 15.5.9, for details).

As discussed in Chapter 3, Project Justification, another 35 mines the size of the current Olympic Dam operation would be required to meet the predicted global demand for copper to 2018 and another 13 mines the size of Olympic Dam would be required to meet the predicted global demand for uranium oxide to 2030. Open pit mining provides the highest rate of recovery and contributes more significantly to this global demand.

4.3.2 REASONS FOR REJECTING UNDERGROUND MINING ONLY

Olympic Dam's underground mining capability could be expanded without significant impact on EPBC Act listed matters of national environmental significance. However, developing an underground mine that could substantially increase production raises the following issues:

- the relative safety records of underground and open pit mining (see Chapter 22, Health and Safety)
- lower resource recovery, therefore leaving much of the mineral resource in the ground
- it is economically less attractive.

In some circumstances, for example where isolated blocks of higher-grade mineral resource are located outside the open pit footprint, underground mining may be used to extract this ore in the future.

4.4 PRODUCTION RATE

The feasibility of open pit mining raises the question of what the optimum production rate should be. If the rate is too small, the upfront capital investment cannot be recovered: if it is too large, the operation would encounter new risks associated with operating at the margin of what today's equipment and practice technologies can achieve.

4.4.1 SELECTED OPTION

The selected option is to increase the average annual production to 750,000 tonnes per annum (tpa) of refined copper equivalent plus associated products. This rate is technically feasible and balances capital and operating costs. BHP Billiton has the capacity and experience to manage the associated environmental, social and cultural issues, which are assessed throughout the Draft EIS.

The proposed rate of production optimises the return on investment. The purpose of the Draft EIS is to explain how the issues raised by this proposal can be addressed, so that governments and the public can consider the overall merits of the development.

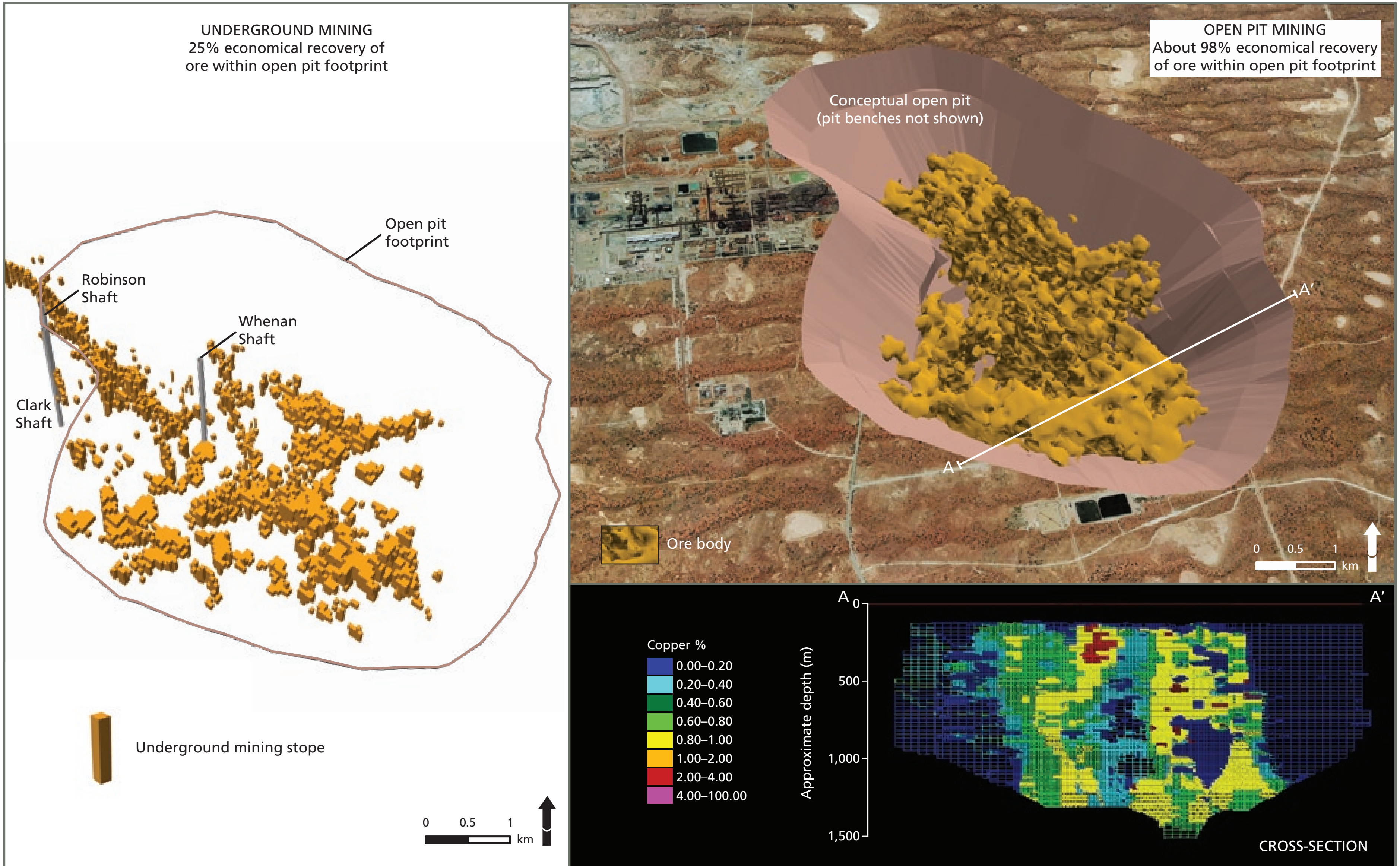

Figure 4.1 Potential ore recovery from underground versus open pit mining

The design capacity for the expanded operation and the resulting requirements for water, energy, labour and equipment are based on extracting about 410 Mtpa of material, of which the estimated throughput (or input) is 72 Mtpa of ore, and not the rate of output or final product. The production volumes of final products depend on the tenor of the ore (i.e. the amount of copper, uranium, gold and silver contained within the ore). This means the projection of 750,000 tpa of copper equivalent is the average annual rate of production once the expansion is fully operational, but the actual annual rate is likely to fluctuate around this average.

4.4.2 REASONS FOR REJECTING OTHER OPTIONS

Expand to less than 750,000 tpa of refined copper equivalent plus associated products

The rationale for open pit mining reflects the economies of scale of bulk mining. Based on current knowledge and assumptions, a production rate less than that proposed would not secure the optimal economic return. More than 300 m of overburden needs to be removed to expose the ore body. Lower production rates translate to smaller revenues, which would not provide a sufficient return against the capital cost of exposing the ore body to justify developing the project.

Expand to greater than 750,000 tpa of refined copper equivalent plus associated products

Practical constraints start to override economies of scale when the ore throughput increases to the point where average annual production rates would routinely exceed 750,000 tpa. For example, the capacity of the mobile plant currently available means that increases in production must translate into more (rather than bigger) vehicles, which in turn raises issues of haul road capacity, dust generation, traffic management and safety. It is likely, however, that technological advances could eventually overcome these constraints and increased production rates could be achieved without compromising the safety or environmental footprint assessed in the Draft EIS.

4.5 PROCESSING OF ORE

Thirteen of the 20 largest copper mines in the world export copper concentrate to other smelters where it is processed to make the final product (i.e. high purity copper cathodes). Olympic Dam currently processes the ore to final product because its ore body contains recoverable quantities of uranium, gold and silver and because removing uranium from the final copper product makes the copper more saleable.

4.5.1 SELECTED OPTION

The selected option is to upgrade the existing metallurgical plant (particularly the smelter and refinery) to produce up to 350,000 tpa of refined copper, and construct a new concentrator and hydrometallurgical plant to produce enough concentrate to feed the upgraded smelter and to export up to 1.6 Mtpa. Although the exported concentrate would contain recoverable quantities of copper, uranium oxide, gold and silver, this option still provides the optimal return on investment to BHP Billiton.

The selected option also removes the operating constraint that is inherent in trying to match the design capacity of an on-site smelter with the volume of ore mined. In other words, at any given time the volume and grade of ore extracted will vary depending on the distribution and mineralisation of the ore within the basement material being mined, but smelters, on the other hand, have an optimal design capacity. Therefore, the variable supply of ore typically results in either large ore stockpiles required to blend the various grades of extracted ore, or the smelter operating under capacity or inefficiently.
The selected option allows for an unconstrained mining operation to supply more than enough ore of a consistent higher grade to operate the on-site smelter at its design capacity and to export the additional concentrate.

4.5.2 REASONS FOR REJECTING OTHER OPTIONS

Construct a new plant at Olympic Dam to process all recovered ore

This alternative was rejected because:

- the capital cost for the additional smelter would not provide the optimal return on investment
- the lower copper grade and lower copper to sulphur ratio of the southern ore body would necessitate a different smelting technology than that currently used at Olympic Dam (i.e. two-staged smelting instead of single-staged smelting), thus increasing the complexity of on-site metallurgical processing by running two smelters with different technologies.

Upgrade the existing smelter to full capacity and construct a new metallurgical plant in Upper Spencer Gulf to process the additional concentrate

This alternative is not preferred at this point in time because:

- the capital cost for the additional metallurgical plant would not provide the optimal return on investment
- a tailings storage facility (TSF) would be required adjacent to the metallurgical plant in Upper Spencer Gulf and no acceptable site has yet been identified.
- it is possible to avoid the coastal storage of tailings as discussed in the dot point above by leaching the concentrate at Olympic Dam prior to transporting the leached concentrate to a coastal smelter. However, this option would require materials to be transported to Olympic Dam for the on-site leaching (including about 1.7 Mtpa of sulphur prill), constructing the additional TSF at Olympic Dam and constructing a new smelter somewhere in Upper Spencer Gulf. This alternative carries the highest economic cost of the options investigated.

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4.6 PORT LOCATION FOR EXPORTING CONCENTRATE

Under the proposed schedule, concentrate would be exported from about 2016 onwards. The volume exported would increase in line with increased mine production to a maximum of about 1.6 Mtpa scheduled to be by 2020.

4.6.1 SELECTED OPTION

The selected option to export concentrate is via the Port of Darwin. The reasons for this choice are:

- the East Arm wharf at the Port of Darwin already has sufficient capacity to accommodate the large Panamax-class vessels preferred for transporting bulk materials
- the East Arm wharf can accommodate a new bulk loading facility for the transfer of the Olympic Dam concentrate to the vessel
- the export of bulk materials from the Port of Darwin is already supported by the Northern Territory Government under the Australasian Trade Route major project
- Olympic Dam has an existing relationship with the Darwin Port Corporation through the current export of uranium oxide via the Port of Darwin
- the cost is comparable to other options investigated, with lower capital costs but higher operating costs
- the recent relocation of the Port of Darwin from the capital city to East Arm avoids potential social issues associated with urban encroachment on port facilities.

4.6.2 REASONS FOR REJECTING OTHER OPTIONS

Port Adelaide was rejected because:

- a new wharf would be required to accommodate the new bulk loading facility
- urban encroachment at Port Adelaide exacerbates the potential social issues surrounding the export of bulk materials such as concentrate.

Whyalla and Port Bonython were identified as opportunities to export concentrate. However, neither port currently has the capability to accommodate the preferred vessel (i.e. a Panamax-class vessel) for bulk mineral export shipments. Both locations currently have land and maritime based constraints that could not immediately be resolved compared to the selected option. If, in the future, these issues can be overcome and BHP Billiton determines that it wishes to export concentrate from either of these ports, use of these ports would be subject to obtaining the relevant environmental and other consents from the Australian and South Australian governments. The use of these ports is not the subject of approval sought by the Draft EIS.

The implications of the alternative port locations on relevant matters under the EPBC Act are described in Appendix E1.

4.7 TAILINGS STORAGE METHOD

The selected production rate would generate an additional 58 Mtpa of tailings over that which is currently produced at Olympic Dam. This defines the capacity of the future tailings storage facilities, for which the minimum requirements are:

- during operations – to design a storage facility that receives tailings at the optimum rate for water balance, beach drying via evaporation and the capacity to store the required volume of tailings safely, with acceptably low emissions to air and water
- post closure – a stable landform with a final surface that ensures ongoing acceptably low emissions to air and water.

Appendix F1 describes and assesses tailings storage options, which are summarised below.

4.7.1 SELECTED OPTION

The selected option for tailings storage is a paddock system with design improvements over the existing operation. The features of the revised design include (see Chapter 5, Description of the Proposed Expansion, for details):

- a series of square storage cells contained by a perimeter embankment (broadly similar to the present design, but with improved embankment design)
- centre-line raising of perimeter embankments, taking advantage of non-reactive mine rock from the open pit (the greater strength of this method allows a higher TSF structure than the existing upstream method of embankment raising, thereby reducing the required disturbance footprint)
- delivery of tailings thickened to a solids concentration of 52–55% (currently about 47%)
- additional recycling of tailings liquor to the metallurgical plant
- an extra tailings cell to optimise evaporation potential and water balances
- disposing of the tailings liquor in rotation from multiple points over large areas (called beaches) to maximise evaporation
- capillary rise of moisture and consolidation of the drying tailings mass and to drain the free liquor to a central decant pond
- a base liner under each central decant pond
- an inner rock, flow-through, filter wall in the centre of the cell to contain the area of the enclosed decant pond and to provide a foundation for bird netting or similar
- netting (or similar) over the central decant pond of each TSF cell to restrict fauna access, particularly migratory birds
- the use of balance ponds where the areas of free liquor are small enough to be covered, in order to restrict fauna access
- no new evaporation ponds.

As with other options, this configuration is able to meet storage requirements and the safety criteria of the Australian National Committee on Large Dams (ANCOLD 1999) under both normal and extreme loading conditions. It is the selected option because, compared with the other options, it offers:

- lower emissions of dust and reduced seepage of liquor
- no open ponding of acidic water that would otherwise be accessible to common and EPBC Act listed water birds
- the smallest disturbance footprint of the four options investigated.

4.7.2 REASONS FOR REJECTING OTHER OPTIONS

Paddock system with no design modifications

Continuing with the existing TSF design would not allow three environmental improvement opportunities to be implemented: enabling a smaller footprint per tonne of tailings stored; reducing the risk to water birds listed under the EPBC Act; and reducing the rate of seepage to groundwater.

Co-disposal of tailings with mine rock

This method mixes the tailings with the mine rock, and uses the voids between the mine rock to store the tailings. However, this option is not viable because the void volume in the dumped mine rock is too small for the volume of tailings.

Co-disposal also has other disadvantages: reduced rock-to-rock contact lowers shear strength and hence the stability of the overall rock storage facility (RSF); and filling the voids with tailings would saturate the structure such that rather than soaking up rainfall, the rainfall would force the tailings to seep into the groundwater in greater volumes than the selected option.

A central discharge system

This system mounds the tailings from a central discharge point and allows the tailings to spread outwards under gravity until the beaches (i.e. the slopes of the tailings mound) reach equilibrium. This method may save some of the cost of the engineered embankments of a conventional TSF but would have its own disadvantages:

- either the storage facility would have to be large enough that the tailings liquor does not pond around the perimeter of the facility (the estimated footprint would be around 7,500 ha compared to the proposed design footprint of around 4,400 ha), or
- perimeter walls would be required if the footprint is to be reduced. However, to maintain the structural integrity of these walls, ponded stormwater and tailings liquor would need to be decanted away from the wall and into large, lined water dams or evaporation ponds. This again increases the footprint size and the ability of common and EPBC Act listed water birds to access the acidic liquor.

Co-locating tailings and the rock storage facility

For the purpose of the Draft EIS, co-location of tailings and the RSF entails construction of the tailings storage cells within the RSF. This would have the benefit of using mine rock to contain and store tailings. In other words, the mine rock is also the containment structure for the tailings.

This option has merits for small open pit operations, but runs into operability and safety constraints for large mines. In particular, it significantly increases the safety risk inherent with frequent interaction between the large number of very large mining trucks and the light vehicles that are used around the tailings infrastructure. The proposed storage solution for the Olympic Dam tailings and mine rock achieves the benefit of using mine rock for the tailings cell embankments, but avoids the safety and operability issues of co-location.

Thickening tailings above 55% solids

In certain situations, thickening of tailings can have a number of advantages, for example it can reduce the volume of water ponding in the TSF, increase the volume of water available to the metallurgical plant, result in less seepage and may have less risk associated with retention structures. For this reason, the Olympic Dam expansion design seeks to thicken the tailings from the current average solids density of 47% to a target around 55%, avoiding the construction of additional evaporation ponds by optimising the evaporation losses from beaches using thin layer deposition techniques.

However, the option to thicken the Olympic Dam tailings above 55% solids has the following disadvantages:

- The beach slope for a paste tailings around 70% solids would be 3% to 5% (compared to the existing 1%). This would create an edge-to-centre height difference of some 40 m over the average 2,000 m tailings cell. This storage profile reduces the surface area of tailings exposed to evaporation and therefore the tailings would need to be re-spread by machinery in order to achieve a reasonable storage efficiency. This would significantly increase health and safety risks and operating costs.
- The quantity of tailings liquor that can be re-used is limited because the acidity and variable quality of the tailings liquor reduces metal recovery. At 55% solids, the maximum amount of process water that can be re-used (without negatively impacting the process) is being recycled, hence thickening above this solids density creates a surplus of process liquor that needs to be stored and evaporated.
- The additional liquor would need to be evaporated in dedicated evaporation ponds. Each further 1% of thickening requires an evaporation pond area of about 125 ha (by comparison, the existing evaporation ponds cover 133 ha). Consequently, thickening to a paste tailings consistency around 65% would thus require a further 1,250 ha evaporation pond area.

Neutralisation of tailings

Neutralising the tailings has potential to provide benefits in terms of ameliorating impacts on fauna, reducing the impact of seepage on groundwater quality and providing opportunities for reuse of tailings liquor in the metallurgical plant. While the neutralisation of tailings is a proven process route in some applications, it is not common within the metallurgical industry. As there is significant cost, carbon dioxide generation and uncertainty associated with the neutralisation of tailings, it is typically implemented only in small operations generating much less tailings, and at sites where there are different environmental receptors and drivers to that experienced at Olympic Dam.

Impacts to ecology and human health and safety

Neutralisation of tailings may reduce the impact on fauna that comes into direct contact with the tailings. However, the neutralisation process would result in the precipitation of potentially toxic metals and chemical compounds, which would increase the risk of more widespread and longer-term impacts through exposure and ingestion. Neutralised tailings would also encourage the growth of vegetation on the TSF, which would reduce evaporation and therefore require a larger TSF footprint to maintain the required water balance. A neutralised tailings stream would also have a lower settled density, resulting in material that would be 'fluffier', significantly increasing the potential for dust generation, the dust containing metals and some radionuclides.

Seepage to groundwater

Investigations into the acidic tailings have concluded that seepage of the acidic liquor currently produced is neutralised by carbonate sediments and limestone underlying the TSF before it reaches the groundwater (see Chapter 12, Groundwater).

Neutralisation of the tailings would provide limited additional protection for the groundwater, and preliminary investigations indicate neutral tailings liquor may seep more readily than acidic liquor.

Reuse of tailings liquor

The suitability of neutralised tailings liquor for reuse is unknown, and would require significant research and metallurgical trials. The neutralised liquor may not be suitable for reuse in the metallurgical plant, as the liquor would have to be returned to an acidic state, requiring significant quantities of reagents and requiring management of the contained precipitates.

Infrastructure requirements

Neutralisation of tailings would require large quantities of neutralising agent such as limestone (around 3.2 Mtpa) or dolomite (around 18.3 Mtpa), which would need to be finely crushed, stored and transported, and would require substantial additional plant and infrastructure dedicated to the neutralisation process. Calcining of the mined dolomite could be undertaken and would reduce the tonnage required, although this would require an increase in energy consumption and generate a large amount of solid waste as sediments and scales, which would require transport and disposal.

4.8 PRIMARY WATER SUPPLY SOURCE

The supply of an additional 200 ML/d of water for the Olympic Dam expansion has been a complex issue. Natural water is a public resource, to which there are many legitimate and competing claims. Moreover, existing sources of supply have natural and regulatory limits. BHP Billiton has elected to use desalination to manufacture the project's primary supply of water.

4.8.1 SELECTED OPTION

BHP Billiton proposes a coastal seawater desalination plant to supplement the existing groundwater supply from the Great Artesian Basin (GAB). The reasons for this choice are:

- it meets the water demand of the proposed expansion
- it does not compete with existing supplies
- it is comparable in cost to its alternatives.

The coastal desalination plant also creates a new water supply option for the towns in the Upper Spencer Gulf and Eyre Peninsula areas that are currently provided with water from the River Murray. The South Australian Government has recognised this opportunity, and the Draft EIS has assessed an additional demand of 80 ML/d from the desalination plant.

4.8.2 REASONS FOR REJECTING OTHER PRIMARY WATER SUPPLY OPTIONS

Figure 4.2 shows the location of the alternative water supply options discussed below.

Expanding the extraction from the Great Artesian Basin

BHP Billiton has investigated options to increase extraction from the two existing wellfields and/or to develop a third wellfield to the north-east (and hence further into the GAB). These options were rejected because:

- current groundwater assessments suggest a third wellfield to the north-east (Wellfield C) could provide only a small additional sustainable supply, which would be unable to meet the demand for the proposed expansion without adversely affecting GAB springs protected under the EPBC Act
- a reliable, sufficient and sustainable supply source further into the GAB would result in the production of much warmer water that would be technically difficult and too expensive to cool to the required temperature.

New groundwater extraction from the Arckaringa Basin

The Arckaringa Basin is a relatively unstudied groundwater resource about 100 km north-west of Olympic Dam. The available information suggests there is insufficient supply for the primary water supply for the Olympic Dam expansion.

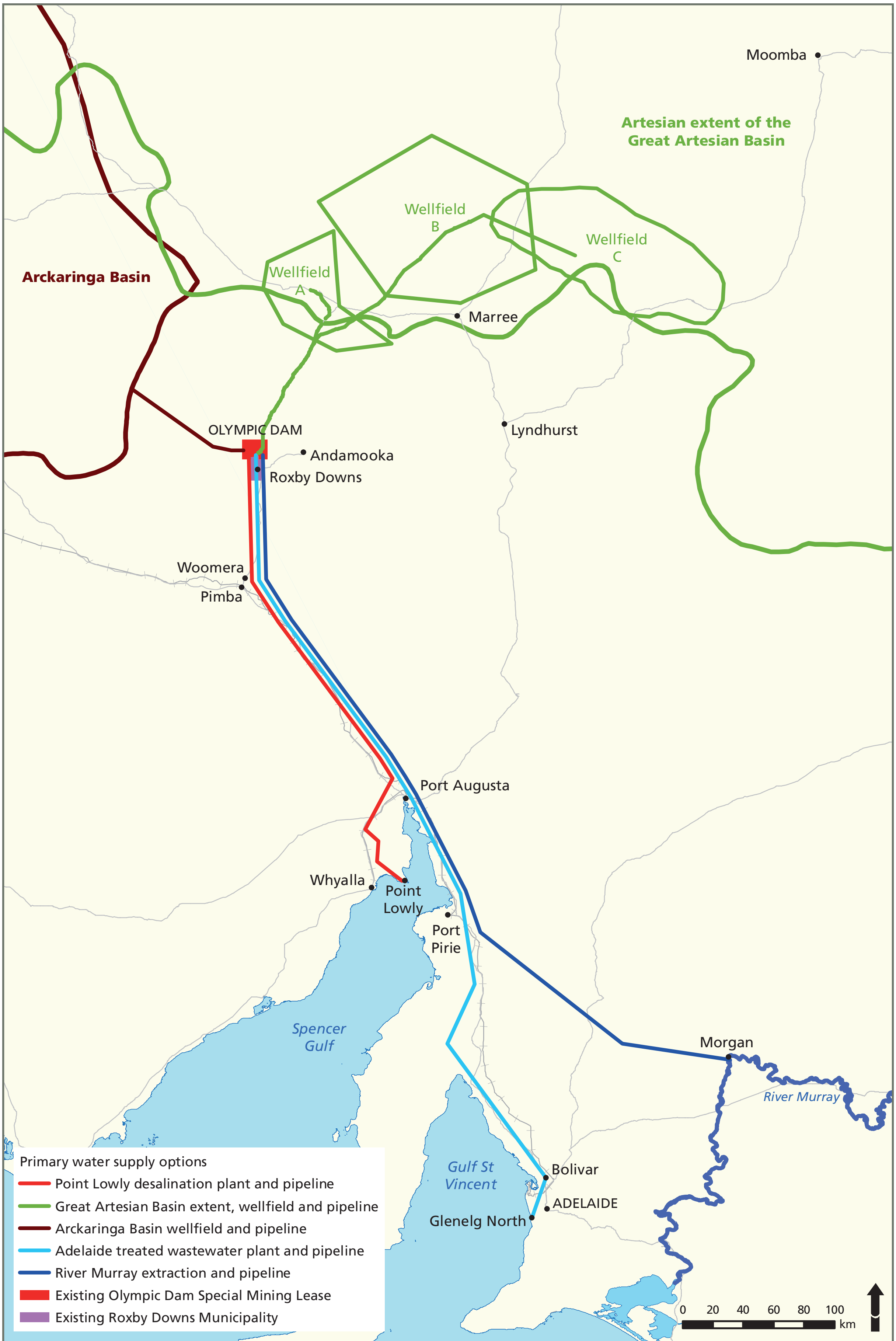

Figure 4.2 Project alternatives – primary water supply

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Adelaide treated wastewater

The majority of Adelaide's treated sewage effluent is routinely discharged to the sea and so the option exists to re-use this water via a 600 km pipeline to Olympic Dam. However, the option was rejected because:

- the short-term security of supply becomes uncertain during the drier summer months, when the local use of this treated wastewater may be high
- the long-term security of supply is uncertain with increased local competition expected for this water in the future
- if these competing demands grow (as seems likely) then the cost of this water would also rise
- the potentially variable quality of the water could jeopardise the efficiency of the Olympic Dam minerals metallurgical plant.

Extraction from the River Murray

The extraction of water from the River Murray was assessed at the request of SA Water. BHP Billiton rejected this option because current water allocations are under review and the long-term security of new allocations is uncertain.

Moreover, a large, new demand would run counter to Australian and South Australian government policy. In particular, South Australia's Strategic Plan identifies the condition of the River Murray as one of the most critical environmental issues for South Australia, with the government aiming to increase river flows by 1,500 GL/a by 2018. Similarly, the Australian and South Australian governments' Living Murray Initiative provides for 500 GL per annum of water to be returned to the river as environmental flows.

Extraction from the River Murray may also exacerbate adverse effects on the Coorong (an EPBC Act listed Ramsar wetland of international importance).

4.9 LOCATION OF DESALINATION PLANT

The ultimate feasibility of the desalination option required a plant to be located where the intake water quality and environmental performance requirements for return water discharge could be met.

BHP Billiton identified possible desalination plant sites at Point Lowly, Port Augusta, Whyalla, south of Whyalla, south of Port Pirie and Ceduna, and assessed these against the following criteria:

- proximity to Olympic Dam with clean, deep (>20 m) and fast flowing water (i.e. water of high plant intake quality and a high-energy environment in which to dilute and disperse return water safely) (an animation for this topic is available at <www.bhpbilliton.com/odxeis> and on the disc accompanying the Executive Summary)
- accessibility and constructability of the water supply pipeline
- availability of land and established utilities such as power, roads and telecommunications infrastructure.

Point Lowly meets the three criteria and became the selected option. Figure 4.3 shows the locations of the sites assessed and summarises the assessment results.

4.10 OPTIONS FOR MANAGING DESALINATION PLANT RETURN WATER

A 280 ML/d seawater desalination plant would produce about 370 ML/d of return water. The return water would be a combination of concentrated seawater (concentrated from about 40 g/L to 78 g/L) and an anti-scalant chemical used to control scale deposits on the reverse osmosis membranes.

4.10.1 SELECTED OPTION

BHP Billiton proposes to discharge the return water to Upper Spencer Gulf from a diffuser located on the seabed and in a depth of at least 20 m of water. The reasons for this choice are:

- the potential environmental impacts are considered manageable
- detailed assessments presented in Chapter 16, Marine Environment, have established that this option would not impact marine species listed under the EPBC Act
- it is the most cost-effective of the options investigated.

4.10.2 REASONS FOR REJECTING OTHER OPTIONS

Land-based discharge

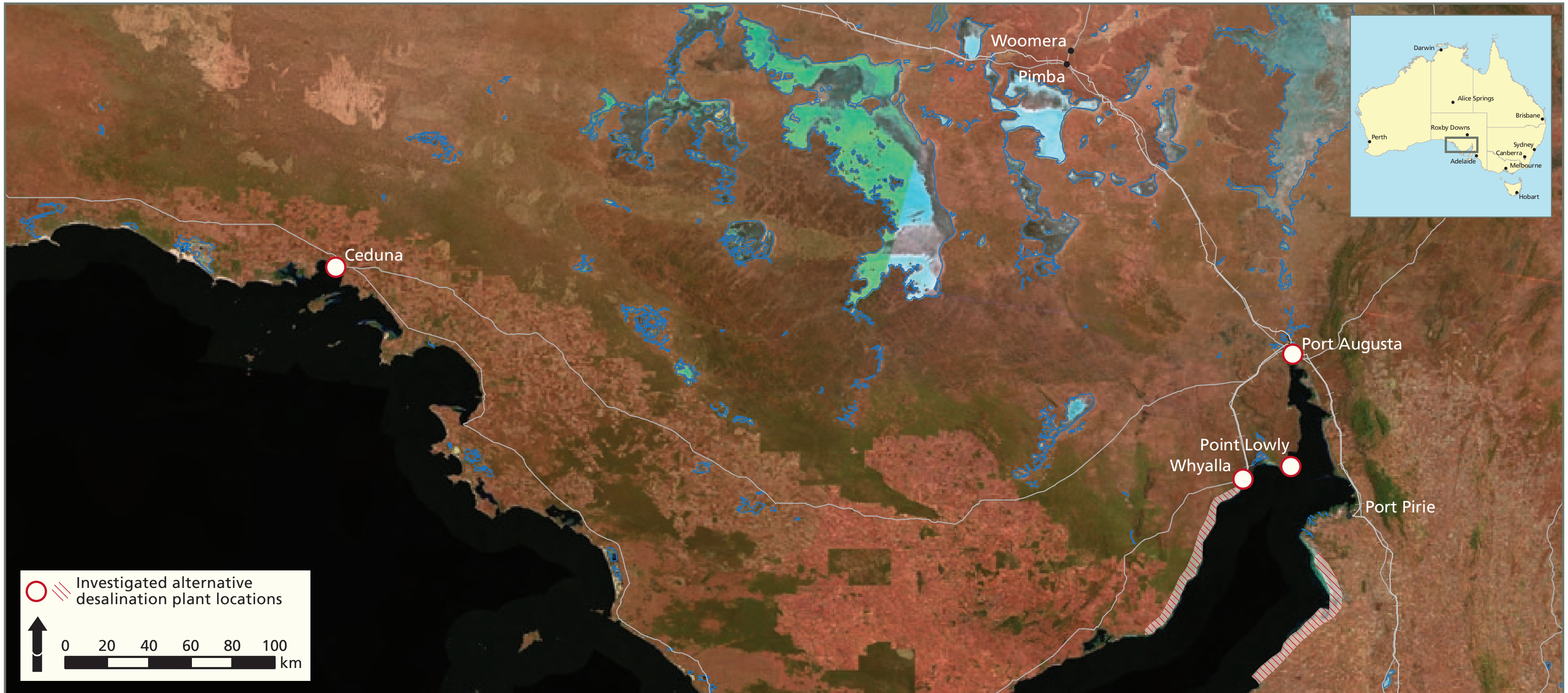
The option to discharge return water to the land was rejected because:

- it would require an area of approximately 7,000 ha to be cleared to construct shallow, lined evaporation ponds, and no acceptable site was identified
- transportation of return water inland would require increased power consumption for pumping, which in turn would increase the greenhouse gas emissions beyond that of the selected option
- this option has higher capital and operating costs than the selected option.

Discharge to an inland salt lake (assumes the desalination plant would be located at Port Augusta)

The option to discharge return water to an inland salt lake has the potential to enhance wetland habitat for listed bird species, particularly the Banded Stilt *Cladorhynchus leucocephalus*. Capital and operating costs are likely to be about the same as the selected option as:

- approximately 70 km of product water pipeline would be saved by locating the desalination plant at Port Augusta
- approximately 80 km of larger diameter return water pipeline would be required to transport return water from Port Augusta to Lake Torrens
- the cost of the underwater pipeline and diffuser would be saved
- costs of pumping return water to Lake Torrens would be about the same as the costs saved by not having to pump product water from Point Lowly to Port Augusta



Criteria	Ceduna	Sites south of Whyalla	Whyalla	Point Lowly	Port Augusta	Sites south of Port Pirie
Length of water supply pipeline (km)	380	>340	320	320	280	>340
Distance to a water depth > 20 m (km)	4	5	7	0.3	>20	10
Suitable available land and infrastructure (e.g. road access and electricity)	No	No	Yes	Yes	Yes	No
Other considerations	Water supply pipeline would need to traverse a conservation park, regional reserves and Defence's Woomera Prohibited Area	Coastline is typified by mangroves and shallow seabed slopes	Extensive seagrass beds in the area and existing dredging would affect intake water quality	Strong tidal currents to maximise dispersion of return water	Existing seawater inlet and outlet infrastructure available but poor dispersion of return water	Coastline is typified by mangroves and shallow seabed slopes

Figure 4.3 Desalination plant location options

- costs of desalinating higher salinity seawater would be off-set to some degree by using warmer water from the power station.

Lake Torrens, covering an area of about 1 million hectares, would be the most appropriate inland salt lake to receive the return water. However, this option was rejected because Lake Torrens is a national park and may have Aboriginal significance and discharge of return water would be inconsistent with the current management principles of this conservation area.

Deep well injection

The option to inject return water via deep wells into groundwater aquifers was rejected because:

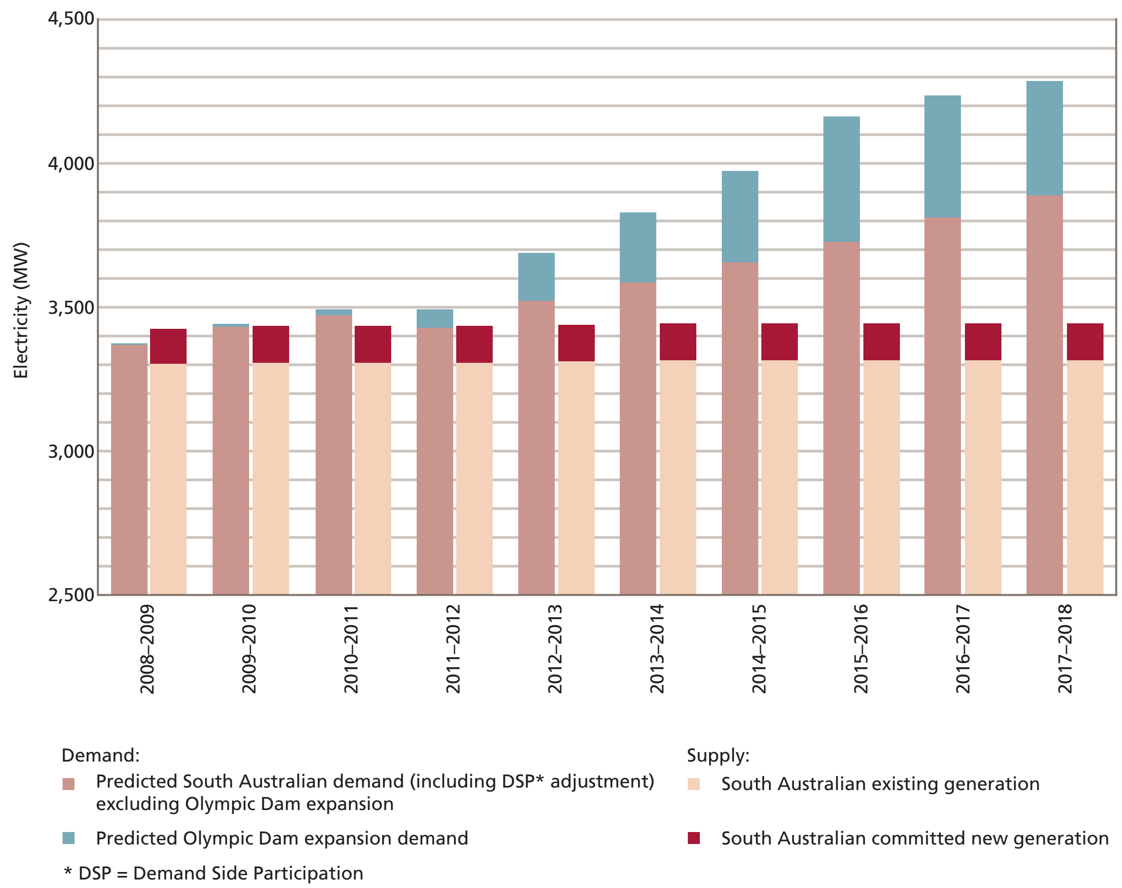
- it would require more than 400 wells to inject the return water into groundwater aquifers and it is likely that the return water would eventually discharge into the sea through natural groundwater flows
- this option has the highest capital and operating costs of the investigated options.

4.11 PRIMARY ELECTRICITY SUPPLY

The national electricity market (NEM) sells wholesale electricity via an interconnected power system across the five states and territories of southern and eastern Australia. The NEM (i.e. grid) would normally be the first choice for electricity when it is available and accessible. Figure 4.4 shows the predicted energy demand and supply for South Australia, with and without the Olympic Dam expansion, up to 2018 (Electricity Supply Industry Planning Council 2008). This shows that the increasing South Australian demand, even without the Olympic Dam expansion, would exceed supply by the 2012–2013 financial year.

Figure 4.4 also shows that additional South Australian capacity would be required about the same time that the electricity demand for the Olympic Dam expansion increased significantly. Therefore, additional electricity generation would be required and the new facilities may be constructed at Olympic Dam or elsewhere in South Australia. While commercial negotiations with prospective suppliers have started, they are not scheduled to conclude until 2010.

For these reasons, BHP Billiton cannot specify final arrangements for electricity supply in the Draft EIS. However, the Draft EIS can outline the options available, indicate which



Source: Adapted from Electricity Supply Industry Planning Council 2008 and BHP Billiton data

Figure 4.4 Electricity demand and supply outlook option or options are preferred and explain how they are feasible in principle, and assess the environmental impacts of the preferred options.

None of the electricity supply options investigated has the potential for significant impact on a matter of national environmental significance as defined in the EPBC Act (see Appendix E1 for details).

4.11.1 SELECTED OPTION

For the purpose of the Draft EIS, full supply of electricity from the NEM via an additional 275 kV transmission line from Port Augusta and full supply from an on-site combined cycle gas power plant have been assessed. It is also possible that both of these facilities could be developed to provide a hybrid solution, and, as such, assessments have been made and approval is sought for all three solutions.

The reasons for selecting these options over the other investigated alternatives are:

- the NEM provides the most reliable supply (with generally less than one outage per year for a duplicated transmission line)
- NEM supply is typically quickest to resume after a disruption to supply
- supply from the NEM has the lowest capital and operating cost of the options assessed
- the combination of both NEM and a combined cycle gas turbine (CCGT) power plant provides the highest level of certainty for a sustained electricity supply at Olympic Dam.

4.11.2 REASONS FOR REJECTING OTHER OPTIONS

Dedicated low carbon emission energy sources – wind and/or solar

Olympic Dam requires energy on a continuous, 24 hours a day, 7 days a week basis. Dedicated wind or solar generation at the scale and availability required by the Olympic Dam expansion are not currently available. Solar and wind energy technologies are at an early stage of market development and are unable to supply baseload power on a continuous basis. Accordingly, they are unsuitable for steady state power supply and their costs are generally higher than for competing conventional systems. The location of existing wind and solar energy sites in South Australia is shown on Figure 4.5.

BHP Billiton is currently studying options for supplementing the primary electricity supply with renewable or low emission energy sources. This will occur through the construction of a waste heat electrical generation plant (cogeneration) and sourcing renewable energy to power the desalination plant. BHP Billiton is also studying the feasibility of an on-site concentrated solar thermal plant and solar photovoltaic applications.

Dedicated low carbon emission energy sources – geothermal

Geothermal energy has potential to supply electricity to Olympic Dam, but is commercially unproven at the scale required. It is unlikely to pass this hurdle soon enough to become the primary source of supply to the expansion project, at least to meet the initial demand.

There are, however, commercial ventures investigating geothermal resources in South Australia (see Figure 4.5 for location of geothermal exploration licences). A private company currently holds exploration tenements within the extended Olympic Dam SML itself, where drilling has established the presence of heat anomalies.

The long life of the expansion project provides an opportunity in which future geothermal electricity could contribute a substantial proportion of the electricity demand, either through the NEM or under direct supply contract. BHP Billiton is receptive in principle to geothermal power and will continue to monitor the progress of the geological exploration and feasibility studies under way in South Australia.

4.12 HILTABA VILLAGE

Fourteen locations to the north, south and east of Roxby Downs were investigated as possible sites for Hiltaba Village (see Figure 4.6). The fully self-contained short-term workforce accommodation facility would cover approximately 60 ha and could accommodate up to 10,000 people during the peak construction period.

4.12.1 SELECTED OPTION

The selected location for Hiltaba Village is on the Andamooka Road, 17 km east of Roxby Downs, approximately midway between Roxby Downs and Andamooka. The reasons for choosing this locality are:

- the expressed views of residents in Roxby Downs and Andamooka to accommodate the construction workforce at a distance from the townships
- to reduce possible social impacts and disruption in Roxby Downs and Andamooka
- to reduce dust and noise impacts from establishing and operating the open pit mine
- it does not have the potential for significant impact on a matter of national environmental significance as defined in the EPBC Act (see Appendix E1 for details)
- the selected location is appropriate for co-locating the new airport and therefore assists in managing the transport logistics associated with the arrival and departure of personnel.

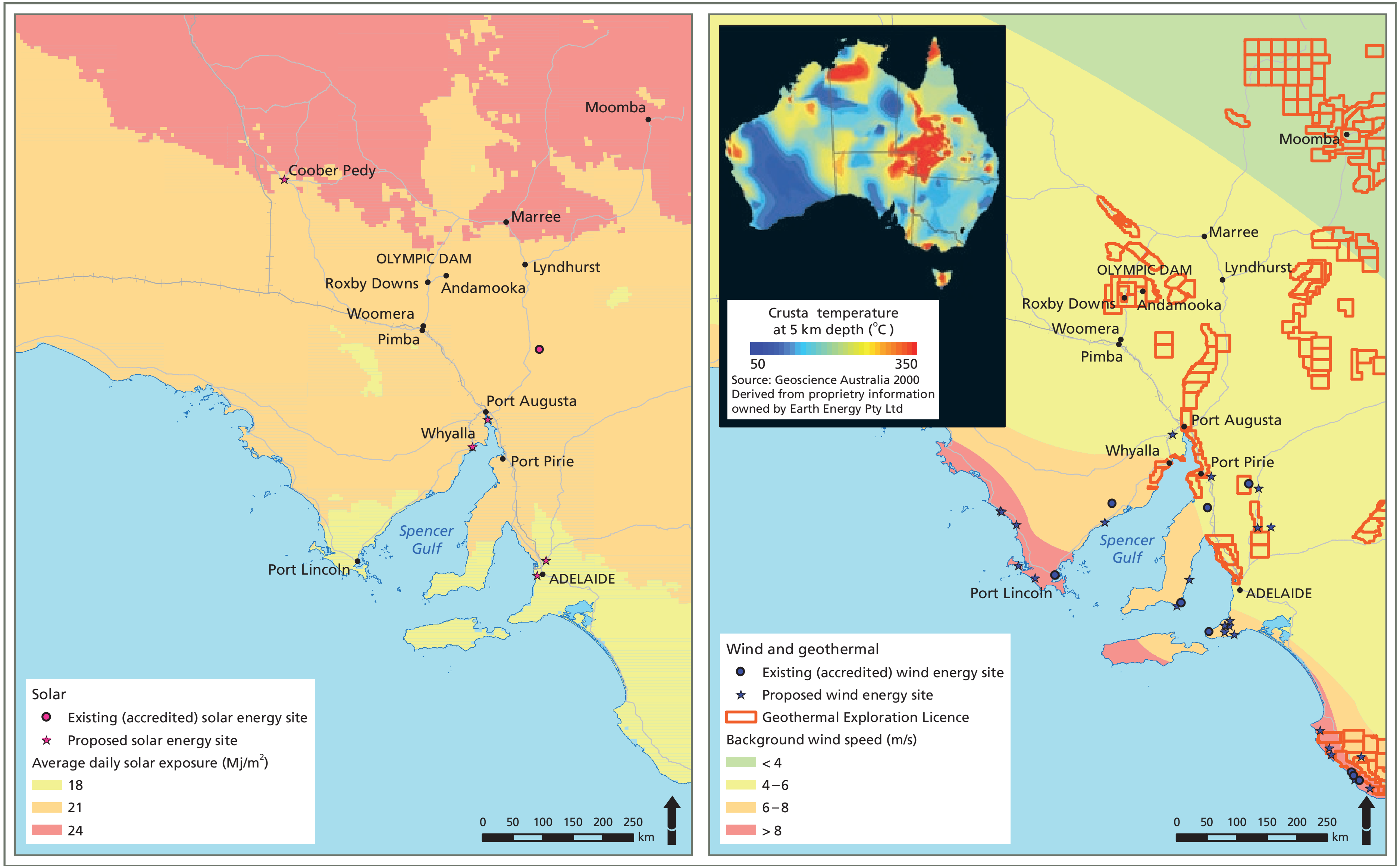


Figure 4.5 Alternative energy resources in South Australia

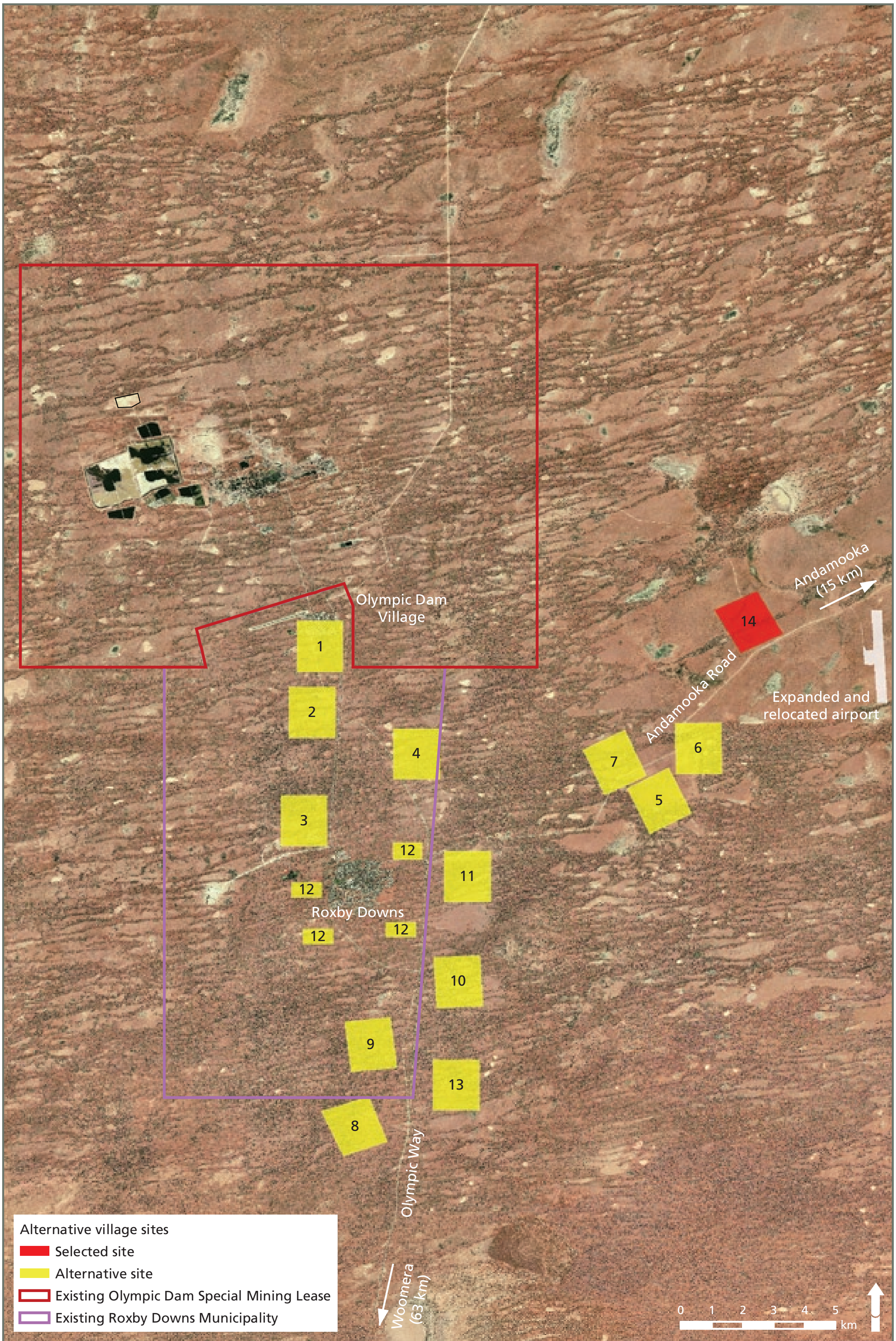


Figure 4.6 Hiltaba Village location options

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4.12.2 REASONS FOR REJECTING OTHER OPTIONS

The alternative locations were rejected because they did not meet one or more of the following criteria (see Table 4.2):

- would not constrain open pit operations by requiring residential dust and noise limits beyond the limit required for Roxby Downs
- would avoid known heritage sites, minimise the impact on native vegetation (particularly Cotton-bush habitat on gibber plains that may support a population of the EPBC Act listed Thick-billed Grasswren)
- would enable co-location with the proposed new airport
- would be located more than 5 km from Roxby Downs to reduce potential social impacts.

4.13 TRANSPORT OF MATERIALS

The primary drivers for the selection of the preferred transport option were safety and cost (both capital and operating expenses). The numbers of heavy vehicles that would be added to the road network to support the expansion were calculated, options to reduce the number of vehicles via bulk transport were identified, and a risk profile for road users was established (see Figure 4.7).

4.13.1 SELECTED OPTION

The selected option is to maximise the bulk transport of materials by rail, with some transport of materials to continue by road. This option comprises:

- a new 105 km rail spur from the existing rail network to Olympic Dam which would be operational by 2016 to reduce safety risks associated with the significantly increased traffic generation after 2016 (see Figure 4.7)
- a new road/rail intermodal facility at Pimba to maximise the transport of construction materials via the existing rail network before the rail spur is constructed
- a new landing facility, dedicated access corridor and pre-assembly yard near Port Augusta to enable the import of pre-assembled modules and prefabricated materials
- road transport of materials to Olympic Dam from the Pimba intermodal facility (prior to the rail spur) and from the pre-assembly yard along the Stuart Highway.

The locations of the Pimba intermodal facility, rail line and pre-assembly yard were chosen to maximise the use of existing facilities (e.g. the existing rail network to Pimba; a previously constructed rail embankment from Pimba to Woomera; and the pre-assembly yard, which is an extension of the same yard used for the 1997 Olympic Dam expansion).

The capital cost of the selected option is higher than the road only option, but would have lower long-term operating costs. The preferred option would not have a significant impact on a matter of national environmental significance as defined by the EPBC Act (see Appendix E1 for details).

4.13.2 REASONS FOR REJECTING ALL BY ROAD OPTION

The option to continue the existing method of transporting all materials by road was rejected because:

- it carries a higher safety risk from increased traffic volumes and therefore does not align with BHP Billiton's aspirational goal of Zero Harm
- it may become compromised by a shortage of truck drivers
- although it is considerably cheaper in terms of initial capital expense, the operating expenses may be higher.

Table 4.2 Criteria for Hiltaba Village site selection

Alternative sites for Hiltaba Village	Assessment criteria			
	Dust and noise	Heritage or native vegetation	Ability for co-location with new airport	Distance from Roxby Downs
Site 1	Did not meet			
Site 2	Did not meet			
Site 3	Did not meet	Did not meet		
Site 4	Did not meet			
Site 5		Did not meet		
Site 6		Did not meet		
Site 7	Did not meet			
Site 8			Did not meet	
Site 9			Did not meet	
Site 10			Did not meet	Did not meet
Site 11			Did not meet	Did not meet
Site 12 (split among four sites)		Did not meet	Did not meet	Did not meet
Site 13			Did not meet	
Site 14	Met	Met	Met	Met

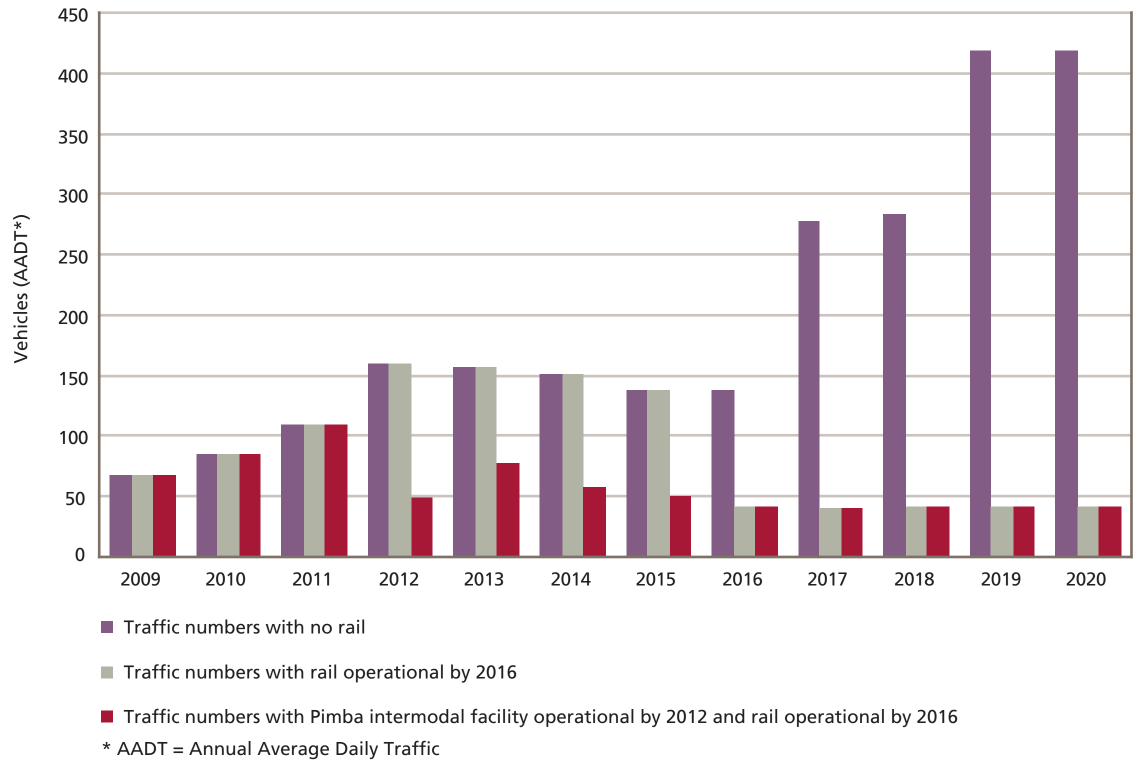


Figure 4.7 Traffic numbers reducing with rail and intermodal facility

4.14 LOCATION OF LANDING FACILITY

The preferred general locality for the landing facility is south of Port Augusta, as:

- it avoids the need to dredge a navigational channel in the gulf and impacts on mangroves
- it offers a relatively short distance to the Port Augusta pre-assembly yard and Olympic Dam
- there is deep water close (i.e. within 200 m) to shore and sufficient land for laydown and quarantine inspection
- it does not interfere with Australian Defence Department access to the Cultana Training Facility.

Several site options were assessed within this general locality (see Figure 4.8). Snapper Point, north of O'Connell Court, was selected (Site 1 on Figure 4.8) because it entailed:

- avoiding noise and visual impacts on a larger number of residences from the movement of large, slow-moving pre-assembled modules
- one of the lowest numbers of proximate residences at, and between, the landing facility and the Port Augusta pre-assembly yard
- site topography was suitable to construct the quarantine laydown area as required by the Australian Quarantine Inspection Service
- it had the least impact on the Cultana Training Area.

4.15 PORT LOCATION FOR IMPORT OF SULPHUR AND DIESEL

4.15.1 SELECTED OPTION

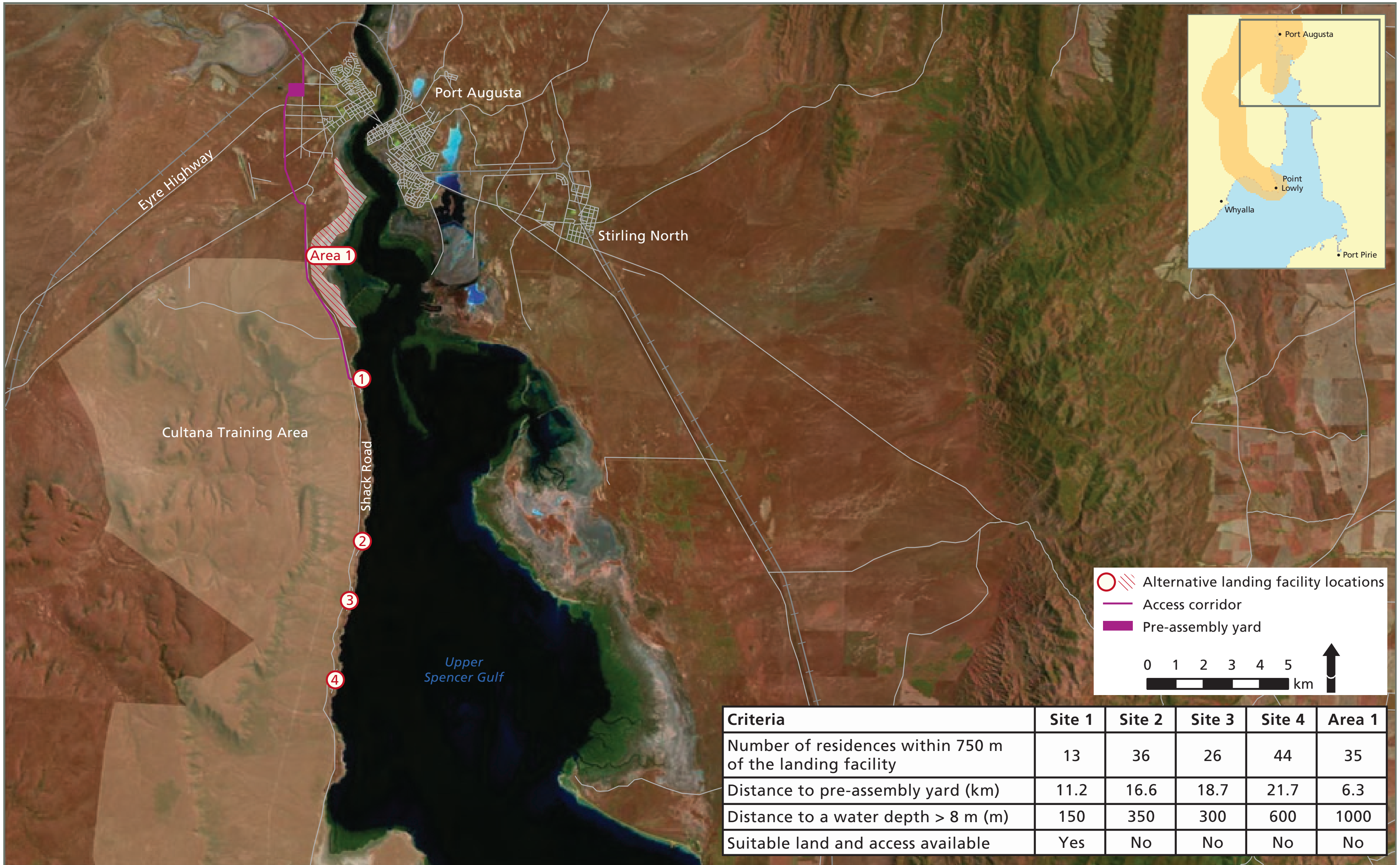
Olympic Dam currently imports sulphur and diesel via Port Adelaide. Although further from Olympic Dam than other South Australian ports, Port Adelaide remains the preferred option for the proposed expansion because:

- the large volume of sulphur (1.72 Mtpa) favours the efficiencies of large Panamax-class vessels and Siwertell discharge units to transfer sulphur containers from ship to wharf. Port Adelaide can accommodate both Panamax-class vessels and Siwertell discharge units
- the bulk terminal at Port Adelaide has access to a standard gauge rail line
- Port Adelaide can accept 30,000-tonne parcels of diesel, which is a convenient size for import and transfer
- this option does not have the potential to have a significant impact on matters of national environmental significance protected under the EPBC Act.

4.15.2 REASONS FOR REJECTING OTHER OPTIONS

Port Augusta and Port Pirie were rejected because:

- they do not currently have the capability to accommodate the required Panamax-class vessels, and dredging to deepen existing navigational channels would be required for the Panamax-class vessels, which carries with it higher operating costs



Criteria	Site 1	Site 2	Site 3	Site 4	Area 1
Number of residences within 750 m of the landing facility	13	36	26	44	35
Distance to pre-assembly yard (km)	11.2	16.6	18.7	21.7	6.3
Distance to a water depth > 8 m (m)	150	350	300	600	1000
Suitable land and access available	Yes	No	No	No	No

Figure 4.8 Landing facility location options

- the wharves, terminals and/or berthing facilities at these ports would need major upgrades and new materials handling equipment, resulting in higher capital costs.

Whyalla and Port Bonython were identified as opportunities for the import of sulphur and diesel. However, neither port currently has the capability to accommodate the preferred vessel (i.e. a Panamax-class vessel). Both locations currently have land and marine based constraints that could not immediately be resolved compared to the selected option. If, in the future, these issues can be overcome and BHP Billiton determines that it wishes to import sulphur and diesel from either of these ports, use of these ports would be subject to obtaining the relevant environmental and other consents from the Australian and South Australian governments. The use of these ports is not the subject of approval sought pursuant to the Draft EIS.

The implications of the alternative port locations on relevant matters under the EPBC Act are described in Appendix E1.

Interstate ports were rejected because they would entail higher costs of longer travel distances and additional rail stock.

4.16 OPTIMISATION INITIATIVES

BHP Billiton has identified several areas in which alternative methods or practices may be implemented in the future to improve the performance of the operation, including improved operability of the metallurgical plant, increased energy efficiency (at Olympic Dam and the accommodation facilities) and reduction of water use. BHP Billiton has already initiated research into these areas, including laboratory and pilot trials, modelling and other studies.

BHP Billiton will continue to investigate the benefits of these initiatives and identify further opportunities to optimise the efficiency of the Olympic Dam operation. Some of the more advanced optimisation projects are discussed in Sections 4.16.1 to 4.16.4. No approval is sought to implement these initiatives at this stage, but the appropriate approval processes would be followed if and when required.

4.16.1 MINING METHOD

Use of waste engine oil in blasting

The main blasting agent used at Olympic Dam is ANFO (ammonium nitrate and fuel oil). The fuel oil component is usually diesel, but waste lubrication oils from engines and other sources could be used to replace some of the diesel component, which would decrease diesel usage and greenhouse gas emissions.

Trolley assisted haul trucks

Trolley assist involves building overhead electricity ‘trolley’ lines to power haul trucks up the haul roads and out of the open pit at depth. The use of trolley assisted haul trucks would increase the speed of haulage, increase diesel engine life and reduce the amount of diesel usage and associated emissions.

Autonomous mining systems

The use of autonomous haul trucks, autonomous blast hole drilling and remotely controlled rope shovels is being investigated. Autonomous systems have the potential to deliver significant improvements in health and safety, risk management, operational reliability, reduced fuel consumption and economic return.

In-pit crushing and conveying of mine rock to the surface

BHP Billiton is investigating the use of a mobile in-pit crushing and conveying system for the removal of the upper benches of overburden. This system would crush and then convey mine rock to the surface and onto the rock storage facility (RSF), which would reduce the requirement for haulage by trucks.

In-pit ore crushing and conveying of ore to the surface

This requires the relocation of the primary ore crusher from the pit rim to the pit floor, substituting haulage via trucks with an electrically powered conveyor. This option could potentially reduce dust emissions and would significantly reduce the number of haul trucks required (and associated greenhouse gas generation), but is typically implemented when a final pit wall is established.

Alternative power supply for vehicles

The conversion of diesel powered haul trucks to liquefied natural gas (LNG) would allow for the substitution of 90% of diesel consumption. Although the technology has not been proven in larger engines, it is technically possible. BHP Billiton will continue to review advances in the technology until it has been proven in sufficiently large engine sizes.

BHP Billiton is also currently investigating alternative fuel sources for its light vehicle fleet at Olympic Dam, including the use of hybrid vehicles, biodiesel and LNG conversion.

Biodiesel is produced from domestic renewable resources, and has lower emissions compared to petroleum diesel. Biodiesel can be used in standard diesel engines in a blend (with petroleum diesel) of between 5% and 30%. While it appears technically viable, BHP Billiton is investigating the potential use of biodiesel at Olympic Dam, with particular focus on the security of supply, financial viability and environmental impacts.

4.16.2 PROCESSING OF ORE

Grinding technology

BHP Billiton is investigating technology to enable grinding configurations at Olympic Dam that would use less water and electricity, reuse water and increase the efficiency of the concentrator. Concepts under review include High Pressure Grinding Rolls (HPGR), the application of fine grinders to reduce the regrinding of ore in the main milling circuit, and microwaving ore to reduce the amount of grinding required.

Water use reduction through increased recycling of tailings liquor

The opportunity exists to generate additional recycled liquor from the tailings retention system. However, this requires further technology advances in the ability of the metallurgical plant to accept this liquor and continue to operate efficiently. If successful, this initiative has the potential to reduce overall water consumption.

Low-intensity leaching

Low-intensity leaching involves the reduction of leach temperature and acid tenor in the flotation leach tails process. Although this concept involves additional oxidant (sodium chlorate) and additional time needed for leaching, there is a considerable reduction in the quantities of acid used (and therefore in the quantities of sulphur to be transported). BHP Billiton is investigating the potential use of an alternative oxidant (other than sodium chlorate), which could make low-intensity leaching a feasible option.

Differential flotation

Differential flotation would enable the separation of copper bearing sulphides following the production of bulk copper mineral concentrate, to produce two concentrates with differing copper to sulphur (Cu/S) ratios depending on the sulphide involved. Differential flotation of the different sulphides would enable optimisation of the treatment of the different concentrates in the smelter.

Recovery of molybdenum and other metals

Initial tests indicate it may be possible to recover molybdenum and other metals from the ore body and produce a saleable product. Assessments of the ore body also indicate that the ore extracted from the proposed open pit during the first 10 years of production would contain elevated amounts of zinc. Further investigations into the recovery of molybdenum and other metals are continuing.

Heap leach

The feasibility of heap leaching of the lower-grade ore at Olympic Dam is under investigation. At this early stage, recoveries of copper and uranium from heap leaching appear too low, but this option continues to be investigated.

4.16.3 ELECTRICITY SUPPLY – SOLAR POWER

BHP Billiton recognises the solar resource at Olympic Dam and is investigating how best to increase the use of solar power. A pre-feasibility study undertaken in late 2007 and early 2008 by BP Alternative Energy determined, at a high level, that a 50 to 150 MWe concentrated solar thermal power station project was technically viable at Olympic Dam. In October 2008, BP Alternative Energy started a twelve month feasibility study to determine the commercial viability of the project.

BHP Billiton is also identifying suitable sites for the use of solar photovoltaic (PV) technology, including the traditional PV cells as well as building-integrated PV.

4.16.4 TRANSPORT OF MATERIALS

Rail spur passing loop

Once the rail spur to Olympic Dam is fully operational, a passing loop between Pimba and Olympic Dam would be investigated and constructed if required to increase the operational capacity of train services.

Backloading of concentrate wagons with sulphur

The proposed expansion at full operating capacity would have similar volumes of sulphur to be imported and concentrate to be exported. As such, additional cost benefits may be realised with the inclusion of an import facility for sulphur to be co-located with the planned export facility for concentrate. Being located at the same port facility provides the opportunity to utilise rail wagons on a round trip basis between the port and Olympic Dam rather than the present configuration, which has different rail solutions for the two products and therefore movements of empty wagons on the return trip.