Australian Government

BIOREGIONAL ASSESSMENTS

PROVIDING SCIENTIFIC WATER RESOURCE INFORMATION ASSOCIATED WITH COAL SEAM GAS AND LARGE COAL MINES

Description of the water-dependent asset register for the Arckaringa subregion

Product 1.3 for the Arckaringa subregion from the Lake Eyre Basin Bioregional Assessment

18 November 2015

A scientific collaboration between the Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia

The Bioregional Assessment Programme

The Bioregional Assessment Programme is a transparent and accessible programme of baseline assessments that increase the available science for decision making associated with coal seam gas and large coal mines. A bioregional assessment is a scientific analysis of the ecology, hydrology, geology and hydrogeology of a bioregion with explicit assessment of the potential direct, indirect and cumulative impacts of coal seam gas and large coal mining development on water resources. This Programme draws on the best available scientific information and knowledge from many sources, including government, industry and regional communities, to produce bioregional assessments that are independent, scientifically robust, and relevant and meaningful at a regional scale.

The Programme is funded by the Australian Government Department of the Environment. The Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia are collaborating to undertake bioregional assessments. For more information, visit http://www.bioregionalassessments.gov.au.

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Cover photograph

Hookeys waterhole in Neales catchment, SA. November 2009

Credit: Dale McNeil (South Australian Research & Development Institute)

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Introduction

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) was established to provide advice to the federal Minister for the Environment on potential water-related impacts of coal seam gas (CSG) and large coal mining developments.

Bioregional assessments (BAs) are one of the key mechanisms to assist the IESC in developing this advice so that it is based on best available science and independent expert knowledge. Importantly, technical products from BAs are also expected to be made available to the public, providing the opportunity for all other interested parties, including government regulators, industry, community and the general public, to draw from a single set of accessible information. A BA is a scientific analysis, providing a baseline level of information on the ecology, hydrology, geology and hydrogeology of a bioregion with explicit assessment of the potential direct, indirect and cumulative impacts of CSG and coal mining development on water resources.

The IESC has been involved in the development of *Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources* (the BA methodology; Barrett et al., 2013) and has endorsed it. The BA methodology specifies how BAs should be undertaken. Broadly, a BA comprises five components of activity, as illustrated in Figure 1. Each BA will be different, due in part to regional differences, but also in response to the availability of data, information and fit-for-purpose models. Where differences occur, these are recorded, judgments exercised on what can be achieved, and an explicit record is made of the confidence in the scientific advice produced from the BA.

The Bioregional Assessment Programme

The Bioregional Assessment Programme is a collaboration between the Department of the Environment, the Bureau of Meteorology, CSIRO and Geoscience Australia. Other technical expertise, such as from state governments or universities, is also drawn on as required. For example, natural resource management groups and catchment management authorities identify assets that the community values by providing the list of water-dependent assets, a key input.

The Technical Programme, part of the Bioregional Assessment Programme, will undertake BAs for the following bioregions and subregions:

- the Galilee, Cooper, Pedirka and Arckaringa subregions, within the Lake Eyre Basin bioregion
- the Maranoa-Balonne-Condamine, Gwydir, Namoi and Central West subregions, within the Northern Inland Catchments bioregion
- the Clarence-Moreton bioregion
- the Hunter and Gloucester subregions, within the Northern Sydney Basin bioregion
- the Sydney Basin bioregion
- the Gippsland Basin bioregion.

Technical products (described in a later section) will progressively be delivered throughout the Programme.

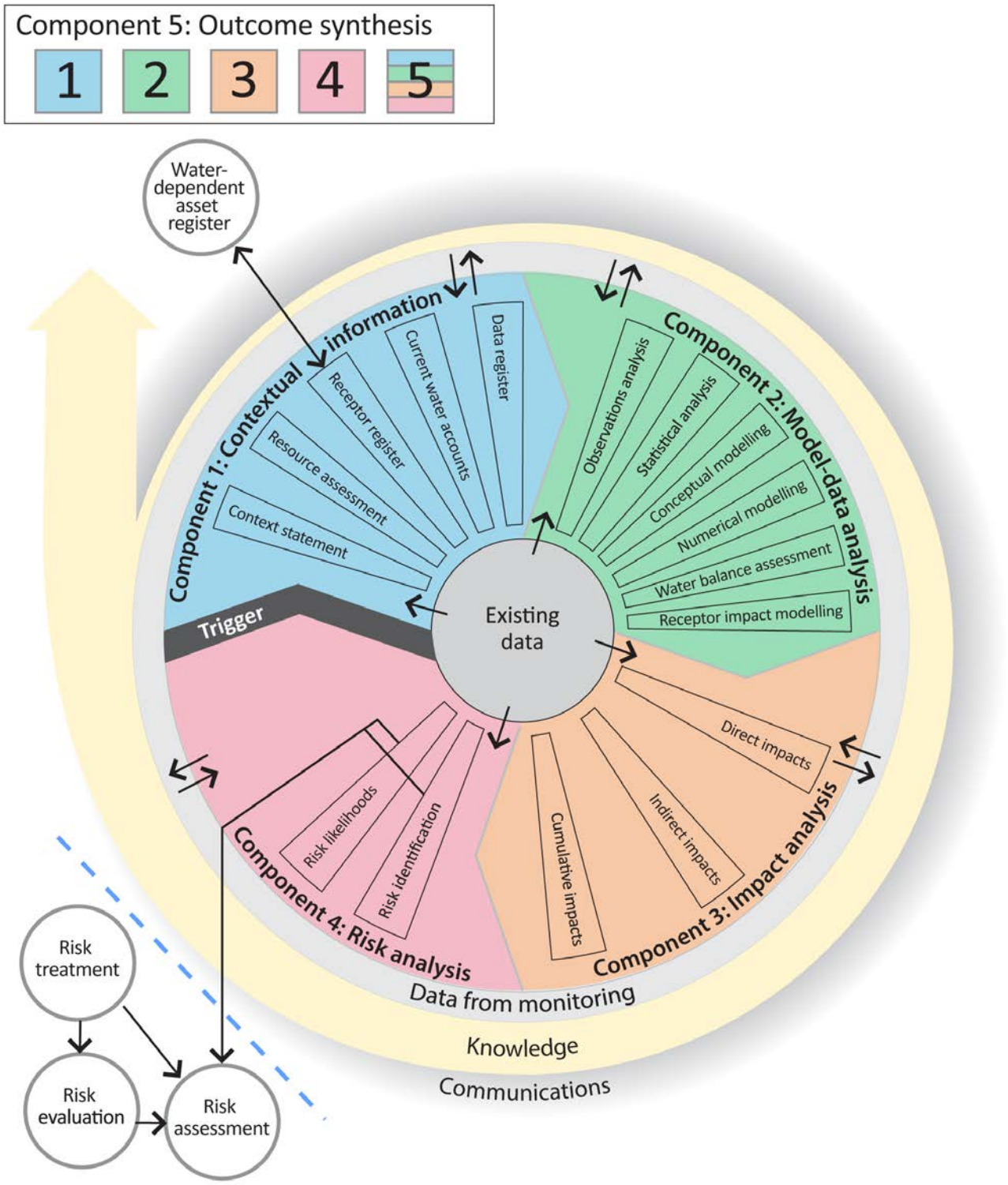


Figure 1 Schematic diagram of the bioregional assessment methodology

The methodology comprises five components, each delivering information into the bioregional assessment and building on prior components, thereby contributing to the accumulation of scientific knowledge. The small grey circles indicate activities external to the bioregional assessment. Risk identification and risk likelihoods are conducted within a bioregional assessment (as part of Component 4) and may contribute activities undertaken externally, such as risk evaluation, risk assessment and risk treatment. Source: Figure 1 in Barrett et al. (2013), © Commonwealth of Australia

Methodologies

For transparency and to ensure consistency across all BAs, submethodologies have been developed to supplement the key approaches outlined in the *Methodology for bioregional assessments of the impact of coal seam gas and coal mining development on water resources* (Barrett et al., 2013). This series of submethodologies aligns with technical products as presented in Table 1. The submethodologies are not intended to be 'recipe books' nor to provide step-by-step instructions; rather they provide an overview of the approach to be taken. In some instances, methods applied for a particular BA may need to differ from what is proposed in the submethodologies – in this case an explanation will be supplied. Overall, the submethodologies are intended to provide a rigorously defined foundation describing how BAs are undertaken.

Table 1 Methodologies and associated technical products listed in Table 2

Code	Proposed title	Summary of content	Associated technical product
M01	*Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources*	A high-level description of the scientific and intellectual basis for a consistent approach to all bioregional assessments	All
M02	*Compiling water-dependent assets*	Describes the approach for determining water-dependent assets	1.3 Description of the water-dependent asset register
M03	*Assigning receptors and impact variables to water-dependent assets*	Describes the approach for determining receptors associated with water-dependent assets	1.4 Description of the receptor register
M04	*Developing a coal resource development pathway*	Specifies the information that needs to be collected and reported in product 1.2 (i.e. known coal and coal seam gas resources as well as current and potential resource developments). Describes the process for determining the coal resource development pathway (reported in product 2.3)	1.2 Coal and coal seam gas resource assessment 2.3 Conceptual modelling
M05	*Developing the conceptual model for causal pathways*	Describes the development of the conceptual model for causal pathways, which summarises how the 'system' operates and articulates the links between coal resource developments and impacts on receptors	2.3 Conceptual modelling
M06	*Surface water modelling*	Describes the approach taken for surface water modelling across all of the bioregions and subregions. It covers the model(s) used, as well as whether modelling will be quantitative or qualitative.	2.6.1 Surface water numerical modelling
M07	*Groundwater modelling*	Describes the approach taken for groundwater modelling across all of the bioregions and subregions. It covers the model(s) used, as well as whether modelling will be quantitative or qualitative. It also considers surface water – groundwater interactions, as well as how the groundwater modelling is constrained by geology.	2.6.2 Groundwater numerical modelling

Code	Proposed title	Summary of content	Associated technical product
M08	*Receptor impact modelling*	Describes how to develop the receptor impact models that are required to assess the potential impacts from coal seam gas and large coal mining on receptors. Conceptual, semi-quantitative and quantitative numerical models are described.	2.7 Receptor impact modelling
M09	*Propagating uncertainty through models*	Describes the approach to sensitivity analysis and quantifying uncertainty in the modelled hydrological response to coal and coal seam gas development	2.3 Conceptual modelling 2.6.1 Surface water numerical modelling 2.6.2 Groundwater numerical modelling 2.7 Receptor impact modelling
M10	*Risk and cumulative impacts on receptors*	Describes the process to identify and analyse risk	3 Impact analysis 4 Risk analysis
M11	*Hazard identification*	Describes the process to identify potential water-related hazards from coal and coal seam gas development	2 Model-data analysis 3 Impact analysis 4 Risk analysis
M12	*Fracture propagation and chemical concentrations*	Describes the likely extent of both vertical and horizontal fractures due to hydraulic stimulation and the likely concentration of chemicals after production of coal seam gas	2 Model-data analysis 3 Impact analysis 4 Risk analysis

Each submethodology is available online at http://www.bioregionalassessments.gov.au. Submethodologies might be added in the future.

Technical products

The outputs of the BAs include a suite of technical products variously presenting information about the ecology, hydrology, hydrogeology and geology of a bioregion and the potential direct, indirect and cumulative impacts of CSG and coal mining developments on water resources, both above and below ground. Importantly, these technical products are available to the public, providing the opportunity for all interested parties, including community, industry and government regulators, to draw from a single set of accessible information when considering CSG and large coal mining developments in a particular area.

The information included in the technical products is specified in the BA methodology. Figure 2 shows the information flow within a BA. Table 2 lists the content provided in the technical products, with cross-references to the part of the BA methodology that specifies it. The red rectangles in both Figure 2 and Table 2 indicate the information included in this technical product.

This technical product is delivered as a report (PDF). Additional material is also provided, as specified by the BA methodology:

- all unencumbered data syntheses and databases
- unencumbered tools, model code, procedures, routines and algorithms
- unencumbered forcing, boundary condition, parameter and initial condition datasets
- the workflow, comprising a record of all decision points along the pathway towards completion of the BA, gaps in data and modelling capability, and provenance of data.

The PDF of this technical product, and the additional material, are available online at http://www.bioregionalassessments.gov.au.

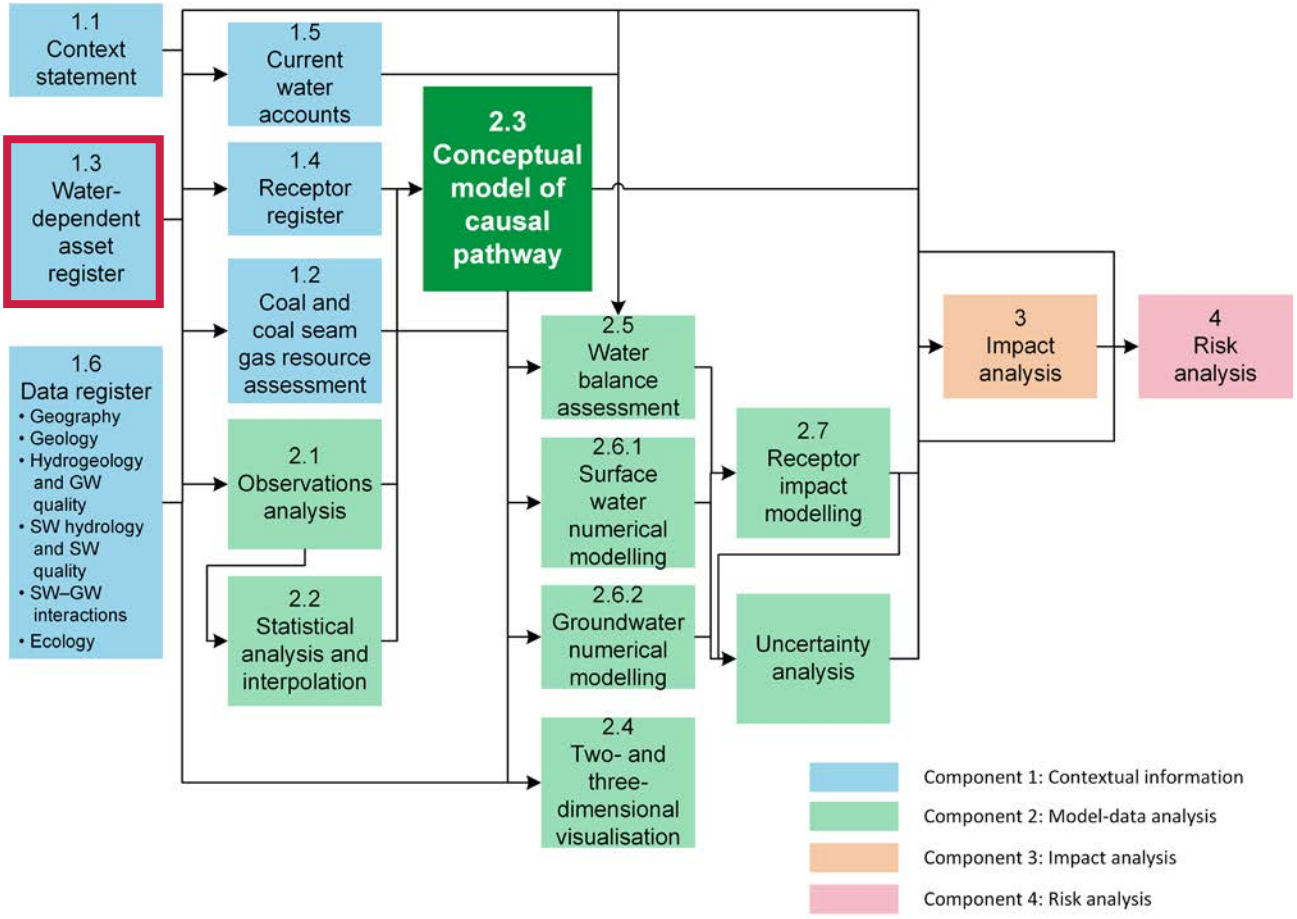


Figure 2 The simple decision tree indicates the flow of information through a bioregional assessment

The red rectangle indicates the information included in this technical product.

Table 2 Technical products delivered by the Lake Eyre Basin Bioregional Assessment

For each subregion in the Lake Eyre Basin Bioregional Assessment, technical products are delivered online at http://www.bioregionalassessments.gov.au, as indicated in the 'Type' column[a]. Other products – such as datasets, metadata, data visualisation and factsheets – are provided online.

Component	Product code	Title	Section in the BA methodology[b]	Type[a]
Component 1: Contextual information for the Arckaringa subregion	1.1	Context statement	2.5.1.1, 3.2	PDF, HTML
	1.2	Coal and coal seam gas resource assessment	2.5.1.2, 3.3	Cross-reference
	1.3	Description of the water-dependent asset register	2.5.1.3, 3.4	PDF, HTML, register
	1.4	Description of the receptor register	2.5.1.4, 3.5	Cross-reference
	1.5	Current water accounts and water quality	2.5.1.5	Cross-reference
	1.6	Data register	2.5.1.6	Register
Component 2: Model-data analysis for the Arckaringa subregion	2.1-2.2	Observations analysis, statistical analysis and interpolation	2.5.2.1, 2.5.2.2	Cross-reference
	2.3	Conceptual modelling	2.5.2.3, 4.3	Cross-reference
	2.5	Water balance assessment	2.5.2.4	Cross-reference
	2.6.1	Surface water numerical modelling	4.4	Cross-reference
	2.6.2	Groundwater numerical modelling	4.4	Cross-reference
	2.7	Receptor impact modelling	2.5.2.6, 4.5	Not produced
Component 3: Impact analysis for the Arckaringa subregion	3-4	Impact analysis	5.2.1	Cross-reference
Component 4: Risk analysis for the Arckaringa subregion		Risk analysis	2.5.4, 5.3	
Component 5: Outcome synthesis for the Lake Eyre Basin bioregion	5	Outcome synthesis	2.5.5	PDF, HTML

aThe types of products are as follows:

- 'PDF' indicates a PDF document that is developed by the Lake Eyre Basin Bioregional Assessment using the structure, standards, and look and feel specified by the programme.
- 'HTML' indicates the same content as in the PDF document, but delivered as webpages.
- 'Register' indicates controlled lists that are delivered using a variety of formats as appropriate.
- 'Cross-reference' indicates material that does not use the same structure, standards, and look and feel specified by the programme. This material is typically developed externally or through aligned research projects funded by the Department of the Environment. A webpage links to this material and explain how it fits into the Assessment.
- 'Not produced' indicates that the product was not developed. A webpage explains why and points to relevant submethodologies (Table 1).

bMethodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources (Barrett et al., 2013)

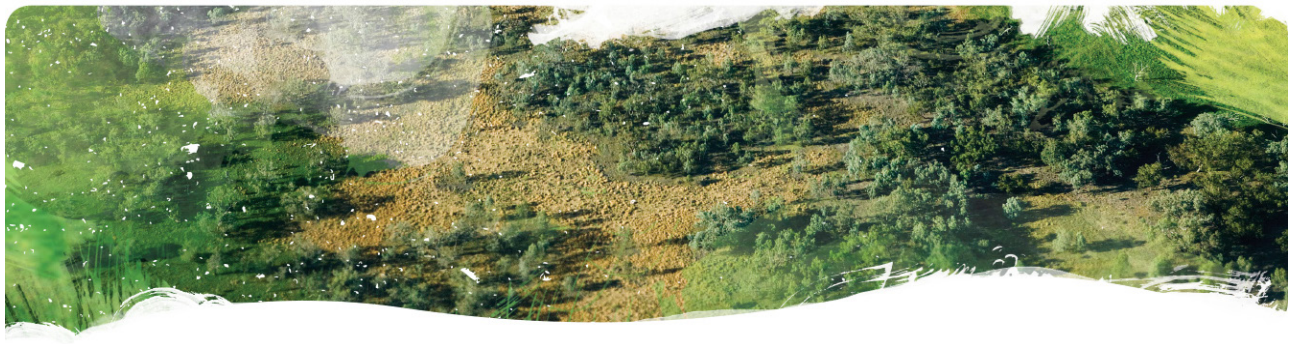
About this technical product

The following notes are relevant only for this technical product.

- All reasonable efforts were made to provide all material under a Creative Commons Attribution 3.0 Australia Licence.
- All maps created as part of this BA for inclusion in this product used the Albers equal area projection with a central meridian of 140.0° East for the Lake Eyre Basin bioregion and two standard parallels of –18.0° and –36.0°.
- Contact bioregionalassessments@bom.gov.au to access metadata (including copyright, attribution and licensing information) for all datasets cited or used to make figures in this product. At a later date, this information, as well as all unencumbered datasets, will be published online.
- The citation details of datasets are correct to the best of the knowledge of the Bioregional Assessment Programme at the publication date of this product. Readers should use the hyperlinks provided to access the most up-to-date information about these data; where there are discrepancies, the information provided online should be considered correct. The dates used to identify Bioregional Assessment Source Datasets are the dataset's published date. Where the published date is not available, the last updated date or created date is used. For Bioregional Assessment Derived Datasets, the created date is used.

References

Barrett DJ, Couch CA, Metcalfe DJ, Lytton L, Adhikary DP and Schmidt RK (2013) Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources. A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment. Department of the Environment, Australia. Viewed 19 January 2016, http://www.iesc.environment.gov.au/publications/methodology-bioregional-assessments-impacts-coal-seam-gas-and-coal-mining-development-water.



1.3 Description of the water-dependent asset register for the Arckaringa subregion

A water-dependent asset has a particular meaning for bioregional assessments; it is an asset potentially impacted by changes in groundwater and/or surface water due to coal or coal seam gas development. Some ecological assets solely depend on incident rainfall and will not be considered as water dependent if evidence does not support a linkage to groundwater or surface water.

This product describes water-dependent assets that have been identified in the bioregional assessment and are listed in the water-dependent asset register (available at http://data.bioregionalassessments.gov.au/product/LEB/ARC/1.3).

1.3.1 Methods

Summary

The water-dependent asset register described in this report is a list of water-dependent assets identified for the bioregional assessment (BA) of the Arckaringa subregion. This section details the specific implementation to the Arckaringa subregion of methods described in the companion submethodology M02 for compiling water-dependent assets (Mount et al., 2015).

The methods involved (i) nominating and collating different groups of assets, (ii) determining the preliminary assessment extent (PAE) for the Arckaringa subregion, (iii) determining water dependency based upon multiple lines of evidence (including literature, remote sensing data and available mapping) and (iv) developing and compiling the water-dependent asset register.

The asset list for the Arckaringa subregion, prior to assessment of water dependence, contains 2373 assets that intersect the Arckaringa PAE, comprising 2239 ecological assets, 47 economic assets and 87 sociocultural assets.

1.3.1.1 Background and context

This product presents information about the water-dependent asset register for the Arckaringa subregion. The name of the dated snapshot of the asset register this description refers to is 'Water-dependent asset register and asset list for Arckaringa subregion on 27 August 2015' (available at Sparrow et al., 2015). The point-of-truth version of the asset register that this snapshot was extracted from resides in the asset database (Bioregional Assessment Programme, Dataset 1). The asset database and the water-dependent asset register can be updated so a more current version might be available at http://data.bioregionalassessments.gov.au/product/LEB/ARC/1.3.

Development of the register used methods and processes defined and outlined in the companion submethodology M02 (as listed in Table 1) for compiling water-dependent assets (Mount et al., 2015); their specific application to the Arckaringa subregion is described in the following sections.

An *asset* is an entity that has value to the community and, for BA purposes, is associated with a subregion or bioregion. Technically, an asset is a store of value and may be managed and/or used to maintain and/or produce further value. Each asset will have many values associated with it and they can be measured from a range of perspectives; for example, the values of a wetland can be measured from ecological, sociocultural and economic perspectives. A *bioregion* is a geographic land area within which coal seam gas (CSG) and/or coal mining developments are taking place, or could take place, and for which BAs are conducted. A *subregion* is an identified area wholly contained within a bioregion.

A *water-dependent asset* has a particular meaning for BAs; it is an asset potentially impacted, either positively or negatively, by changes in the groundwater and/or surface water regime due to coal resource development. Some assets are solely dependent on incident rainfall and will not be considered as water dependent if evidence does not support a linkage to groundwater or surface water.

The *water-dependent asset register* is a simple and authoritative listing of the assets within the *preliminary assessment extent* (PAE) (discussed in Section 1.3.1.3) that are potentially subject to water-related impacts. A PAE is the geographic area associated with a bioregion or subregion in which the potential water-related impact of coal resource development on assets is assessed. The compiling of the asset register is the first step to identifying and analysing potentially impacted assets, which is the goal of the overall BA.

The asset source data are compiled into an *asset database*, including the geographic location, which are designated as *elements* (individual spatial features – points, lines and polygons) and *assets* (combinations of one or more elements). During the compilation process, assets are classified into three groups: (i) ecological, (ii) economic and (iii) sociocultural. Many assets are obtained from state and national databases and an important group of assets is provided by natural resource management organisations (NRMs) via the BA-purpose-built *Water Asset Information Tool* (WAIT) database.

The *asset list* is created through selection of assets in the asset database that occur within the PAE. The assets in the asset list that pass the BA water-dependency test are then 'registered' in the water-dependent asset register. A preliminary version of the asset register is presented to experts and organisations with local knowledge at organised workshops. Feedback is sought about whether the asset register is complete and correct; appropriate amendments are then made. It is at this stage – when assets have been selected using the PAE and the amended water-dependent assets have been recorded in the database – that the water-dependent asset register is complete for the purposes of producing product 1.3. Note, however, that the addition of new assets to the asset database, or a review of the status of existing assets in the database will mean that the asset register may be updated. As this has implications for other BA components, any updates must be documented and only be done with approval and tight version control. The product 1.3 will not be updated or republished as part of BAs but an updated version of the asset register (derived from the asset database) may be published at the same time as other products, for example, those associated with Component 3: Impact analysis (Figure 1 and Figure 2).

Following development of the asset register, the connection of the registered assets to coal resource development is assessed using ‘materiality’ tests and, if potentially subject to water-related impacts, assigned *receptors* (after Barrett et al., 2013). A receptor is a point in the landscape where water-related impacts on assets are measured and/or estimated. The approach to assigning receptors and impact variables to water-dependent assets is described in the companion submethodology M03 (as listed in Table 1) for assigning receptors to water-dependent assets (O’Grady et al. 2015).

1.3.1.2 Compiling assets and developing the water-dependent asset register

1.3.1.2.1 Ecological assets

One natural resource management organisation (NRM) nominated assets through contribution of data to the Water Asset Information Tool (WAIT) database (Australian Government Department of the Environment, Dataset 2). These NRM-nominated assets were added to the asset database (Table 3). There were no NRM-nominated assets in the NT.

Additional assets were nominated from analysis of data provided by national, state and regional databases (Table 4). These datasets included:

- areas with various designations of formal conservation at national or state level
- ecosystem types with a threatened status recognised by national legislation
- potential distributions of species with a threatened status recognised by national legislation
- previously identified water-dependent ecosystem types or water-related topographic features, nominated regardless of any designated conservation status.

Table 3 Natural resource management organisations that contributed data to the Water Asset Information Tool database for the Arckaringa subregion

Organisation	Description in asset register	Elements	Assets (asset list)
SA Arid Lands Natural Resources Management Board	WAIT_SA	12,409	511
Total		12,409	511

Data: Australian Government Department of the Environment (Dataset 2)

Table 4 Federal, state and regional data sources for ecological assets in the Arckaringa subregion

Dataset[a]	Dataset citation	Elements	Assets (asset list)
Australian Hydrological Geospatial Fabric version 2.1.1	Bureau of Meteorology (Dataset 3)	700	15
Collaborative Australian Protected Areas Database (CAPAD)	Australian Government Department of the Environment (Dataset 4)	13	13
Directory of Important Wetlands in Australia (DIWA) Spatial Database	Australian Government Department of the Environment (Dataset 5)	2,281	3
Great Artesian Basin Groundwater Recharge	Geoscience Australia (Dataset 6)	97	5
National Groundwater Dependent Ecosystems Atlas	Bureau of Meteorology (Dataset 7)	49,254	1,260
Birds Australia Important Bird Areas (IBA)	Birds Australia (Dataset 8)	3	3
Lake Eyre Basin Rockholes and Waterholes in Queensland	Queensland Department of Environment and Resource Management (Dataset 9)	1	1
Threatened ecological communities listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)	Australian Government Department of the Environment (Dataset 10)	209	1
Threatened species listed under the EPBC Act	Australian Government Department of the Environment (Dataset 11)	624	19
Northern Territory - Lake Eyre Basin - Wetlands Mapping	Northern Territory Department of Natural Resources, Environment, the Arts and Sport (Dataset 12)	108	1

Dataset[a]	Dataset citation	Elements	Assets (asset list)
SA Lake Eyre Basin Aquatic Ecosystems Mapping and Classification	South Australian Department of Environment, Water and Natural Resources (Dataset 13)	10,553	55
SA Wetland Groundwater Dependent Ecosystem Classification	South Australian Department of Environment, Water and Natural Resources (Dataset 14)	10,819	351
Total		74,662	1,727

[a]The asset database (Bioregional Assessment Programme, Dataset 1) is a collation of all these source datasets. Some assets may be captured in multiple databases. These replicates are retained in the asset register as boundaries may differ between databases.

The asset database includes a wide range of information about each asset, including unique asset identifier (AID), name, type and geographic location. Geographic location is specified as 'shapes' in the sense of geographic information systems (GIS). A shape may be a polygon (for an area of land), a line (for a linear feature such as a watercourse) or a point (for a specific location whose area is smaller than the areal resolution of the geographic information (e.g. a spring). Many nominated assets are composed of several geographic parts. For example, a national park may comprise several blocks of land separated by road or railway reserves, the potential habitat of a threatened species of bird may include patches of remnant habitat separated by agricultural land, and the potential habitat of a threatened species of fish may be restricted to the artesian springs scattered widely across a landscape. To accommodate assets composed of many parts, the asset database specifies each shape as an 'element' and one or more elements are then grouped to create assets. A detailed description of the process for classifying and aggregating elements to assets is presented in the companion submethodology M02 (as listed in Table 1) for compiling water-dependent assets (Mount et al., 2015).

A preliminary version of the asset list, along with associated maps and data, was presented to experts and organisations with local knowledge at workshops in Adelaide in March 2015, for comment and feedback. The meeting was attended by representatives from the South Australian Department of the Environment, Water and Natural Resources (DEWNR), Outback Communities Authority and South Australian Arid Lands Natural Resource Management Board. The attendees were given two weeks to review the asset list and preliminary assessments of water dependence, and to return comments and suggestions.

1.3.1.2.2 Economic assets

As described in the companion submethodology M02 (as listed in Table 1) for compiling water-dependent assets (Mount et al., 2015), formal economic assets are classed as either a 'basic water right' (stock and domestic) or a 'water access right' in the BA asset classification (subclass level):

- basic water right (stock and domestic) – this is the right to take water for domestic and stock purposes only. A basic right for 'take of groundwater' requires approval for any works that may be involved (e.g. a bore), but does not require a licence for the extraction of groundwater. A basic right for 'take of surface water' does not require approval for any works or for the extraction of surface water.

- water access right – this requires a licence both for the works and the extraction of the water. The extraction of the water can be for a range of purposes including irrigation, commercial, industrial, farming, dewatering, mining and intensive agriculture.

Licensing data were sourced from the DEWNR and the Northern Territory Department of Land Resource Management (DLRM) (Table 5).

Within the asset database, every 'water access right' and 'basic water right (stock and domestic)' is an element, and elements are grouped by type and spatial location (according to water management zones or areas) to create assets.

Two other, less formal subclasses of economic assets occur in the Arckaringa subregion:

- groundwater features used for water supply
- water supply and monitoring infrastructure.

Assets that are classed as 'groundwater features used for a water supply' were nominated by the Northern Territory Department of Land Resource Management (DLRM). Assets that are classed as 'water supply and monitoring infrastructure' were nominated through datasets from the Bureau of Meteorology and SA Arid Lands Natural Resources Management Board (SA WAIT data) (Table 5).

Table 5 Data sources for economic assets in the Arckaringa subregion

Dataset[a]	Dataset citation	Elements	Assets (asset list)
National Groundwater Information System version 1.2 (NGIS)	Bureau of Meteorology (Dataset 15)	6826	5
South Australia groundwater licensing from the water management system (bore locations)	South Australian Department of Environment, Water and Natural Resources (Dataset 16)	1	1
South Australia groundwater licensing from the water management system (areas around wells)	South Australian Department of Environment, Water and Natural Resources (Dataset 17)	67	2
South Australian WAIT data	Australian Government Department of the Environment (Dataset 2)	113	37
NT groundwater management units in the Great Artesian Basin	Northern Territory Department of Land Resource Management (Dataset 18)	2	2
Total		7009	47

[a]The asset database (Bioregional Assessment Programme, Dataset 1) is a collation of all these source datasets. Some assets may be captured in multiple databases. These replicates are retained in the asset register as boundaries may differ between databases.

1.3.1.2.3 Sociocultural assets

Sociocultural assets were sourced from the Australian Heritage Database (Australian Government Department of the Environment, Dataset 19, Dataset 20), which includes assets sourced from the National Heritage List and the Register of the National Estate.

In the Arckaringa subregion, the Bioregional Assessment Programme has funded the DEWNR to research cultural values associated with water assets, including Indigenous values. Reports from this study will be available at the Bioregional Assessment website (http://www.bioregionalassessments.gov.au) when finalised.

Table 6 Data sources from the Australian Heritage Database and Water Asset Information Tool database for sociocultural assets in the Arckaringa subregion

Dataset[a]	Dataset citation	Elements	Assets (asset list)
National Heritage List (NHL)	Australian Government Department of the Environment (Dataset 19)	4	4
Register of the National Estate (RNE)	Australian Government Department of the Environment (Dataset 19)	76	76
South Australian WAIT data	Australian Government Department of the Environment (Dataset 2)	7	7
Total		87	87

[a]The asset database (Bioregional Assessment Programme, Dataset 1) is a collation of all these source datasets. Some assets may be captured in multiple databases. These replicates are retained in the asset register as boundaries may differ between databases.

1.3.1.2.4 Duplicated or overlapping assets

Some specific areas within the Arckaringa PAE were nominated several times from different databases. For example, Kati Thanda – Lake Eyre and the immediate surrounding areas (in the eastern part of the PAE) were nominated as:

- a protected area (Collaborative Australian Protected Areas Database; CAPAD)
- an important wetland (*A directory of important wetlands in Australia*; DIWA)
- an Important Bird Area (Birds Australia)
- an area of heritage significance on both the National Heritage List and the Register of the National Estate (NHL and RNE)
- a groundwater-dependent ecosystem (SA wetland GDE classification)
- an NRM asset (WAIT database).

Likewise, some assets sourced from different datasets overlie each other, as they consider slightly different aspects of the same geographic area. For example, a national park may include springs, wetlands, and groundwater-dependent woodlands, and therefore the park may partially overlap assets describing:

- areas of heritage significance to the Register of the National Estate (RNE)
- groundwater-dependent ecosystems (GDEs)

- threatened ecological community distributions listed in the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- potential habitats of federal or state-listed threatened species.

Duplicate and overlapping assets were treated as entirely separate assets for the purposes of compiling the register of water-dependent assets for the Arckaringa subregion. Such an approach meant that no judgment need be made of the priority of one asset or asset type over another asset or asset type, and thereby that equal respect and attention was paid to all stakeholders' asset nominations and contributed databases.

1.3.1.3 Determining the preliminary assessment extent

The development of the PAE for the Arckaringa subregion was carried out by South Australian Department of Environment, Water and Natural Resources and only a summary of their work is provided in this section.

The following methodology was used to formulate the Arckaringa PAE:

- The geological Arckaringa Basin boundary and the mapped areas of economic coal beds and lodged exploration licences (obtained from SA Department of State Development (DSD)) were used as the starting point for calculations.
- Coal beds outside of Arckaringa Basin were excluded from consideration.
- Potential for mining related water diversions were excluded from the assessment.
- A potentiometric surface was generated for the Great Artesian Basin (GAB) aquifer (Cadna-owie Formation – Algebuckina Sandstone and equivalents) for the SA and NT portions of the GAB.
- The extent of potential groundwater drawdown was assumed to be 210 km around coal beds, based upon DEWNR conceptual modelling undertaken previously for the Pedirka Basin. Modelling of the Arckaringa Basin had not been completed at the time of the determination of the Arckaringa PAE.
- The 210 km drawdown extent was applied in a northerly and easterly direction from coal beds within the basin.
- Inferred 210 km groundwater drawdown extent assumes potential for up to a 50-year life of mine (LOM) and large scale mining operations.
- Western and southern boundaries follow the GAB and Arckaringa Basin boundaries taking the further boundary from coal beds to identify potential groundwater connectivity (i.e. Arckaringa Basin formations were excluded from the PAE where outside of the GAB). The extent of the PAE along the south-western boundary of the Arckaringa Basin is based upon extent of potential drawn down from coal beds for which there is limited groundwater knowledge.
- A 20 km buffer boundary was included as a contingency around known surface waters and groundwater drawdown extents.
- A 10 km buffer was included where the PAE intersects with fractured rock aquifer (FRA) extents.

- Paleogene and Neogene sediments were excluded from consideration as a buffer to the GAB where they intersect with coal deposits, as direct impact to these Cenozoic sediments was assumed should open-cut mining occur.
- GAB discharge springs near the 210 km radius of coal beds in an easterly direction based upon knowledge of DEWNR groundwater system were included.
- GAB springs of the Lake Eyre supergroup were included with a 5 km buffer around the point location to accommodate the extensive wetland and terrestrial ecosystems that the springs support.
- The entire Kati Thanda – Lake Eyre (north and south) boundary was incorporated (based on SA Waterbodies mapping).
- Phreatic surface information was utilised to identify connectivity to shallow groundwater potentially utilised by vegetation (defined as groundwater up to 10 m deep), based upon decisions made by the BA team for other PAEs.
- Upstream watercourses were excluded where no direct link from mining, where outside the extent of drawdown.

The Arckaringa PAE is a composite of these groundwater and surface water components (Figure 3).

The following data gaps were identified during definition of the Arckaringa PAE:

- A sufficiently parameterised and tested groundwater model was not available for the entire Arckaringa Basin at the time of definition of the PAE.
- More information is required to define relationships between alluvial groundwater and the GAB, particularly at the far extent of the drawdown zone of influence.
- Further refinement is required where overlaps with Stuart Shelf occur, noting that BHP Billiton modelling undertaken as part of the proposed Olympic Dam Expansion Project identified a large cone of depression and impact of groundwater flow to Stuart Shelf.

Figure 3 Surface and groundwater preliminary assessment extents (PAE) for the Arckaringa subregion

1.3.1.4 Assessing water dependence

1.3.1.4.1 Assessment principles

Once assets were compiled into the asset database and checked for inclusion in the PAE, they were assessed for water dependence. Although most nominated assets are, by definition of their database sources, 'water dependent' (e.g. groundwater bores, rivers, lakes and wetlands), there are a number of types of assets that are less clearly 'water dependent' (e.g. a national park with a varied landscape, the habitat of a non-aquatic species and historical places). Because of the diversity of asset types, the spectrum of degrees to which assets might be water dependent, and the need for all assessment decisions to be transparent and recorded, a highly structured, formal approach was developed for assessment of water dependency.

Six principles formed the foundation of the approach to assessment of water dependence of assets in the Arckaringa PAE:

1. *Efficiency*. The methods were suitable for effective application for large numbers of assets.
2. *Transparency*. All decisions in assessments were tracked, including their rationale, as well as any data sources and dates of assessments.
3. *Rigour*. Decision making was based on sound ecological, economic and sociocultural principles and clear logic, and was able to withstand close peer and expert scrutiny.
4. *Multiple lines of evidence*. Wherever possible, assessment decisions were based on as many sources of information about water dependence as possible. Three broad groups of evidence were used: (i) asset naming conventions, (ii) documents describing asset management and (iii) GIS and remote sensing databases containing layers that directly or indirectly quantify surface water and groundwater availability.
5. *Precaution*. Where part of an asset is water dependent, the entire asset was assessed as water dependent. Where there is inconclusive evidence, assessment decisions consistently erred on side of assuming potential water dependence (i.e. if one data source indicates water dependence, then the overall decision across the multiple lines of evidence was water dependence). On this basis, the maximum number of assets was retained within the database for subsequent analysis of potential development impacts.
6. *Separate tracking of assessment for dependence on groundwater and surface water*. Later stages of the BA impact analysis are likely to demonstrate separate causal pathways for potential impact of coal resource development via surface water and groundwater systems. If that proves to be the case, then potential for impact on an asset via the surface water or groundwater pathway will only be true if the asset depends on the corresponding above or below-ground water resource (Figure 4).

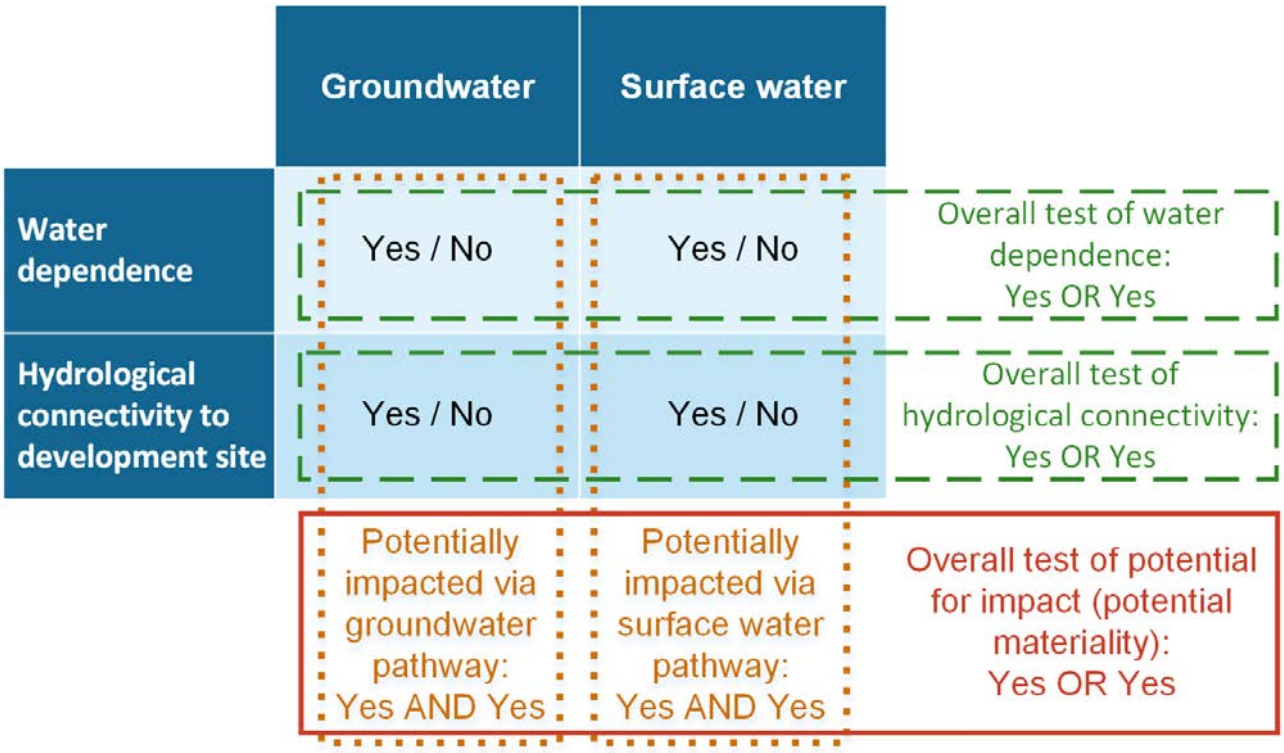


Figure 4 Logic for separate assessment and tracking of dependence on groundwater and surface water

This report focuses exclusively on assessment of water dependence i.e. the upper part of this logic. Future bioregional assessments for the Arckaringa subregion will assess hydrological connectivity and response, and thus the potential for impact on assets.

1.3.1.4.2 Assessment criteria using asset naming conventions

For some asset sources, the only direct information available for assessing water dependence of each asset is its name. The Australian Hydrological Geospatial Fabric (AHGF), Great Artesian Basin Groundwater Recharge Beds database and National Groundwater Information System (NGIS) are databases in which little asset data other than name and geographic coordinates are available. The Queensland, South Australia and Northern Territory groundwater licensing from the water management system databases are also restricted in terms of information other than asset name and type.

Two simple naming criteria were used to assess water dependence for assets of these types:

- if asset name includes ‘spring’, ‘soakage’, ‘bore’ or ‘groundwater’, then the asset is groundwater dependent
- if asset name includes ‘river’, ‘stream’, ‘floodplain’, ‘waterhole’, ‘billabong’, ‘lake’, ‘wetland’, ‘marsh’ or ‘surface water’, then the asset is surface water dependent.

Although initially developed for specific, information-poor data sources, these rules were subsequently applied to all assets in the asset list, regardless of data source.

1.3.1.4.3 Assessment criteria using documents describing asset management

Most assets sourced from the CAPAD, DIWA, and EPBC Act list of threatened ecological communities are subject to legislatively required management plans that include some degree of ecosystem description. For these assets, management plans and/or asset descriptions were

obtained from federal, state and territory agencies. The management plans and their constituent ecosystem descriptions were then subjected to text analysis, using the following simple criteria to assess water dependence:

- if ecosystem description includes 'spring', then asset is groundwater dependent
- if ecosystem description includes any ecosystem type, community type, habitat type or dominant species and has been identified in any published literature as accessing groundwater (e.g. river redgum, coolibah (*Eucalyptus coolabah*), fish species), then asset is groundwater dependent
- if ecosystem description includes 'riverine vegetation', 'floodplain', 'waterhole', 'billabong', 'lake', 'wetland' or 'marsh', then asset is surface water dependent
- if ecosystem description includes any ecosystem type, community type, habitat type or dominant species known to access surface water (e.g. river redgum, coolibah (*Eucalyptus coolabah*), lignum, most waterbird species, fish), then asset is surface water dependent.

According to these criteria, examination of documents about one asset may yield determination for both groundwater dependence and surface water dependence in one ecosystem type or in different ecosystem types in different parts of the asset.

The water dependency of threatened species' habitats, including threatened species listed under the EPBC Act and under Queensland's *Nature Conservation Act 1992* (Nature Conservation Act), was assessed by a review of the habitat requirements for each species. It is important to emphasise that BAs consider the potential impact to the habitat of species, not to the population of the species *per se*. In most cases, profiles from the Species Profile and Threats Database (SPRAT) (Bioregional Assessment Programme, Dataset 21) and the Queensland Government's Wetland*Info* website (DEHP, 2015) were examined.

Any information suggesting that water dependence was 'certain', 'likely' or 'possible' was interpreted as 'water dependent' for the purposes of the asset register.

1.3.1.4.4 Assessment criteria using GIS and remote sensing databases

Criteria based upon asset naming and upon available, published asset descriptions and management plans proved to be inadequate for satisfactory assessment of water dependence in a large proportion of assets. Other sources of information were sought to expand the range of data available for assessment of asset water dependence.

Five mapped GIS and remote sensing data layers were identified as providing additional information relevant to assessing dependence on surface water or groundwater. GIS analyses were used to spatially intersect each asset with each of the five data layers. If any part of an asset was found to overlap with any one of these layers, then that observation was used as evidence for water dependence, according to the precautionary principle previously described in Section 1.3.1.4.1.

The five data layers were:

1. Groundwater-dependent ecosystems reliant on subsurface presence of groundwater, derived from the *National atlas of groundwater dependent ecosystems* (GDE Atlas; Bureau of Meteorology, 2012). Subsurface presence of groundwater is defined as groundwater that contributes to the soil water and near-surface aquifers accessible to plant roots without generating a flow of water at the soil surface. Only those GDEs derived from previous field work or possessing a high or moderate potential for groundwater dependency were used in the intersection. Positive intersection of an asset with this layer indicates potential dependency on groundwater. A map of this data layer across the Arckaringa PAE is shown in Figure 5.
2. Groundwater-dependent ecosystems reliant on surface expression of groundwater, derived from the GDE Atlas (Bureau of Meteorology, 2012). Surface expression of groundwater is defined as groundwater that flows at the soil surface in the form of a spring or seep, including those springs that lie under surface water bodies such as streams, waterholes, lakes or swamps, for which the primary source of water may be from surface flows. Only those GDEs derived from previous field work or possessing a high or moderate potential for groundwater dependency were used in the intersection. Positive intersection of an asset with this layer indicates potential dependency on groundwater and/or surface water. A map of this data layer across the Arckaringa PAE is shown in Figure 6.
3. A combined multi-state and territory map of wetlands defined according to the SA Wetlands Groundwater Dependent Ecosystem Classification and Northern Territory - Lake Eyre Basin - Wetlands Mapping. Positive intersection of an asset with this layer indicates potential dependency on subsurface or surface expression of groundwater. A map of this data layer for the Arckaringa PAE is shown in Figure 7.
4. Mean annual evapotranspiration in excess of incident rainfall across the Arckaringa PAE (Reside et al., 2013). This layer is calculated as the difference between actual evapotranspiration assessed through remote sensing techniques during 1992 to 2011 and a predicted model of evapotranspiration if water were sourced only from incident rainfall. A positive difference means that long-term observation of the amount of water released into the atmosphere by plant evapotranspiration exceeds the inputs of water from rainfall, and the vegetation is accessing additional water from groundwater pools or contributions to soil water. These contributions to soil water result from surface water flowing from elsewhere in the catchment; however, the data were not able to be interpreted to indicate whether the additional water is from a groundwater pool or surface water flow. Thus, intersection of an asset with high excess evapotranspiration values (>100 mm per annum) in this layer indicates potential dependency on groundwater and/or surface water. A map of this data layer across the Arckaringa PAE is shown in Figure 8.
5. Percentage duration of flood inundation during 1987 to 2015, from the Water Observations from Space database (Bioregional Assessment Programme, Dataset 23). Positive intersection of an asset with higher percentage inundation classes (>1 % of time) in this layer indicates potential dependency on surface water. A map of this data layer across the Arckaringa PAE is shown in Figure 9.

Application of this approach is demonstrated for a single asset in the Arckaringa PAE, Witjira National Park (Figure 10 and Figure 11). Witjira National Park sits to the west of the Simpson Desert, immediately south of the border between South Australia and the Northern Territory (see Figure 9), and includes the Dalhousie Springs complex. All five GIS and remote sensing layers provide clear evidence for dependence on groundwater and/or surface water in and around watercourses in the northern and central portions of the park, and in and around the swales, claypans and salt lakes in the southern portion of the park. Therefore, this asset was assessed to be water dependent and is included in the register of water-dependent assets. However, it is important to note that in the eastern and south-west portions of the park, each of the five layers provides evidence for different patterns of potential water dependence. Thus the five layers provide independent and complementary lines of evidence for the assessment of asset dependence on water.

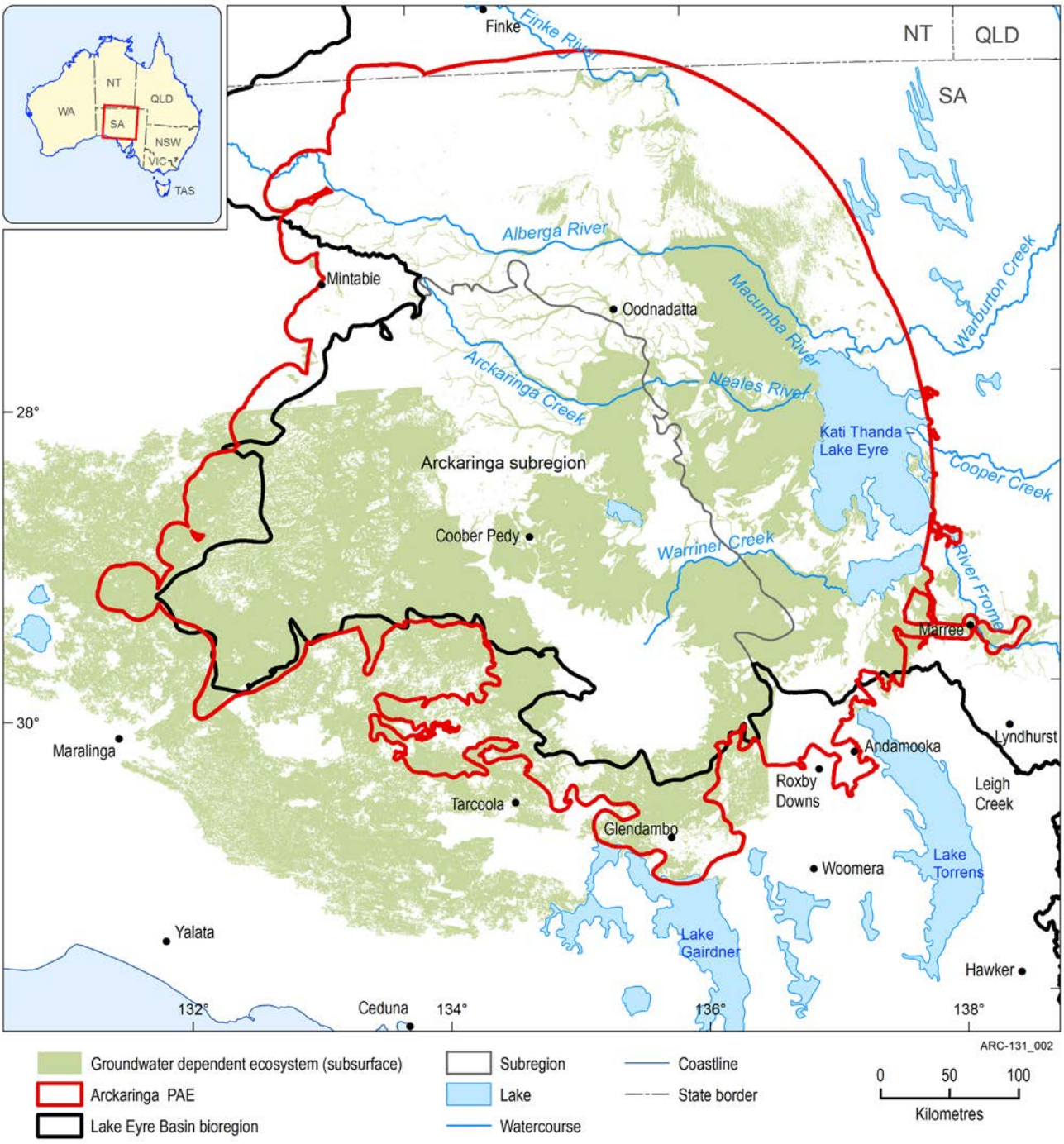


Figure 5 Groundwater-dependent ecosystems reliant on subsurface presence of groundwater in the Arckaringa preliminary assessment extent (PAE)

Data: Bureau of Meteorology (Dataset 7)

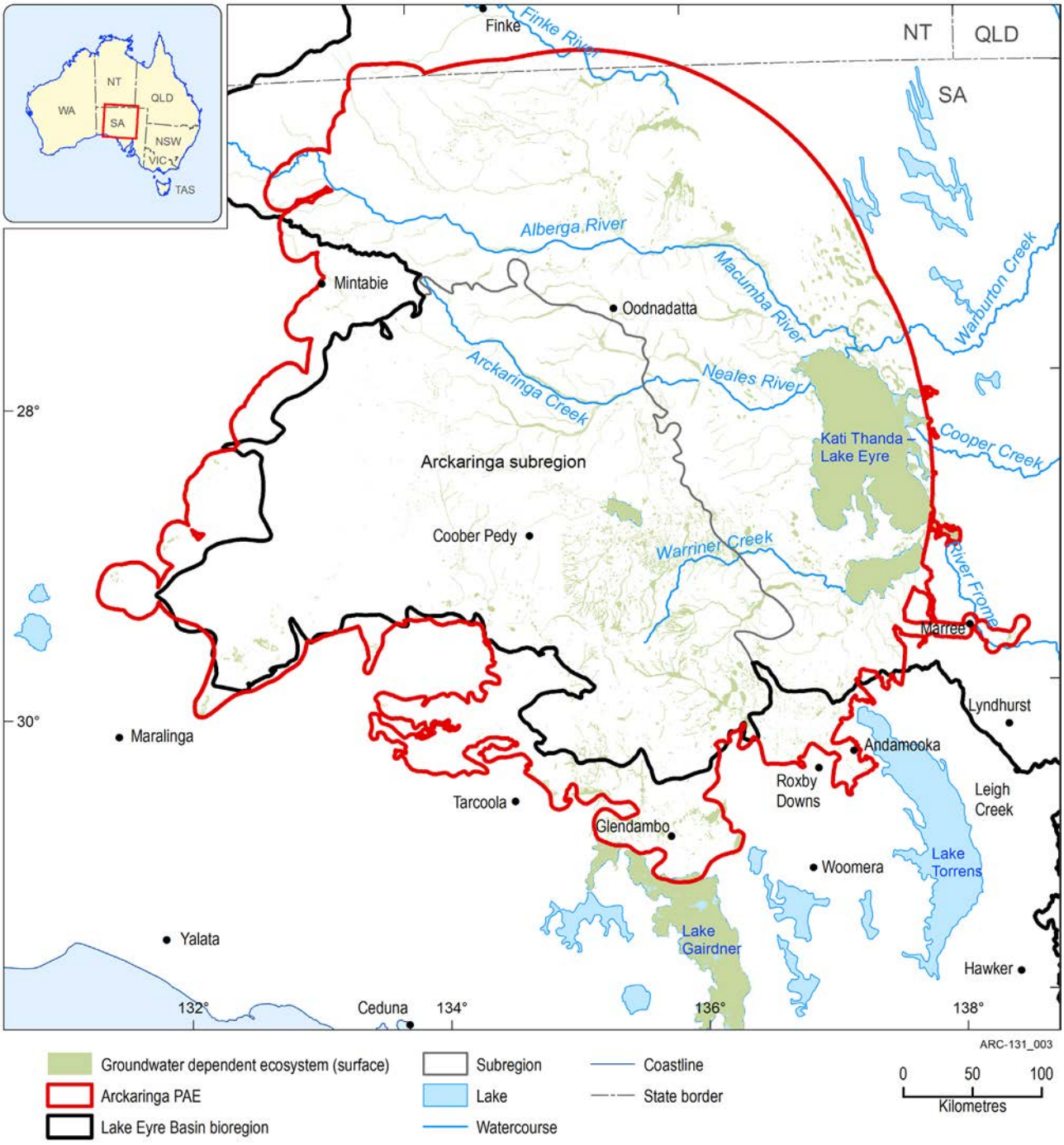


Figure 6 Groundwater-dependent ecosystems reliant on surface expression of groundwater in the Arckaringa preliminary assessment extent (PAE)

Data: Bureau of Meteorology (Dataset 7)

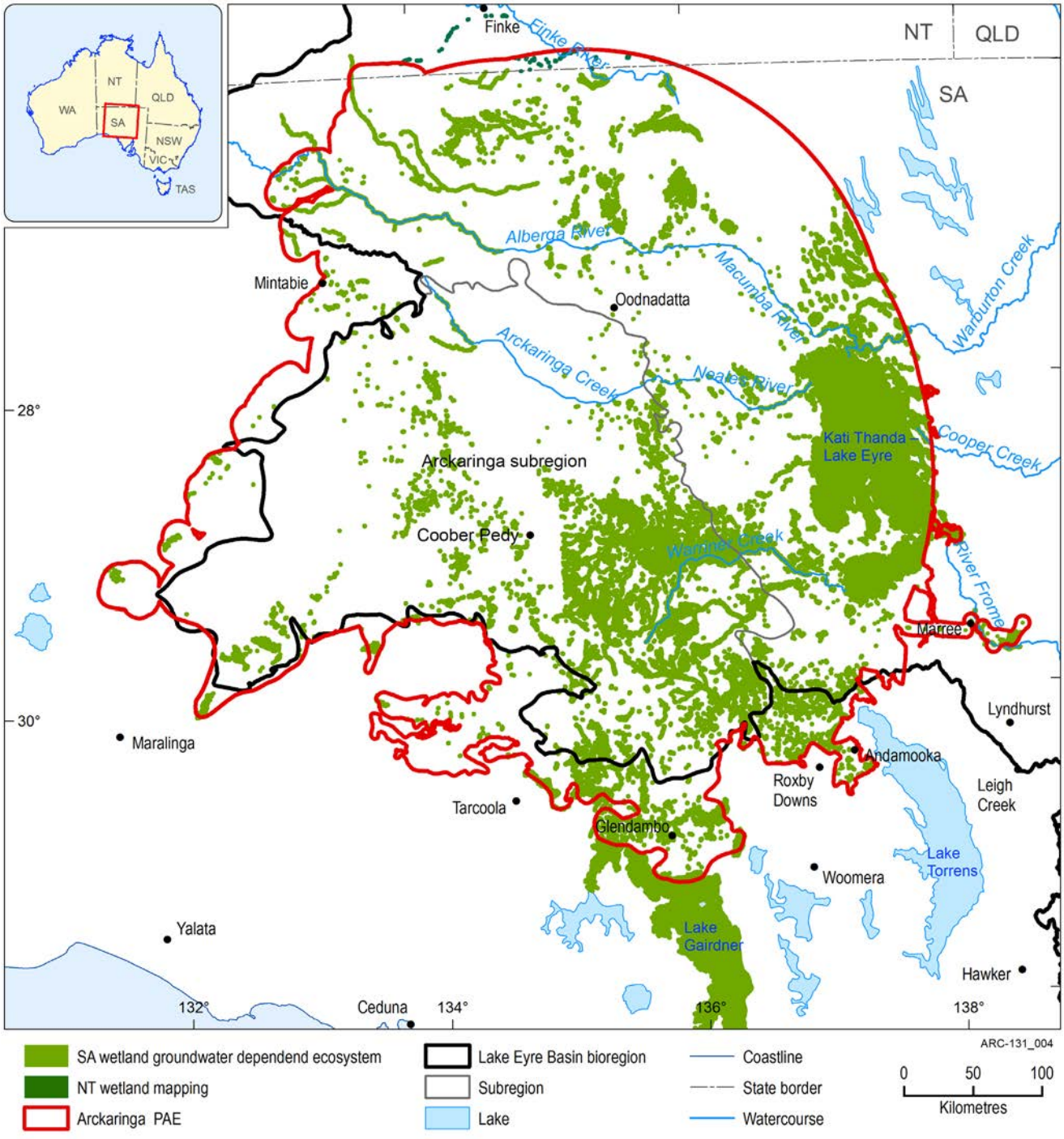


Figure 7 Distribution of wetland ecosystems types in the Arckaringa preliminary assessment extent (PAE), according to the South Australia wetland groundwater-dependent ecosystem mapping and Northern Territory wetland mapping

Data: South Australian Department of Environment, Water and Natural Resources (Dataset 13) and Northern Territory Department of Natural Resources, Environment, the Arts and Sport (Dataset 12)

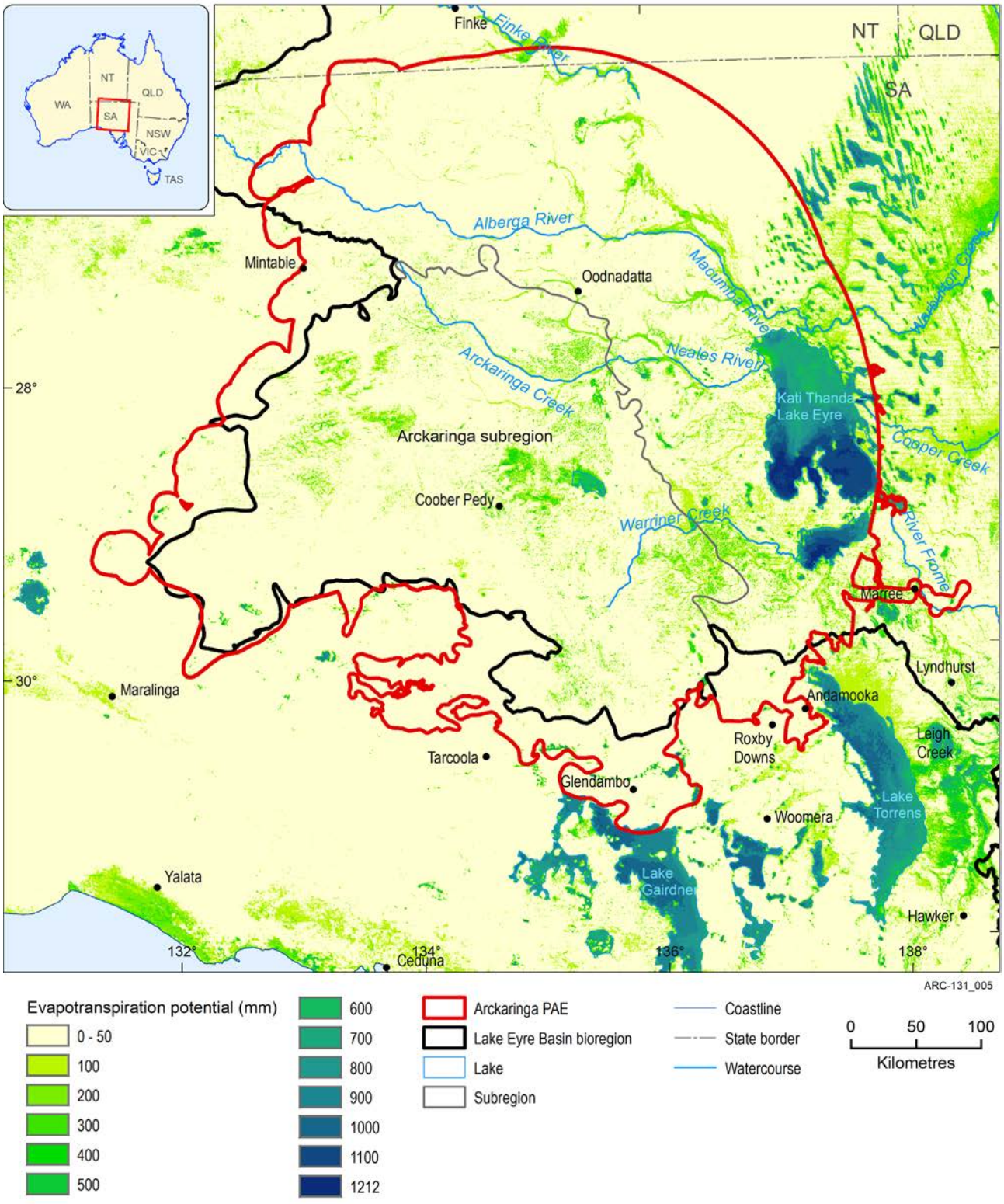


Figure 8 Mean annual evapotranspiration in excess of incident rainfall across the Arckaringa preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 22)

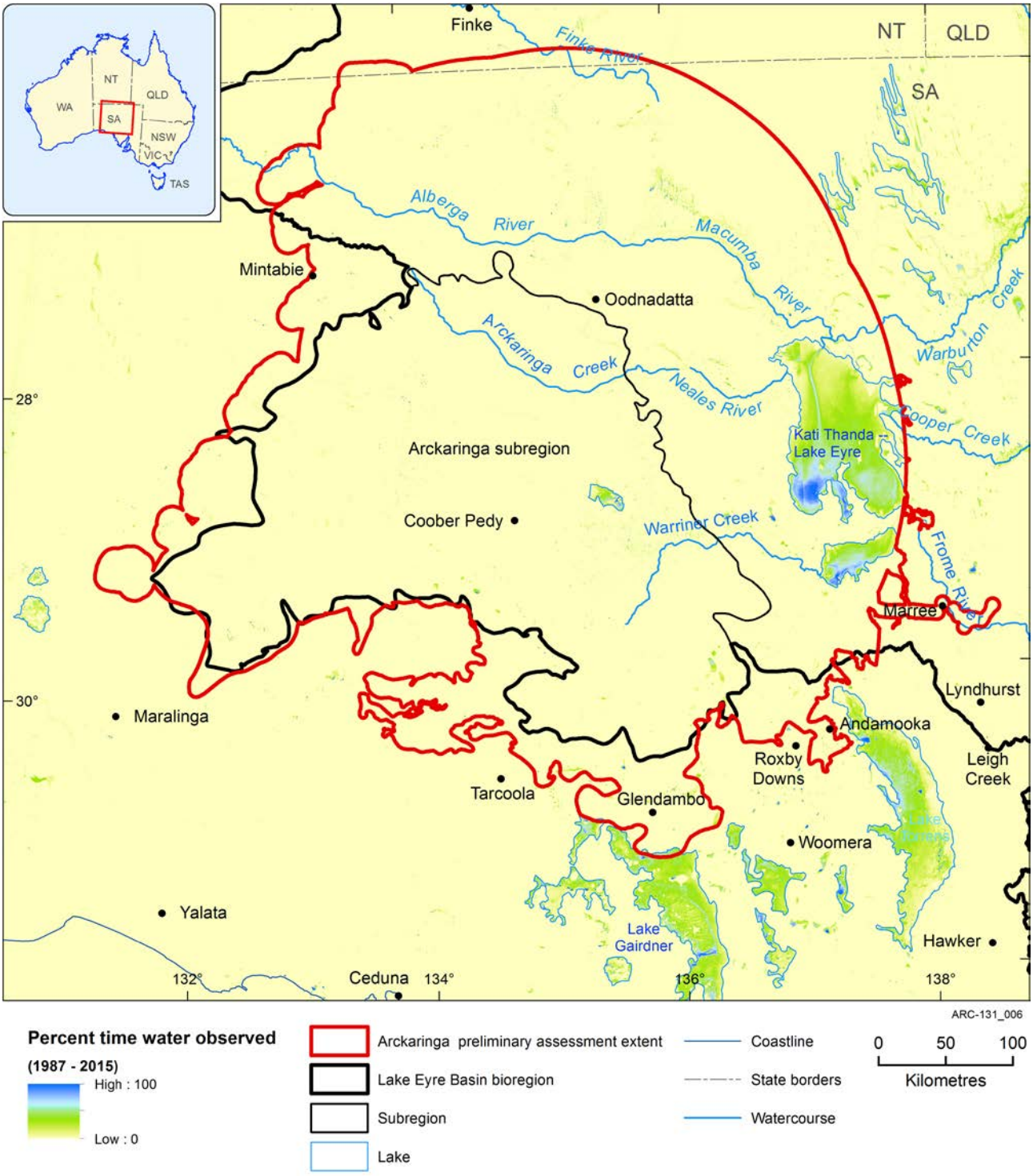


Figure 9 Percentage duration of flood inundation during 1987 to 2015 across the Arckaringa preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 23)

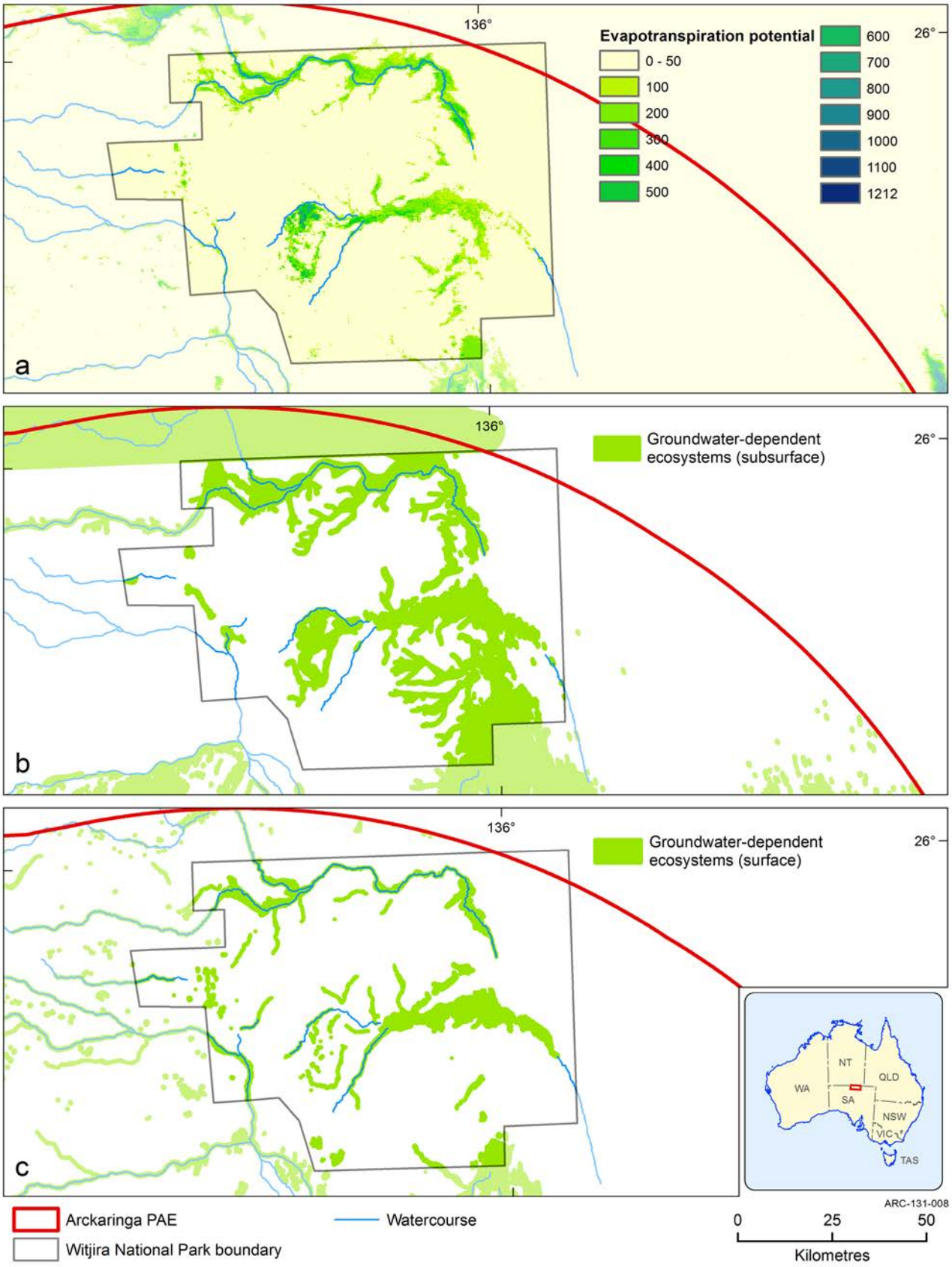


Figure 10 Spatial intersection of a specific asset, Witjira National Park, with layers of (a) mean annual evapotranspiration in excess of incident rainfall, (b) groundwater-dependent ecosystems reliant on subsurface presence of the water and (c) groundwater-dependent ecosystems reliant on surface expression of the water

Data: Bioregional Assessment Programme (Dataset 22), Bureau of Meteorology (Dataset 7)

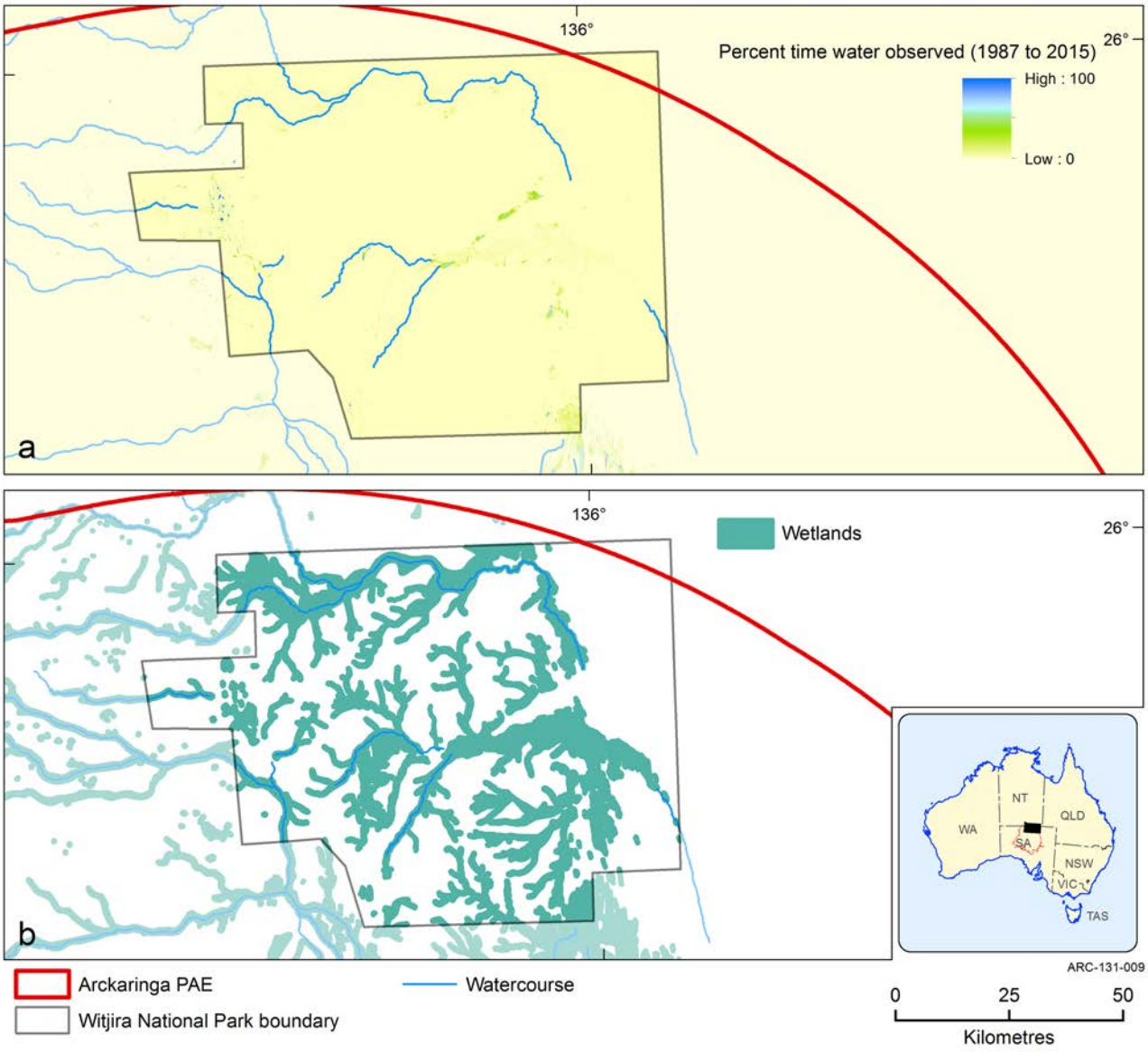


Figure 11 Spatial intersection of a specific asset, Witjira National Park, with layers of (a) percent duration of flood inundation and (b) wetland ecosystems types according to the South Australia wetland groundwater-dependent ecosystem mapping and Northern Territory wetland mapping

Data: Bioregional Assessment Programme (Dataset 23), South Australian Department of Environment, Water and Natural Resources (Dataset 13) and Northern Territory Department of Natural Resources, Environment, the Arts and Sport (Dataset 12)

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1.3.2 Ecological assets

Summary

The water-dependent asset register for the preliminary assessment extent (PAE) of the Arckaringa subregion contains 1845 individual ecological assets. The water-dependent ecological assets encompass a large proportion of the area of the PAE. The asset register consists of 1027 assets in the 'Vegetation' subgroup, 88 in the 'Groundwater' subgroup and 730 in the 'Surface water' subgroup. All nominated surface water and groundwater assets were assessed as water dependent. Of the nominated 'Vegetation' subgroup assets, 383 groundwater-dependent ecosystem (GDE) assets were excluded because of their low reliability status and a lack of evidence of water dependence using the datasets based on satellite imagery. Furthermore, 10 species habitat assets were excluded as the habitats could not be shown to fulfil the criteria for water dependence. The asset register includes one threatened ecological community and the potential spatial habitat distribution of nine species listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

1.3.2.1 Description

1.3.2.1.1 Introduction to assets by subgroup, class and data source

The total number of ecological water-dependent assets in the PAE of the Arckaringa subregion is 1845 (from a total of 2239 ecological assets in the asset list). Of the water-dependent assets, 1027 assets are vegetation features, 730 assets are surface water features and 88 assets are groundwater features (Table 7). Most of the vegetation features are groundwater-dependent ecosystems (GDEs) and most of the surface water features are wetlands, wetland complexes or swamps. Of the ecological assets, 1719 assets were assessed as dependent on surface water and 1448 assets were assessed as dependent on groundwater. Of these assets, 396 assets were assessed as dependent or possibly dependent on surface water alone, 122 assets were assessed as dependent or possibly dependent on groundwater alone, and 1327 assets were assessed as dependent or possibly dependent on both surface water and groundwater.

Table 8 summarises the ecological assets and their water dependence according to database source. Maps of the distributions of the key data sources are shown in Figure 12 to Figure 17. Total assets cover a large proportion of the 82,505 km^2 area of the Arckaringa PAE, giving confidence that the asset register is a thorough basis for the assessment of potential impacts of coal resource developments during later stages of the BA. In some datasets, at least some large assets intersect with only a small part of the Arckaringa PAE and extend far beyond the boundaries of the PAE. This is most strongly the case for the Water Asset Information Tool (WAIT) database, in which Great Artesian Basin (GAB) groundwater aquifers, recharge beds and dependent ecosystems extend to the west, south and east far beyond the boundary of the Arckaringa PAE.

Table 7 Summary of ecological assets within the preliminary assessment extent (PAE) of the Arckaringa subregion, according to asset subgroup and class

Subgroup	Asset class	Number of water-dependent assets	Number of assets dependent on surface water	Number of assets dependent on groundwater
Groundwater feature	Aquifer, geological feature, alluvium or stratum	88	12	88
Surface water feature	Floodplain	14	14	1
	Lake, reservoir, lagoon or estuary	65	65	51
	Marsh, sedgeland, bog, spring or soak	145	102	143
	River or stream reach, tributary, anabranch or bend	86	86	38
	Waterhole, pool, rockpool or billabong	111	111	111
	Wetland, wetland complex or swamp	309	304	291
Vegetation	Groundwater-dependent ecosystem	1001	1000	712
	Habitat (potential species distribution)	26	25	13
Total		1845	1719	1448

Data: Bioregional Assessment Programme (Dataset 1)

Table 8 Summary of ecological assets in the preliminary assessment extent (PAE) of the Arckaringa subregion, according to asset data source

Dataset	Number of water-dependent assets	Number of assets dependent on surface water	Number of assets dependent on groundwater
Australian Hydrological Geospatial Fabric	15	15	4
Collaborative Australian Protected Areas Database (CAPAD)	13	13	8
A directory of important wetlands in Australia (DIWA)	3	2	3
Great Artesian Basin Groundwater Recharge	5	4	5
National atlas of groundwater dependent ecosystems (subsurface)	63	63	37
National atlas of groundwater dependent ecosystems (surface)	814	813	551
Birds Australia Important Bird Areas (IBA)	3	3	1
Northern Territory – Lake Eyre Basin - Wetlands Mapping	1	1	0
Queensland Lake Eyre Basin Rockholes and Waterholes in Queensland - Indigenous	1	1	1
SA Lake Eyre Basin Aquatic Ecosystems Mapping and Classification	55	55	0
SA Wetland Groundwater Dependent Ecosystem Classification	351	351	351
Threatened species listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)	9	8	3
Threatened ecological communities listed under the EPBC Act	1	1	1
WAIT SA Arid Lands	511	389	483
Total	1845	1719	1448

Data: Bioregional Assessment Programme (Dataset 1)

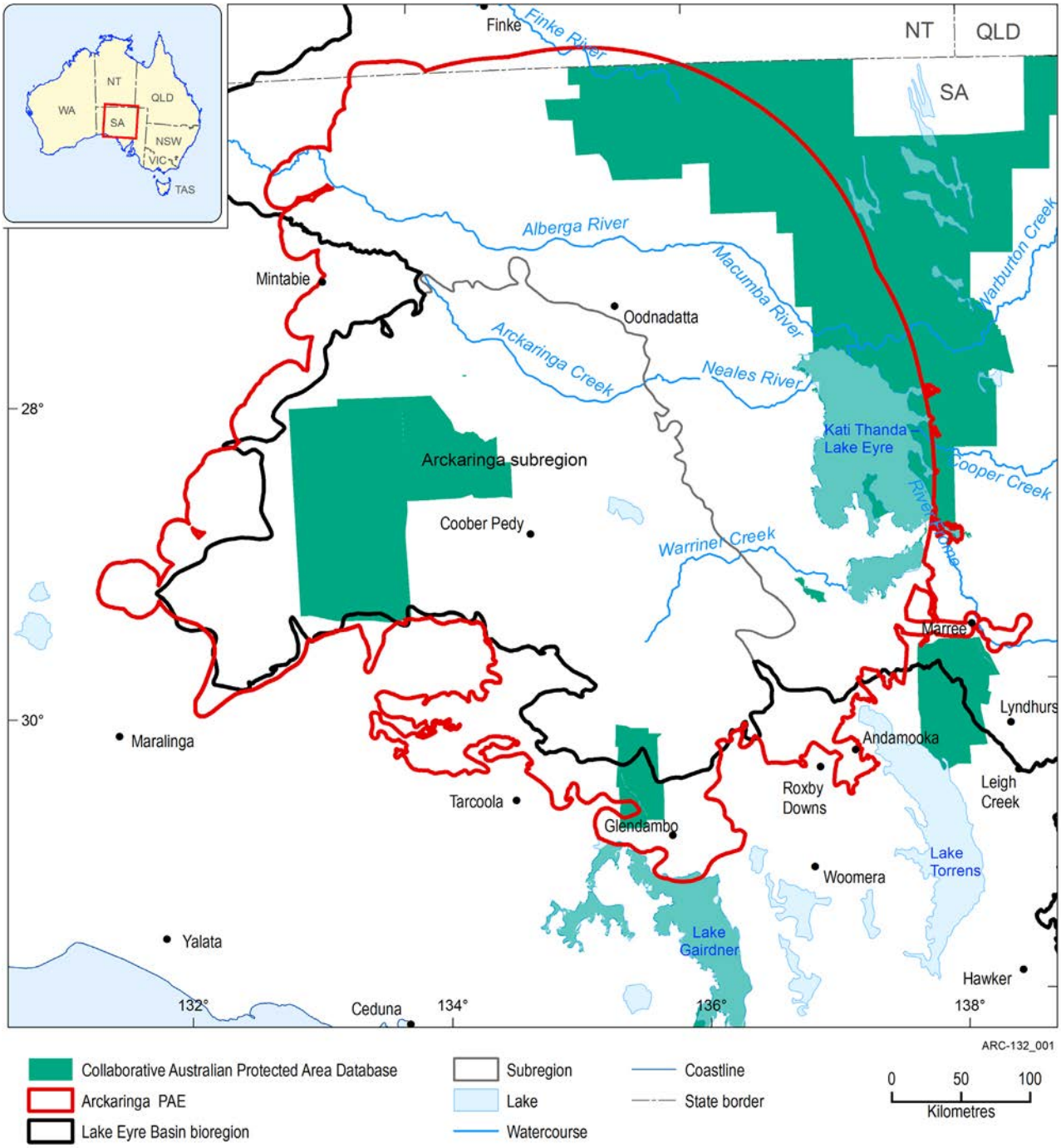

Figure 12 Collaborative Australian Protected Areas Database (CAPAD) assets in the Arckaringa preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)

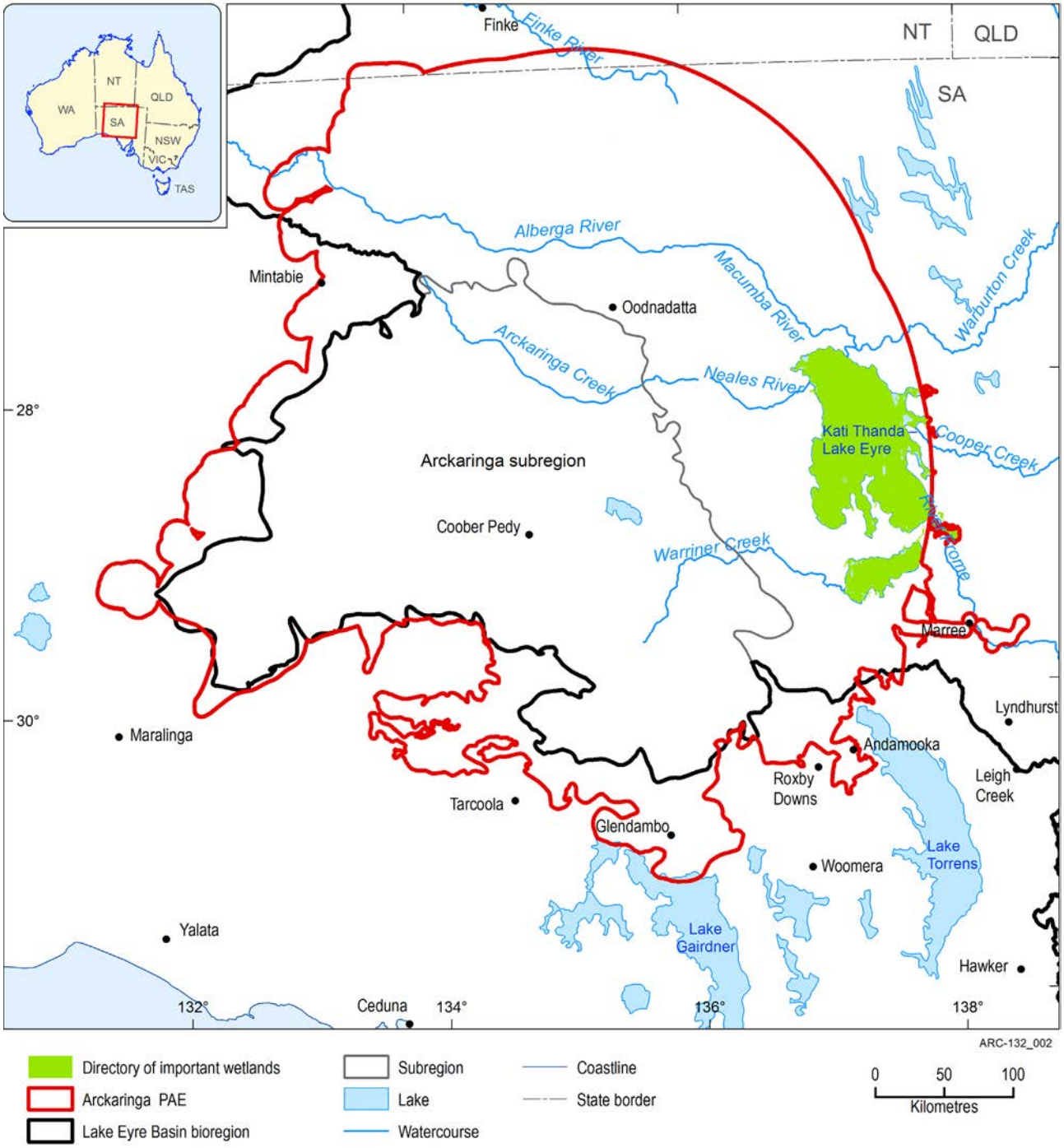

Figure 13 *A directory of important wetlands in Australia* (DIWA) assets in the Arckaringa preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)

Figure 14 Great Artesian Basin groundwater recharge assets in the Arckaringa preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)

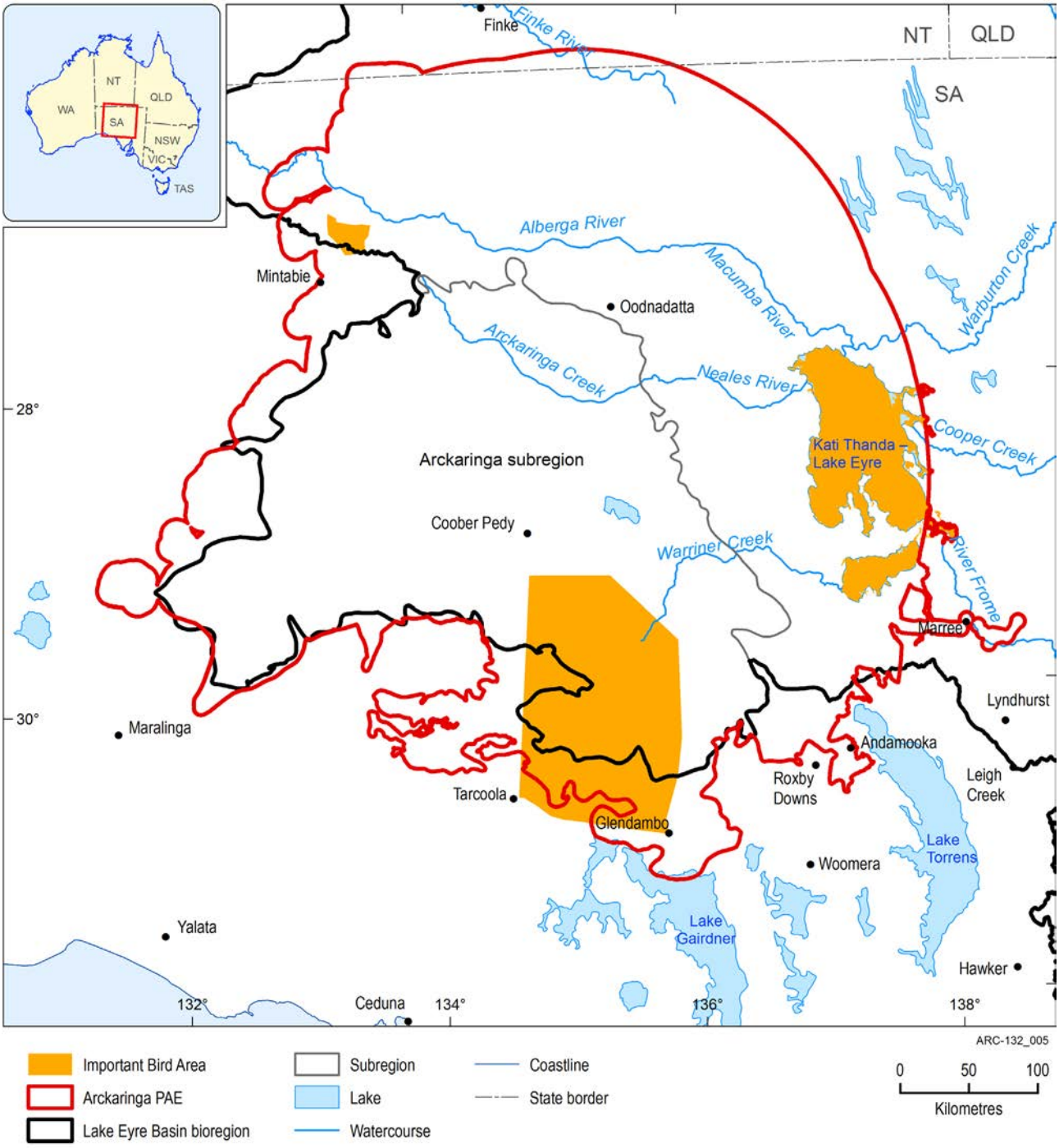

Figure 15 Map of Birds Australia Important Bird Areas (IBA) assets in the Arckaringa preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)

Figure 16 Threatened ecological communities listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* in the Arckaringa preliminary assessment extent (PAE)

These are polygons representative of the combined area of assets.
Data: Bioregional Assessment Programme (Dataset 1)

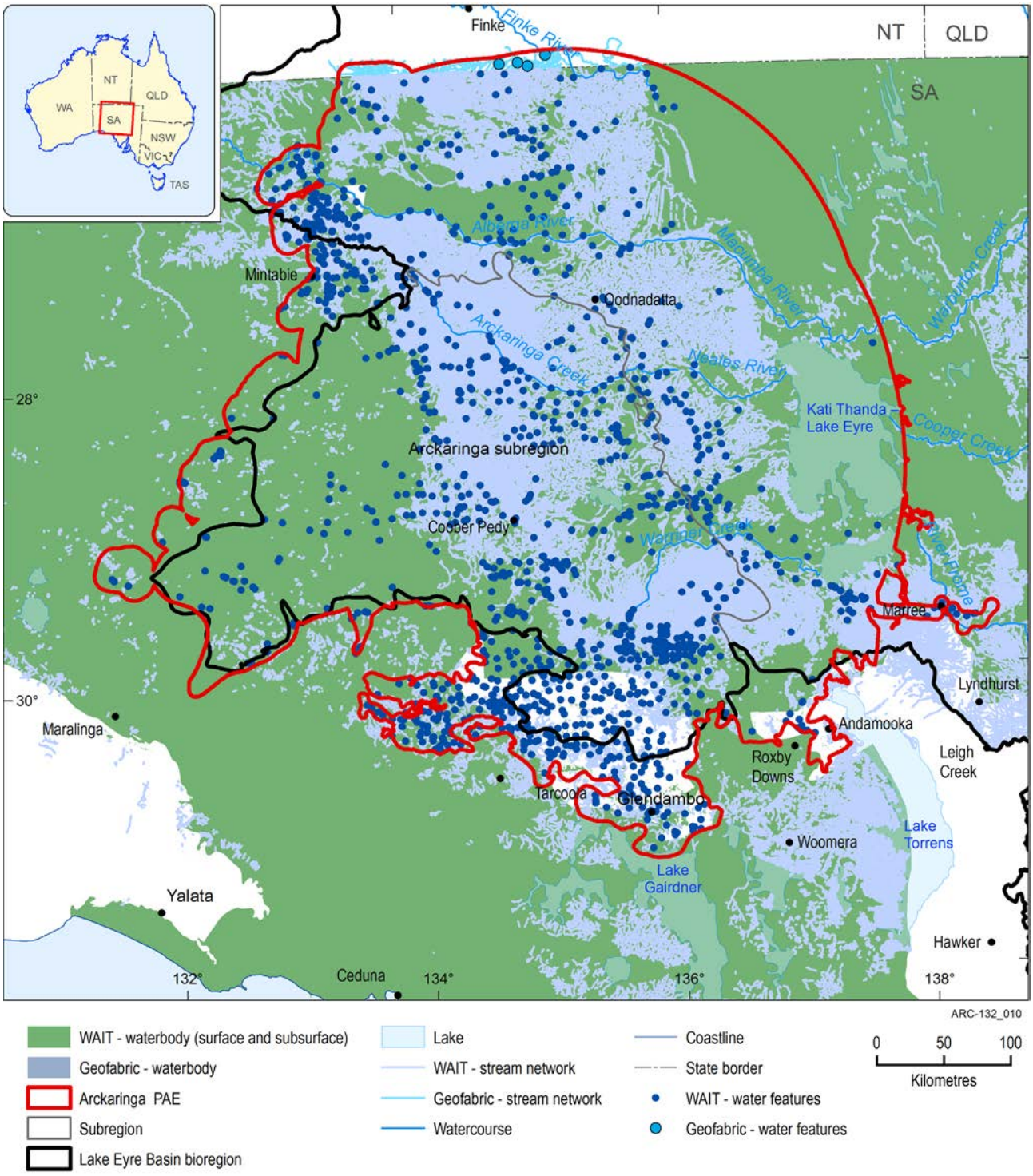

Figure 17 Water Asset Information Tool (WAIT) database assets for South Australia, and equivalent Geofabric database assets for the Northern Territory, within the Arckaringa preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)

1.3.2.1.2 Threatened ecological communities

Only one ecological community listed under the EPBC Act occurs in the Arckaringa PAE. Management plans indicate that 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin threatened ecological community' depends eponymously on groundwater. Assessment data based on all satellite imagery data layers

provides independent corroboration that this ecological community is water dependent. Most of these discharge springs occur to the west and south of Kati Thanda – Lake Eyre, with the Dalhousie Springs group lying further north, between Oodnadatta and the NT–SA border (Figure 16).

1.3.2.1.3 Habitats of threatened species

Of the 19 species listed as threatened under the EPBC Act and occurring in the Ackaringa PAE, 9 species were assessed to rely upon water-dependent habitats, with 6 species dependent on surface water, 1 species dependent on groundwater and 2 species dependent on both surface water and groundwater (Table 9). Application of the precautionary principle means that any species that is 'possibly' dependent on water in excess of incident rainfall is determined to be water dependent and its habitat is included in the register of water-dependent assets. One of the three EPBC Act-listed species that are at least partly dependent on groundwater (*Eriocaulon carsonii*) is exclusively associated with 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin threatened ecological community'. For the other two species (both egrets), evidence for dependence on groundwater or surface water is much less clear cut. The species occur across a wide range of community types that are more commonly ephemeral rivers, creeks, swamps and floodplains than permanent waterbodies. Groundwater may contribute to the water supply in some of these community types, through contributions to subsurface baseflow in rivers and creeks, or to soil water in swamps and floodplains. In all these community types, determination of absolute dependence on water in excess of rainfall (i.e. flows down drainage lines and across floodplains) cannot be made with complete confidence, and in all cases the precautionary principle has been applied to assess these species' habitats.

Table 9 Water-dependent threatened species listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* and within the preliminary assessment extent (PAE) of the Arckaringa subregion

Although examples of individual species are listed, bioregional assessments consider the potential impact to the habitat of species not individual species per se.

Scientific name[a]	Common name	Dependence upon surface water	Dependence upon groundwater	Comments
Acacia latzii	Latz's Wattle	Possible	No	Occurs on shallow gravelly soils in small watercourses, gullies and rocky slopes
Ardea alba	Great Egret	Yes	Possible	Occurs in a wide range of wetland habitats, including freshwater and saline, permanent and ephemeral, open and vegetated
Ardea ibis	Cattle Egret	Yes	Possible	Occurs in a wide range of wetland habitats, including freshwater and saline, permanent and ephemeral, open and vegetated
Calidris acuminata	Sharp-tailed Sandpiper	Yes	Unlikely	Occurs in lagoons, swamps, lakes, dams, waterholes, soaks, bore drains and bore swamps, saltpans and hyper-saline salt lakes
Eleocharis papillosa	Dwarf Desert Spike-rush	Yes	No	All records are from ephemeral wetlands, predominantly freshwater and semi-saline swamps
Eriocaulon carsonii	Salt Pipewort	Unlikely	Yes	Great Artesian Basin springs are the only habitat of this asset species
Macrotis lagotis	Greater Bilby	Possible	No	Historically associated with drainage systems, salt lake systems and other alluvial areas
Notoryctes typhlops	Itjaritjari	Possible	No	Few data on the habitat preferences of the Itjaritjari; may occupy sandy river flats where aeolian dunes occur nearby. River flats may be rich in food resources for the Itjaritjari
Pandion haliaetus	Osprey	Yes	No	Mostly found in coastal areas, but occasionally travel inland and utilise lakes and waterholes for foraging

Data: Bioregional Assessment Programme (Dataset 1)
[a]Typology and punctuation are given as they are used in the legislation.

1.3.2.2 Gaps

The Arckaringa subregion asset workshop in Adelaide in March 2015 confirmed two data gaps that had been identified previously during collation of the asset list:

- species listed as threatened under SA's *National Parks and Wildlife Act 1972,* including their threat status in the South Australian Outback region as assessed by Gillam and Urban (2013)
- species listed as threatened under the NT's *Territory Parks and Wildlife Conservation Act 2000*.

In each case, insufficient available spatial data meant that the habitats of these species could not be adequately geographically circumscribed as assets able to be nominated to the asset list, and thus it was not possible to determine the level of potential water dependence of these species during compilation of the register of water-dependent assets. Future assessments would be able to include the habitats of these species should suitable spatial data become available.

References

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Datasets

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1.3.3 Economic assets

Summary

The water-dependent asset register for the Arckaringa subregion has 47 economic water-dependent assets comprising 7009 elements. There are 12 assets in the subgroup 'Surface water management zone or area', comprising one surface water access right asset and 11 water supply and monitoring infrastructure assets. There are 35 assets in the subgroup 'Groundwater management zone or area', comprising one basic water right asset, one water access right asset, 31 water supply and monitoring infrastructure assets, and two groundwater features used for water supply.

1.3.3.1 Description

The total number of economic water-dependent assets in the preliminary assessment extent (PAE) of the Arckaringa subregion is 47 (comprising 7009 elements). This includes one surface water access entitlement and one groundwater access entitlement, both in SA. There are also 31 water supply and monitoring infrastructure assets in SA. In the NT, there are also two assets that are groundwater features forming parts of the Great Artesian Basin. All assets are water dependent.

A *water access right* is defined as a perpetual or ongoing entitlement to exclusive access to a share of water from a specified consumptive pool as defined in the relevant water plan (Council of Australian Governments, 2004). Water access rights are tradeable with land in a bundled system, or may be tradeable without land in an unbundled system. The consumptive pool may be a body of groundwater or an interconnected set of surface water bodies. For a groundwater pool, access is by bores for domestic, stock, irrigation and/or other commercial uses, or for town water supplies. For surface waters, access is direct by pumping from a river or lake. Pool size and access right allocation of consumptive rights are subject to planning and management within zones, as used here to group the individual elements representing single bores and pumping locations into assets. Within the Arckaringa subregion, one water access right is for the bore that supplies the township of Oodnadatta, and the remainder are bores that supply pastoral stations.

A basic water right (stock and domestic) is a water right held by a rural landowner for domestic, on-farm purposes (Department of the Environment, 2015). Stock purposes are watering stock of a number that would normally be depastured on the land on which the water is used, including pets. Domestic purposes include use within a house and for irrigating a garden not exceeding 0.25 ha, cultivated for domestic use rather than sale. Stock and domestic does not include use for dairies, piggeries, feed lots, poultry or any other intensive or commercial use. They may apply to domestic and farm bores, or to pumps in rivers and lakes. In the Arckaringa subregion, all basic water rights are for bores on pastoral stations.

Table 10 shows the breakdown of water access entitlements (economic elements) for groundwater and surface water in the Arckaringa PAE. The locations of the economic assets are shown in Figure 18 and Figure 19.

Table 10 Summary of water-dependent economic assets in the Arckaringa subregion asset register

Subgroup	Asset class	State or territory	Number of assets	Number of elements
Groundwater management zone	Groundwater feature used for water supply	Northern Territory	2	2
	Basic water right (stock and domestic)	South Australia	1	35
	Water access right	South Australia	1	33
	Water supply and monitoring infrastructure	South Australia	31	6926
Surface water management zone	Water access right	South Australia	1	1
	Water supply and monitoring infrastructure	South Australia	11	12
Total			47	7009

Data: Bioregional Assessment Programme (Dataset 1)

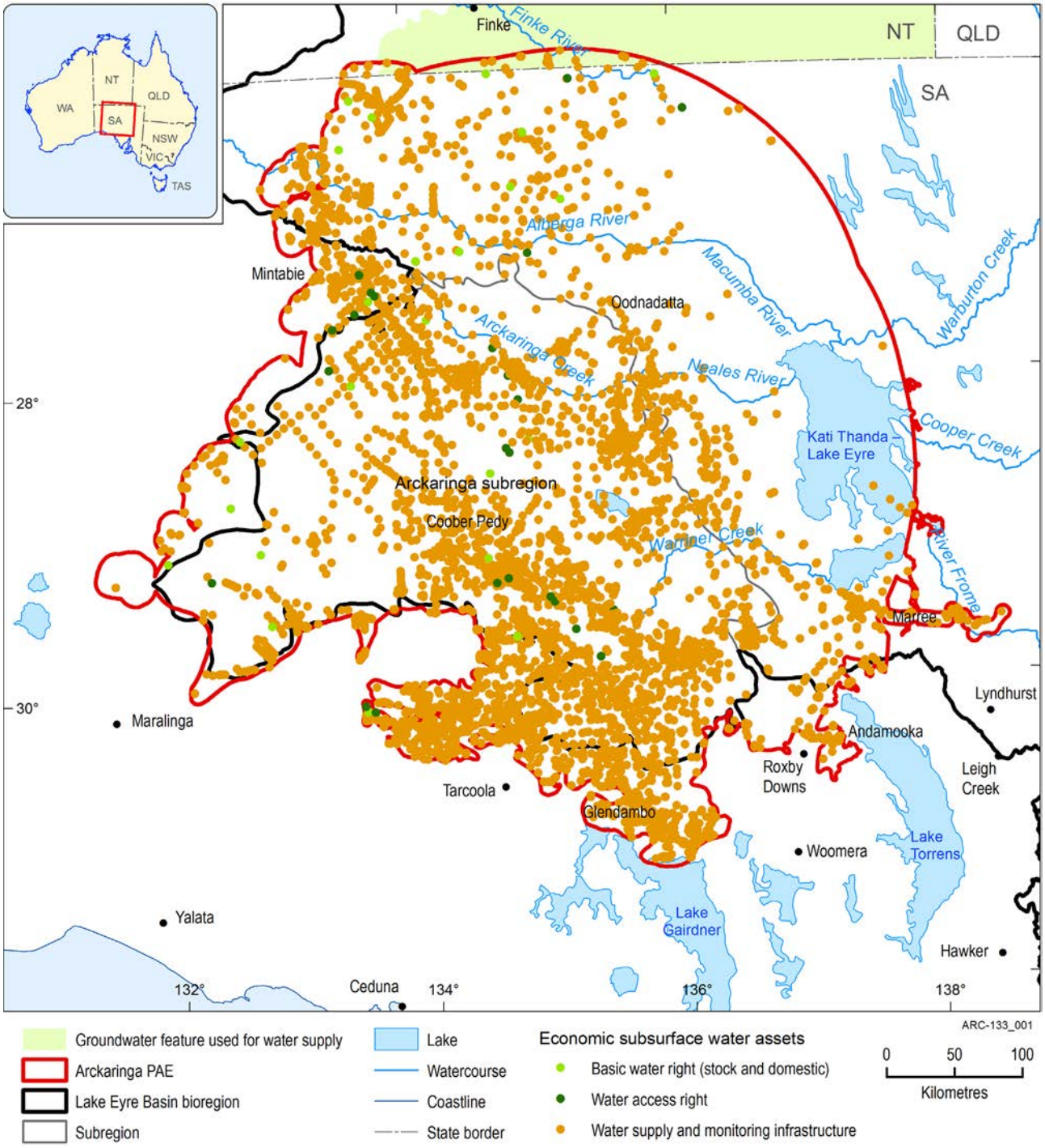

Figure 18 Location of water-dependent assets in the preliminary assessment extent (PAE) of the Arckaringa subregion: basic water rights (stock and domestic) and water access rights (all groundwater assets)

Data: Bioregional Assessment Programme (Dataset 1)

Figure 19 Location of water-dependent assets in the preliminary assessment extent (PAE) of the Arckaringa subregion: Water Asset Information Tool (WAIT) database assets (water supply and monitoring infrastructure assets – bores and dams)

Data: Bioregional Assessment Programme (Dataset 1)

1.3.3.2 Gaps

No additional economic assets were nominated following the Arckaringa subregion asset workshop in Adelaide in March 2015.

References

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688

1.3.4 Sociocultural assets

Summary

There were 87 nominated sociocultural assets, of which 72 were considered to be water dependent (surface and/or groundwater) and included in the water-dependent asset register. No additional sociocultural assets were nominated at the Arckaringa subregion asset workshop in Adelaide in March 2015.

Some sociocultural assets with identified heritage values are also areas with natural values. Consequently they are partly or entirely protected under national and/or state conservation legislation, and thus were also nominated as ecological assets. These sociocultural assets are water dependent. Other sociocultural assets are historical places, including places associated with British tests of nuclear weapons and with the Overland Telegraph Line from Adelaide to Darwin. Most of the historical places are also water dependent because they are located near groundwater discharge springs or include floodplains.

Forty-six Indigenous assets were nominated and, in the absence of detailed location descriptions, all were considered to be potentially water dependent.

1.3.4.1 Description

A total of 87 sociocultural assets were nominated in the asset list for the Arckaringa subregion. Eighty of those asset nominations were sourced from the Australian Heritage Database (Department of the Environment, 2015; Bioregional Assessment Programme, Dataset 1), comprising 76 assets from the Register of the National Estate (RNE) and 4 assets from the National Heritage List. In addition, 7 assets were nominated by the SA Arid Lands Natural Resource Management Board through the Water Asset Information Tool (WAIT) (Bioregional Assessment Programme, Dataset 1). Of these, 72 assets were considered to be water dependent and were included in the water-dependent asset register. No additional sociocultural assets were nominated at the Arckaringa asset workshop in Adelaide in March 2015.

Table 11 shows the breakdown of water-dependent sociocultural assets by dataset, subgroup and class. The geographic locations of the assets are shown in Figure 20. There are 55 assets in the ‘Cultural’ subgroup and 17 assets in the ‘Social’ subgroup. Forty-six assets are classed as Indigenous sites. In the north, east and south of the Arckaringa preliminary assessment extent (PAE), several large assets intersect with only a small part of the PAE and extend far beyond the boundaries of the PAE. During subsequent stages of the Bioregional Assessment Technical Programme, impact will only be assessed for those parts of such assets that lie within the Arckaringa PAE.

Table 11 Summary of the water-dependent sociocultural assets in the preliminary assessment extent (PAE) of the Arckaringa subregion

Dataset	Subgroup	Asset class	Number of assets	Number of assets dependent on groundwater	Number of assets dependent on surface water
National Heritage List (NHL)	Cultural	Heritage site	4	2	3
Register of the National Estate (RNE)	Cultural	Heritage site	5	2	4
Register of the National Estate (RNE)	Cultural	Indigenous site	39	38	39
Register of the National Estate (RNE)	Social	Recreation area	17	8	11
WAIT_SA	Cultural	Indigenous site	7	7	7
Total			72	57	64

Data: Bioregional Assessment Programme (Dataset 1)

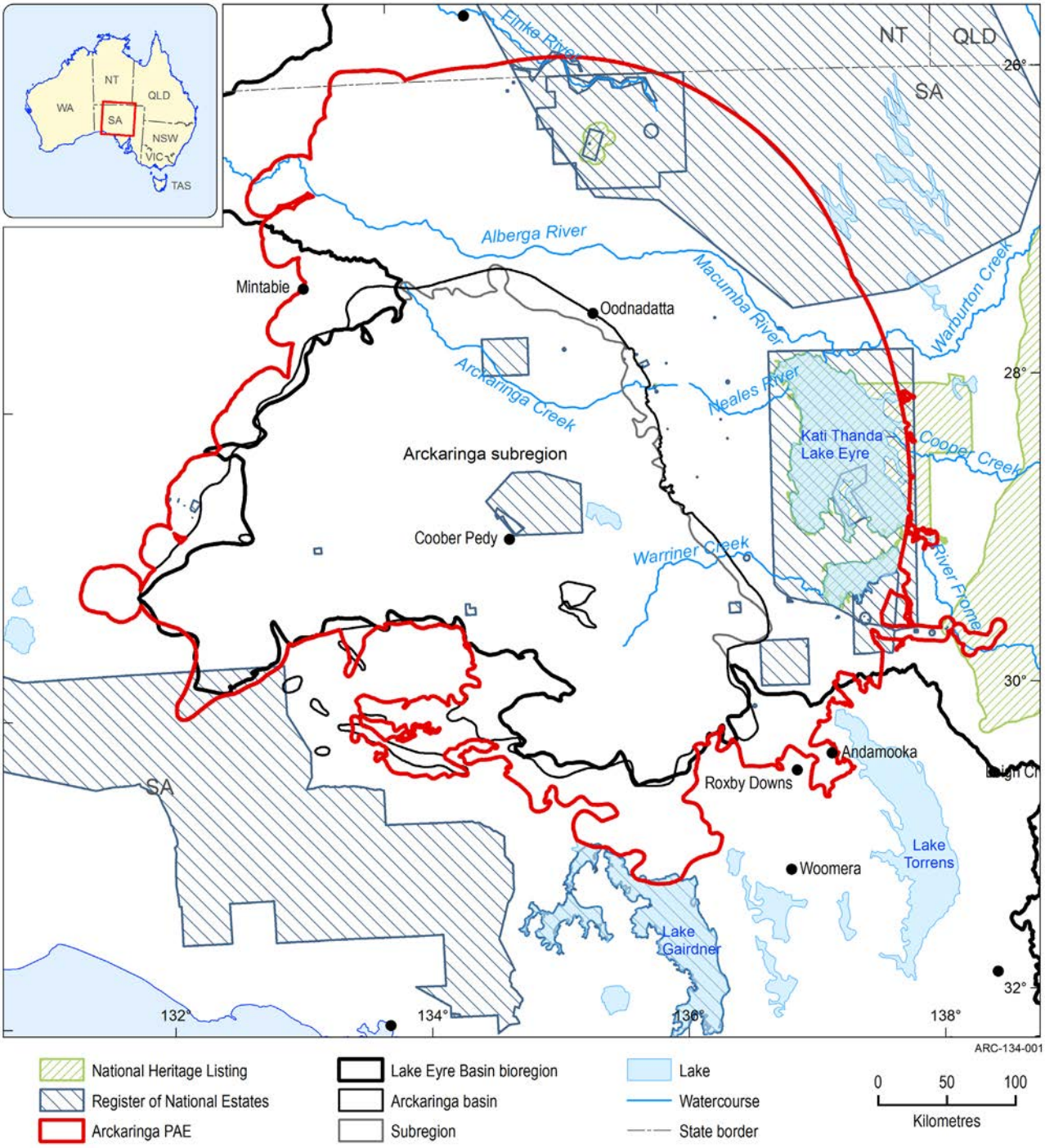

Figure 20 Location of the water-dependent sociocultural assets in the Arckaringa subregion

Data: Bioregional Assessment Programme (Dataset 1)

The four assets from the National Heritage List: the Birdsville and Strzelecki Tracks area, Dalhousie Springs, Freeling Springs and Lake Eyre National Park are all areas that have natural values and are partly or entirely protected under national and/or state conservation legislation. These sociocultural assets were also nominated as ecological assets.

Three of the five assets sourced from the RNE that are classed as heritage sites are also natural areas that have federal or state-level conservation designations (Elliot Price Conservation Park, Kati Thanda – Lake Eyre and the Simpson Desert). They were also nominated as assets from other

databases that were classified as containing ecological assets and depend on surface water, at least in part. Elliot Price Conservation Park is also groundwater dependent.

The remaining assets sourced from the RNE and classed as a heritage site (Emu Field and Strangways Springs) are historical places. Emu Field was the site of tests of nuclear weapons in 1953 (Commonwealth of Australia, 1985). It was assessed as water dependent in part, on the basis of the remotely sensed data layers. Strangways Springs was an active part of the Overland Telegraph Line from Adelaide to Darwin during the 19th century. It was assessed as water dependent because it is located near a complex of Great Artesian Basin discharge springs, after which the telegraph station was named.

The water-dependent asset register includes 46 Indigenous sites sourced from the RNE and the SA WAIT database. Other than the name and location of the asset, very little information was available to assess water dependence. Hercus (2009) described locations with similar or related names in northern SA and associated many of those locations with waterholes and rockholes. On the basis of this naming information and the secondary analyses through intersections with remotely sensed data sources, and applying the precautionary principle in each case, all of these Indigenous sites are likely or possibly dependent on surface water, and all but one site may also be dependent on groundwater.

1.3.4.2 Gaps

No further sociocultural assets were nominated following the Arckaringa asset workshop in Adelaide in March 2015.

In the Arckaringa subregion, the Bioregional Assessment Programme is awaiting the outcomes of commissioned research into the cultural values associated with water assets, including Indigenous values. The Bioregional Assessment Programme will be able to incorporate this new information once it becomes available in the future.

For bioregional assessment purposes, no other specific gaps in the knowledge base related to sociocultural assets in the Arckaringa subregion have been identified.

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