Healthy Waters Management Plan

Warrego, Paroo, Bulloo and Nebine Basins

This Healthy Waters Management Plan meets accreditation requirements for relevant water quality sections under the Water Act 2007- Basin Plan 2012.

Queensland Government

Acknowledgement of the Traditional Owners of the South West Queensland region

The Department of Environment and Heritage Protection (the department) would like to acknowledge and pay respect to the past and present Traditional Owners of the region and their Nations, and thank the representatives of the Aboriginal communities, including the Elders, who provided their knowledge of natural resource management throughout the consultation process. The department acknowledges that the Traditional Owners of the Warrego, Paroo, Bulloo and Nebine basins have a deep cultural connection to their lands and waters. The department understands the need for recognition of Traditional Owner knowledge and cultural values in water quality planning.

Prepared by: Environmental Policy and Planning, Department of Environment and Heritage Protection

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February 2016

Foreword

This document has been prepared in accordance with the Healthy Waters Management Plan requirements under the Queensland *Environmental Protection Act 1994* and Environmental Protection (Water) Policy 2009. This document also contributes to meeting particular requirements of a Water Quality Management Plan under the Commonwealth *Water Act 2007—Basin Plan 2012* (Basin Plan). The requirement for a Water Quality Management Plan is listed under Chapter 10, Part 7 of the Basin Plan. Where required, this document includes an explanation as to how the Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins contributes to meeting the requirements of a Water Quality Management Plan under the Basin Plan, as indicated by these text boxes.

What is a Healthy Waters Management Plan?

The Environmental Protection (Water) Policy 2009 (EPP Water), subordinate legislation under the *Environmental Protection Act 1994* (Qld.), establishes Healthy Waters Management Plans (HWMPs) as a key planning mechanism to improve the quality of Queensland waters.

HWMPs advance the achievement of the purpose of the EPP Water to protect Queensland's water environment whilst allowing for development that is ecologically sustainable. Healthy Waters Management Plans include:

- the identification and mapping of environmental values, the desired levels of aquatic ecosystem protection and management goals for Queensland waters
- water quality objectives (under the National Water Quality Management Strategy (NWQMS)[1] adopted by all jurisdictions) to protect the environmental values
- management responses, which address point and diffuse emission sources, and may include market-based instruments, best management practice and adaptive management.

HWMPs provide an ecosystem based approach to integrated water management, supported by best available science. The preparation of Healthy Waters Management Plans includes:

- engagement with the local government, natural resource management groups, industry groups, local Aboriginal Nations and the community
- addressing identified priority threats to water quality
- incorporating local catchment-based approaches to develop management responses.

What is a Water Quality Management Plan?

The Commonwealth *Water Act 2007—Basin Plan 2012* (Basin Plan) requires a water resource plan to include a Water Quality Management Plan (WQM Plan), prepared in accordance with Chapter 10, Part 7 of the Basin Plan. WQM Plans advance the achievement of the Basin Plan objectives and outcomes through:

- identifying the key causes of water quality degradation
- including measures to address risks arising from water quality degradation
- identifying water quality target values
- specifying measures to be undertaken in, or in relation to, the water resources of the water resource plan area
- identifying locations of water quality targets for irrigation water
- assessing and having regard to the impact of the WQM Plan on the water resources of another Basin State.

Queensland's approach to the WQM Plan is an index which refers to relevant State and Commonwealth instruments to fulfil the requirements of the Basin Plan Chapter 10, Part 7. The HWMP prepared under the EPP Water fulfils the majority of requirements of a WQM Plan. As a result, the HWMP is the primary document referred to under the WQM Plan (Refer to Figure 1).

The sections of this report that fulfil requirements of a WQM Plan under the Basin Plan include Section 7, Section 9, Section 11 and Section 13.

[1] The NWQMS is a joint strategy developed by two Ministerial Councils – the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ).


140°E
145°E
150°E
25°S
30°S
35°S
Queensland
South Australia
Bulloo River
Paroo River
Warrego River
Nebine, Mungallala and Wallam Creeks
Murray-Darling Basin
New South Wales
Victoria
SYDNEY
ADELAIDE
CANBERRA
MELBOURNE
Legend
Queensland South West region planning zones
Murray-Darling Basin planning zone
Location of Warrego, Paroo, Bulloo and Nebine basins in the Murray-Darling Basin
N
0 80 160 240 320 400
Kilometres
Prepared on: 9 February 2016
Scale: 1:10,000,000 @ A4
NT
WA
Qld
SA
NSW
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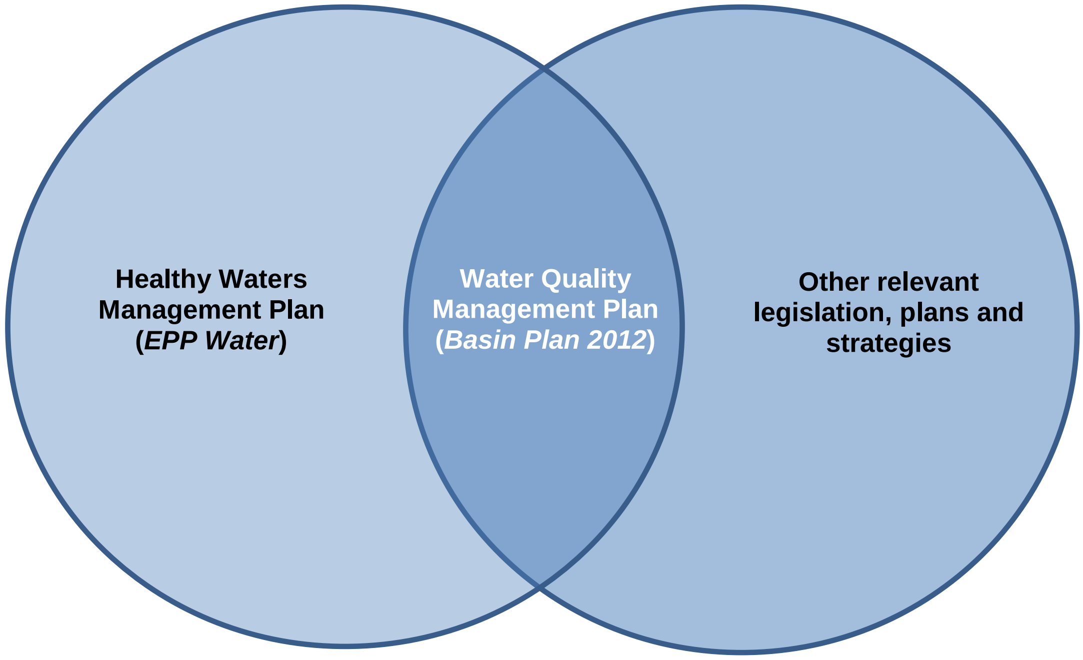

Figure 1: The WQM Plan, prepared under Chapter 10, Part 7 of the Basin Plan, is an index that refers to relevant legislation, plans and strategies that address water quality. HWMPs, prepared under the EPP Water, are the primary document referred to under the WQM Plan. Other relevant instruments that are referenced by the WQM Plan include Queensland Water Resource Plans prepared under the *Water Act 2000* and the Basin Salinity Management Strategy (Schedule B to the Murray-Darling Basin Agreement).

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Executive summary

The Healthy Waters Management Plan (HWMP) for the Warrego, Paroo, Bulloo and Nebine basins has been prepared under the Environmental Protection (Water) Policy 2009 (EPP Water), subordinate legislation under the *Environmental Protection Act 1994* (Qld.). HWMPs present ways to improve the quality of water for a specified region in Queensland. As the Warrego, Paroo and Nebine basins are located within the Murray-Darling Basin, this HWMP also contributes to the requirements of a Water Quality Management Plan (WQM Plan) under the Commonwealth *Water Act 2007— Basin Plan 2012.*

The HWMP for the Warrego, Paroo, Bulloo and Nebine basins identifies the environmental, cultural, economic and social values associated with the rivers, creeks, waterholes, floodplains, overflow channels, lakes, wetlands and groundwaters of the South West Queensland region. These are referred to under the EPP Water as 'environmental values' and are the qualities that make water suitable for supporting aquatic ecosystems and human use. The HWMP also identifies and maps the levels of aquatic ecosystem protection to inform the management of different types of aquatic ecosystems. The HWMP for the Warrego, Paroo, Bulloo and Nebine basins was developed in consultation with Queensland and New South Wales government representatives, natural resource management groups, industry groups, local Aboriginal Nations, and the community.

Management goals are established in the HWMP for the Warrego, Paroo, Bulloo and Nebine basins as the objectives and outcomes for water resources. They focus management on the achievement of locally appropriate water quality target values (water quality objectives) that have been established at sub-catchment level to protect identified aquatic ecosystem and human use environmental values for the waters. Long-term salinity planning and management is also addressed, with reference to the End-of-Valley Targets in Appendix 1 of Schedule B to the Murray-Darling Basin Agreement.

The extent and distribution of freshwater wetlands is the most important indicator of the state of wetland resources in Queensland, as any loss will mean that the services provided by that wetland will be diminished. Targets to maintain the extent of wetlands and riparian forest in the plan area are included in this report to help protect these important ecosystems.

A water quality risk assessment was conducted to identify the key types of water quality degradation occurring in the Warrego, Paroo, Bulloo and Nebine drainage basins. The risks that were identified included:

- degradation of aquatic habitat connectivity and condition, within and between water-dependent ecosystems, and the degradation of riparian extent, connectivity and condition as high risk in all four basins
- elevated levels of suspended matter and deposited sediment as very high risk in the Paroo and Bulloo basins and high risk in the Warrego and Nebine basins
- dissolved oxygen outside natural (ambient) ranges as medium risk in the Paroo and Bulloo basins
- pest fauna (land) as high risk in all four basins
- pest fauna (aquatic) as high risk in the Warrego, Paroo and Nebine basins and very high risk in Bulloo basin
- pest flora (land) as medium risk and pest flora (aquatic) as high risk in all four basins
- elevated levels of salinity a medium risk in the St George Alluvium (Deep) (WPBN).

The HWMP for the Warrego, Paroo, Bulloo and Nebine basins includes management responses to address the identified risks. The management responses seek to maintain, and where practical improve, water quality towards the achievement of water quality target values (water quality objectives) that protect the environmental values across the plan area. These management responses recognise the existing projects being conducted across Queensland Murray-Darling Basin drainage basins, which may inform future updates to this document. The HWMP for the Warrego, Paroo, Bulloo and Nebine basins also presents opportunities to strengthen the protection of Aboriginal values and uses of water, based on consultation with people from local Aboriginal Nations.

The HWMP for the Warrego, Paroo, Bulloo and Nebine basins advances the protection of the South West Queensland aquatic environment in order to achieve objectives and outcomes in relation to water quality and salinity. The plan seeks to maintain appropriate water quality for environmental, social, cultural and economic uses; protect and restore water-dependent ecosystems; and ensure water resources remain fit-for-purpose.

SECTION 1: INTRODUCTION

1 Introduction

A Healthy Waters Management Plan (HWMP) presents ways to improve the quality of water for a specified region. HWMPs are a component of the framework for managing water quality in Queensland under the Environmental Protection (Water) Policy 2009 (EPP Water), subordinate legislation to the *Environmental Protection Act 1994* (Qld.).

1.1 Water to which this plan applies

HWMPs address water quality improvement within spatially defined geographic planning areas referred to as ‘management units’, which may range in scale from sub-region, to whole of catchment, to whole of basin (comprised of multiple catchments). A HWMP applies to all Queensland State waters within the defined management units (that is rivers, creeks, wetlands, lakes and groundwaters), except the types of water listed in section 10(3) of the EPP Water.

This HWMP applies to the surface waters and groundwaters in the Warrego, Paroo, Bulloo and Nebine drainage basins that encompass the South West Natural Resource Management Region (Refer to Figure 2). This HWMP has the additional function of contributing to the Water Quality Management Plan for the Warrego, Paroo and Nebine water resource plan area[2] under Chapter 10, Part 7 of the *Basin Plan 2012* (Basin Plan).

1.2 Healthy Waters Management Plans under the Environmental Protection (Water) Policy 2009

In the following section, terminology under the Basin Plan is indicated in brackets.

HWMPs support the achievement of the purpose of the EPP Water by identifying the environmental values (values and uses), water quality objectives (water quality target values) and management goals (objectives and outcomes) of the waters in a specified region, and identifying and prioritising ways to improve water quality.

The issues identified through a HWMP are broader than ‘just water quality’. They include land management issues that have the potential to impact water quality, such as the health of the riparian zone or the management of grazing lands.

The EPP Water provides the structure for establishing HWMPs and the features contained within them—including environmental values (values and uses), water quality objectives (water quality target values) and management goals (objectives and outcomes).

The economic and social impacts of protecting environmental values (values and uses) through water quality objectives (water quality target values) are considered through consultation. At the completion of consultation and consideration of all submissions, the environmental values (values and uses) and water quality objectives (water quality target values) are subsequently recommended for inclusion under Schedule 1 of the EPP Water.

Water quality objectives under the EPP Water are long-term goals for water quality management. They are measurements, levels or narrative statements of particular indicators of water quality that protect identified environmental values. Once scheduled within the EPP Water, environmental values and water quality objectives inform statutory and non-statutory water quality management planning and decision-making.

[2] The Bulloo drainage basin is a closed drainage system and is therefore outside the scope of the Basin Plan. The Bulloo drainage basin has been included in the Healthy Waters Management Plan for Queensland planning and management purposes.

1.3 Water Quality Management Plan under the Basin Plan

The Basin Plan, prepared by the Murray-Darling Basin Authority under the Commonwealth *Water Act 2007*, was approved in November 2012. The Basin Plan provides a coordinated approach to water use across the State and Territory government areas that intersect the Murray-Darling Basin (specifically Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory). The Basin Plan aims to achieve a balance between environmental, economic and social considerations.

The Basin Plan specifies that a WQM Plan is a component of a Water Resource Plan (Commonwealth Water Resource Plan). Commonwealth Water Resource Plans under the Basin Plan are to be submitted to the Murray-Darling Basin Authority for accreditation by the Commonwealth Minister responsible for water. In Queensland, Commonwealth Water Resource Plans will be comprised of a package of existing State instruments, primarily Queensland water resource plans and resource operations plans under the *Water Act 2000* (Qld.) (Refer to Section 1.5 of this report for more information) and HWMPs under the EPP Water.

A HWMP prepared under the EPP Water contributes to meeting the requirements of a Water Quality Management Plan under Chapter 10, Part 7 of the Basin Plan. HWMPs that fulfil select requirements of a WQM Plan are progressively being developed for all Queensland Murray-Darling Basin (QMDB) drainage basins in collaboration with the three Natural Resource Management (NRM) groups of the QMDB region—South West NRM Ltd, Condamine Alliance and the Queensland Murray-Darling Committee. For each Commonwealth Water Resource Plan package submitted to the Murray-Darling Basin Authority for accreditation under the Basin Plan, the Queensland Government will include a HWMP for the relevant water resource plan area.

Four Commonwealth Water Resource Plan packages will be prepared for QMDB catchments, to be compliant with the Basin Plan by 2019:

1. Warrego-Paroo-Nebine water resource plan area
2. Condamine and Balonne water resource plan area
3. Moonie water resource plan area
4. Queensland Border Rivers water resource plan area.

Note: The Bulloo drainage basin is external to the Murray–Darling Basin and is therefore not subject to the Basin Plan.

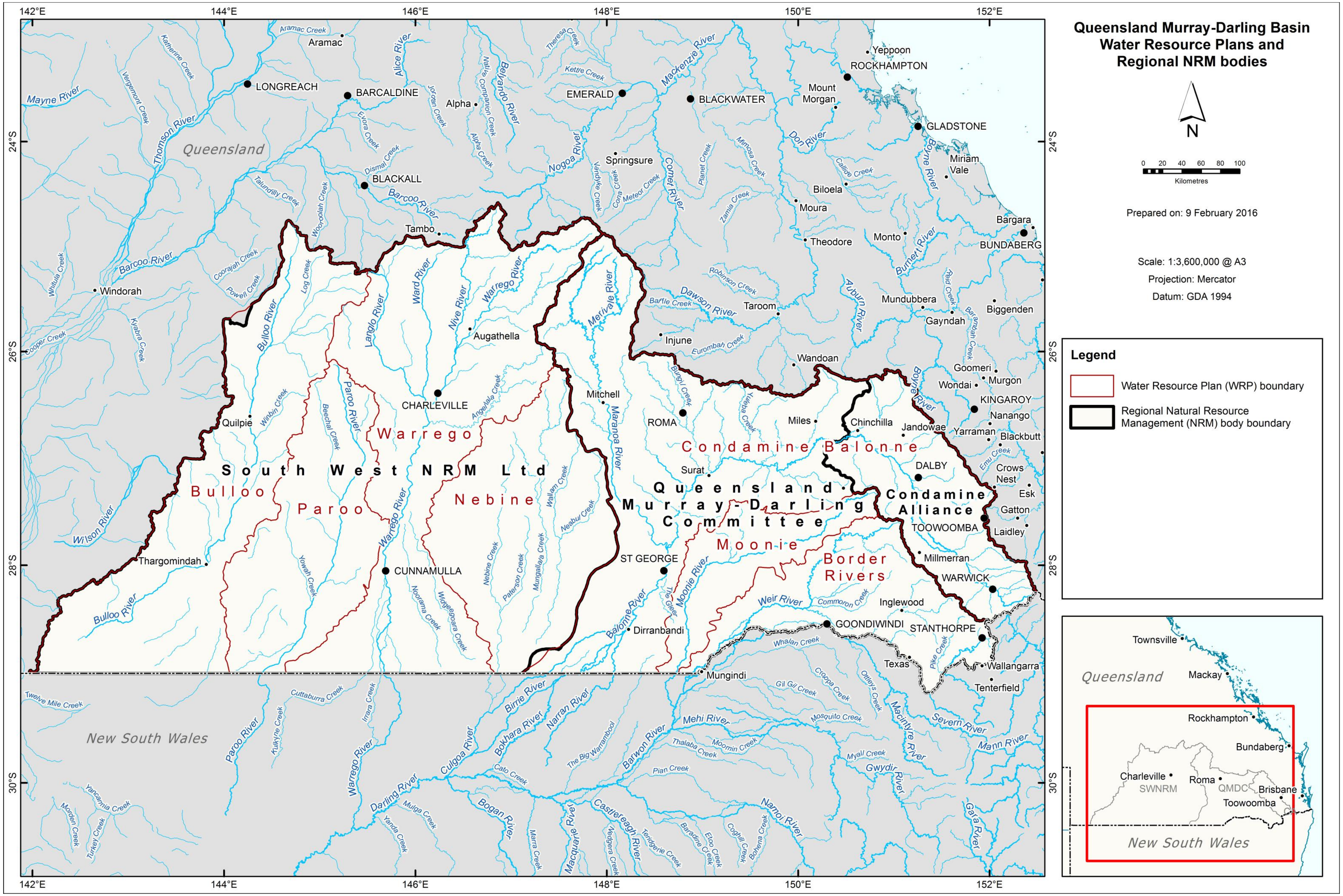

Figure 2: Queensland Murray-Darling Basin Water Resource Plans and Regional Natural Resource Management bodies. This HWMP applies to the surface waters and groundwaters in the South West NRM Ltd region, which encompasses the Warrego, Paroo, Bulloo and Nebine drainage basins.

1.4 South West Queensland Region

The South West Queensland region (SW region) covers approximately 187,000 square kilometres and contains the Bulloo, Paroo and Warrego river basins and the Nebine, Mungallala and Wallam creek catchments (collectively the Nebine drainage basin). A number of rural towns are located in the region including Augathella, Bollon, Charleville, Cunnamulla, Quilpie and Thargomindah. The local government areas that intersect the plan area are Balonne, Blackall-Tambo, Bulloo, Central Highlands, Longreach, Maranoa, Murweh, Paroo and Quilpie (WetlandInfo, 2016). Cattle and sheep grazing is the predominant industry in terms of land use area. The region is dominated by Mulga (*Acacia aneura*) vegetation. South West NRM Ltd. is the designated regional body for natural resource management in the plan area.

1.4.1 Climate

The SW region climate ranges from semi-arid to arid (<600mm rainfall per year) and is subject to extended periods of very low or no rainfall, interspersed with rainfall events often associated with monsoonal and cyclonic systems. In the western section of the region, rainfall is dominated by high intensity storms from October to January which can be very localised (Waters, 2008). Downstream flooding may occur as a result of major rainfall events in the headwaters without local rainfall. As a result, surface water flows in the region are highly variable with portions of many watercourses being ephemeral in nature.

1.4.2 Surface water

The SW region comprises approximately 51% of the Queensland section of the Murray-Darling Basin. The Warrego, Paroo and Nebine drainage basins form the headwaters of Murray-Darling Basin river systems that flow through the southern States. The Bulloo drainage basin is a closed drainage system and is not connected to the Murray-Darling Basin. Key features of the drainage basins in the SW region are:

- Bulloo—An internally draining system located between the Queensland Lake Eyre and Murray-Darling Basins, covering an area of approximately 52,000km^2.
- Paroo—The Queensland component of the drainage basin covers an area of approximately 32,000km^2, with the remaining component in New South Wales.
- Warrego—The largest drainage basin in the SW region. The majority of the basin lies in Queensland (approximately 66,000km^2) and the remainder in New South Wales.
- Nebine—This drainage basin is also connected to New South Wales. The Queensland component covers an area of approximately 37,000km^2 and includes the catchments of Nebine, Mungallala and Wallam Creeks.

1.4.2.1 Wetlands

Queensland's wetlands are important habitats and include rivers (riverine), lakes (lacustrine) and swamps (palustrine). Queensland's wetlands support the state's native biodiversity, including migratory birds, frogs, fish and threatened species. They are important for our economy because they provide nurseries for fish, water for farming and other uses. Wetlands remove sediments and transform nutrients and pesticides—protecting other downstream habitats. Wetlands are also great places to enjoy Queensland's natural wonders. Many of Queensland's wetlands are international important habitat for migratory birds and other values[3]. Wetlands of state, national and international significance (as identified through Matters of State Environmental Significance and declared Ramsar wetlands) are located in the plan area. They are a focus of ecological diversity and abundance, and are subject to booms and busts determined by seasonal and sometimes decadal conditions. The Currawinya National Park, located immediately north of the New South Wales border and south-west of Cunnamulla, includes the only Ramsar listed site in the Queensland Murray-Darling Basin, the Currawinya Lakes Ramsar site[4]. Two wetlands associated with the Paroo River in northern New South Wales (Nocoleche Nature Reserve and Peery Lake) are also declared Ramsar Wetlands. Lake Numalla and Lake Wyara wetlands, between Thargomindah and Hungerford are the two largest lakes within the Currawinya Lakes Ramsar site and National Park.

[3] What are wetlands?, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 1 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/what-are-wetlands/>.

[4] Refer to the Australian Wetlands Database listing for Currawinya Lakes (Currawinya National Park).

For an extensive range of information, tools and maps on wetlands in Queensland refer to the Wetland*Info* website.

AquaBAMM

AquaBAMM is the state endorsed method for the identification and assessment of wetlands in Queensland. AquaBAMM is a decision support tool that utilises existing information and expert input to assess conservation value in aquatic ecosystems. The output of the AquaBAMM method is an Aquatic Conservation Assessment (ACA) for a specified study area[5]

The Aquatic Conservation Assessment for the wetlands of the Queensland Murray-Darling Basin was published in July 2011 (Fielder et al., 2011). An ACA has also been prepared for the Bulloo drainage basin, as part of the broader Lake Eyre Basin assessment (EHP, 2015). ACAs provide a source of baseline, wetland conservation/ecological information to support natural resource management and planning processes. They are useful as an independent product or as an important foundation upon which a variety of additional environmental and socio-economic elements can be added and considered. The Aquatic Conservation Assessments for the wetlands of the Queensland Murray-Darling Basin and Bulloo drainage basins were a source of information for the development of this report.

The ACAs assess riverine and non-riverine (palustrine and lacustrine) wetlands separately. A project area, such as the Queensland Murray-Darling Basin, is divided into smaller subcatchment units for the assessment. The riverine or non-riverine wetlands within the subcatchment units are then assigned an AquaScore based on an assessment of eight criteria. The criteria are naturalness aquatic, naturalness catchment, diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity and representativeness. The AquaScore represents the overall conservation value of a subcatchment unit and varies from very low, low, medium, high and very high.

Figures 3 and 5 display the riverine and non-riverine AquaScores for the Queensland Murray-Darling and Bulloo drainage basins. To highlight the significant wetland areas in the plan area, Figures 4 and 6 present the riverine and non-riverine special features that were used in the development of the AquaScores. Special features are areas identified by flora, fauna and ecology expert panels. These features display characteristics which expert panels consider to be of the highest ecological importance. Special features include geomorphic features, unique ecological processes, presence of unique or distinct habitat and presence of unique or special hydrological regimes e.g. spring-fed streams[6].

1.4.2.2 Waterholes

Permanent waterholes along the river systems in the plan area provide aquatic habitat during extended periods of low or no flow and, as a result, are referred to as ‘refugial waterholes’. They are critical components of a functioning ‘source and sink’ system for aquatic organisms in the semi-arid landscapes of the SW region (Silcock, 2009).

Refugial waterholes experience variable patterns of connection and disconnection which is a fundamental driver of ecological processes in these riverine environments and is vital for dispersal and survival of diverse populations of biota. Permanent refugial waterholes require careful management, not as individual waterholes, but as an integrated system of waterholes along the length of rivers and channels.

1.4.2.3 Barriers to fish passage

Instream infrastructure, such as weirs, dams and road crossings, can limit the passage of aquatic fauna and affect their ability to migrate to new habitats for the purposes of food and spawning. Some opportunities for fish passage are provided through barrier drown-out, where water depth downstream of the barrier increases during flooding to equal or exceed the height of the barrier. However, not all fish will be able to utilise these opportunities due to their size and speed. Note that barriers in the centre of a drainage basin impact inland fish more than barriers in lowland reaches, because barriers higher in the catchment typically drown-out less frequently (Kerr et al., 2015). Figure 7 lists the barriers to fish passage in the plan area based on best available information. Further work may identify additional barriers in the plan area. It is important to consider barriers to fish passage for the purposes of the management of aquatic fauna in the plan area.

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[5] AquaBAMM, WetlandInfo 2007, Department of Environment and Heritage Protection, Queensland, viewed 1 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/resources/tools/assessment-search-tool/3/>.

[6] Aquatic Conservation Assessment FAQs, WetlandInfo 2013, Department of Environment and Heritage Protection, Queensland, viewed 1 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/assessment/assessment-methods/aca/faq/>.

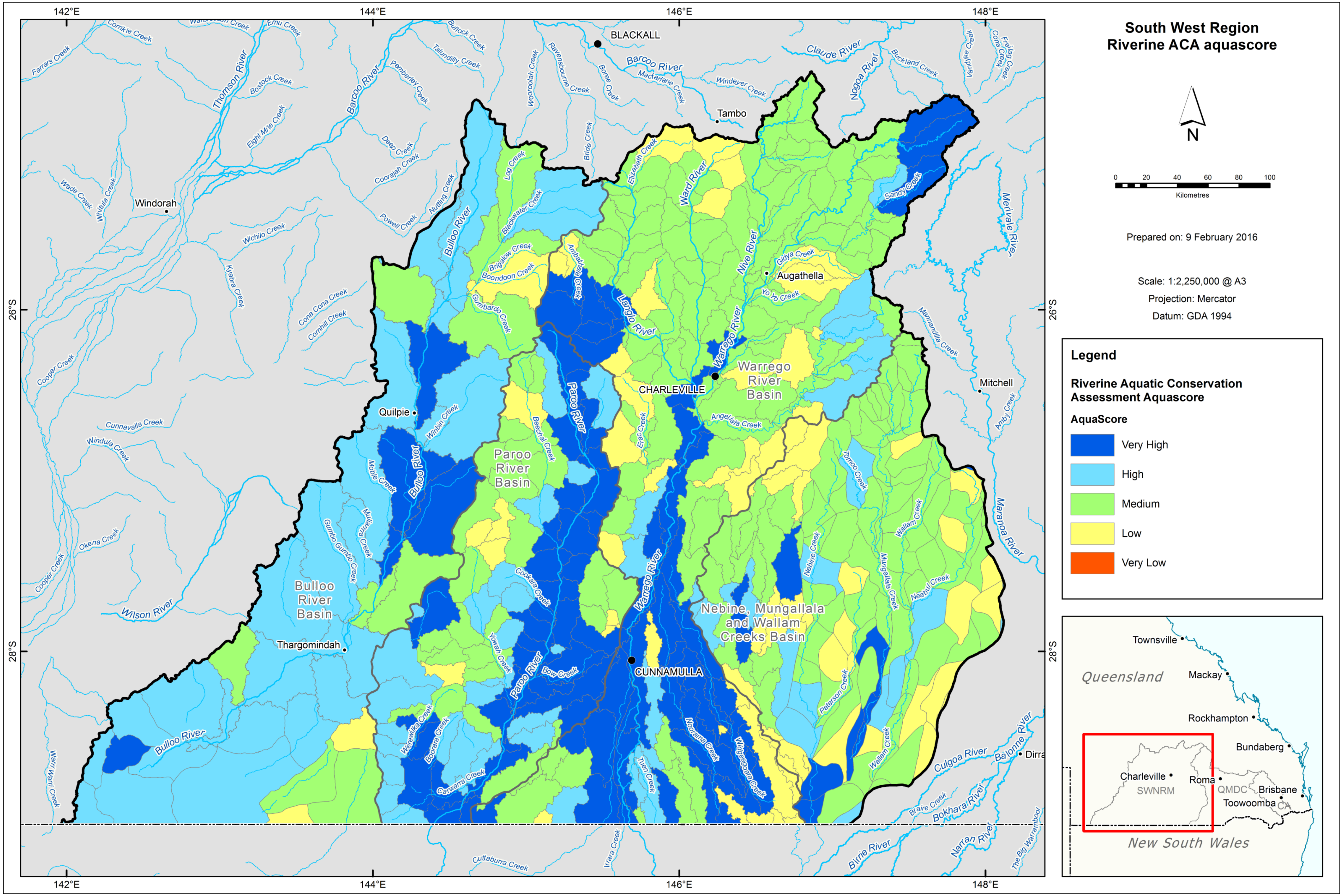

Figure 3: Riverine Aquatic Conservation Assessment AquaScores for the Warrego, Paroo, Bulloo and Nebine drainage basins (Fielder et al., 2011; EHP, 2015).

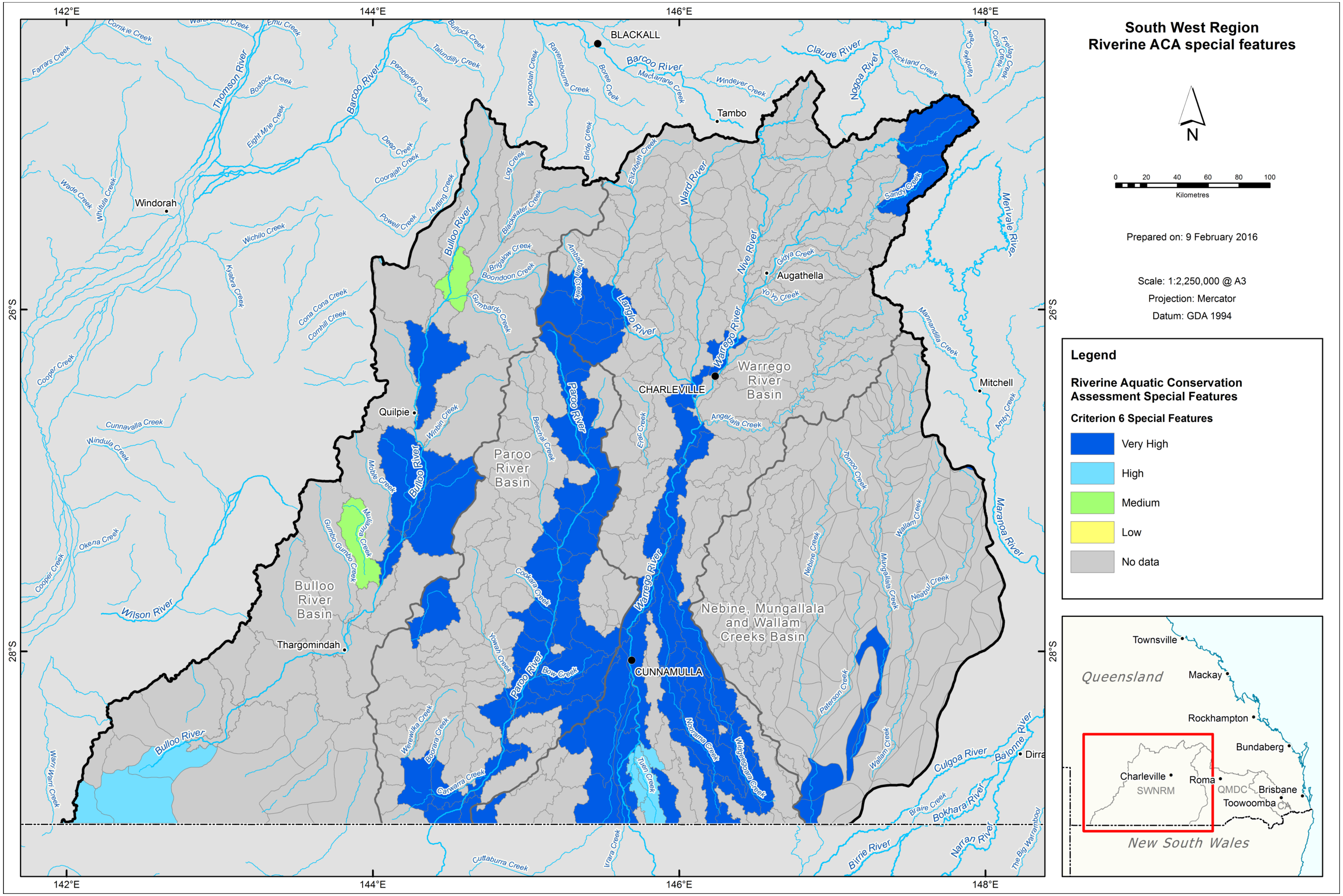

Figure 4: Riverine Special Features contributing to the Aquatic Conservation Assessment for the Warrego, Paroo, Bulloo and Nebine drainage basins (Fielder et al., 2011; EHP, 2015).

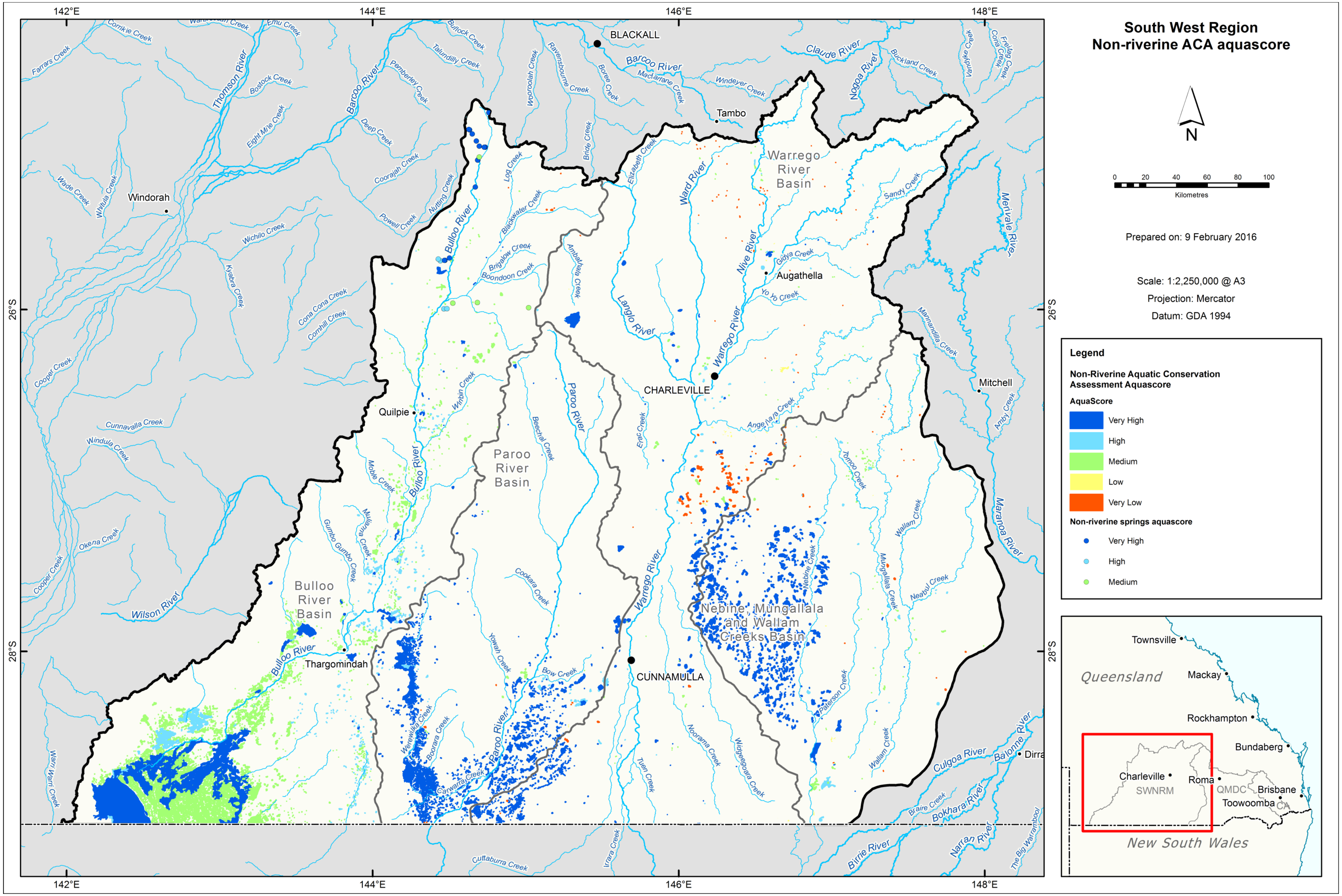

Figure 5: Non-Riverine Aquatic Conservation Assessment AquaScores for the Warrego, Paroo, Bulloo and Nebine drainage basins (Fielder et al., 2011; EHP, 2015).

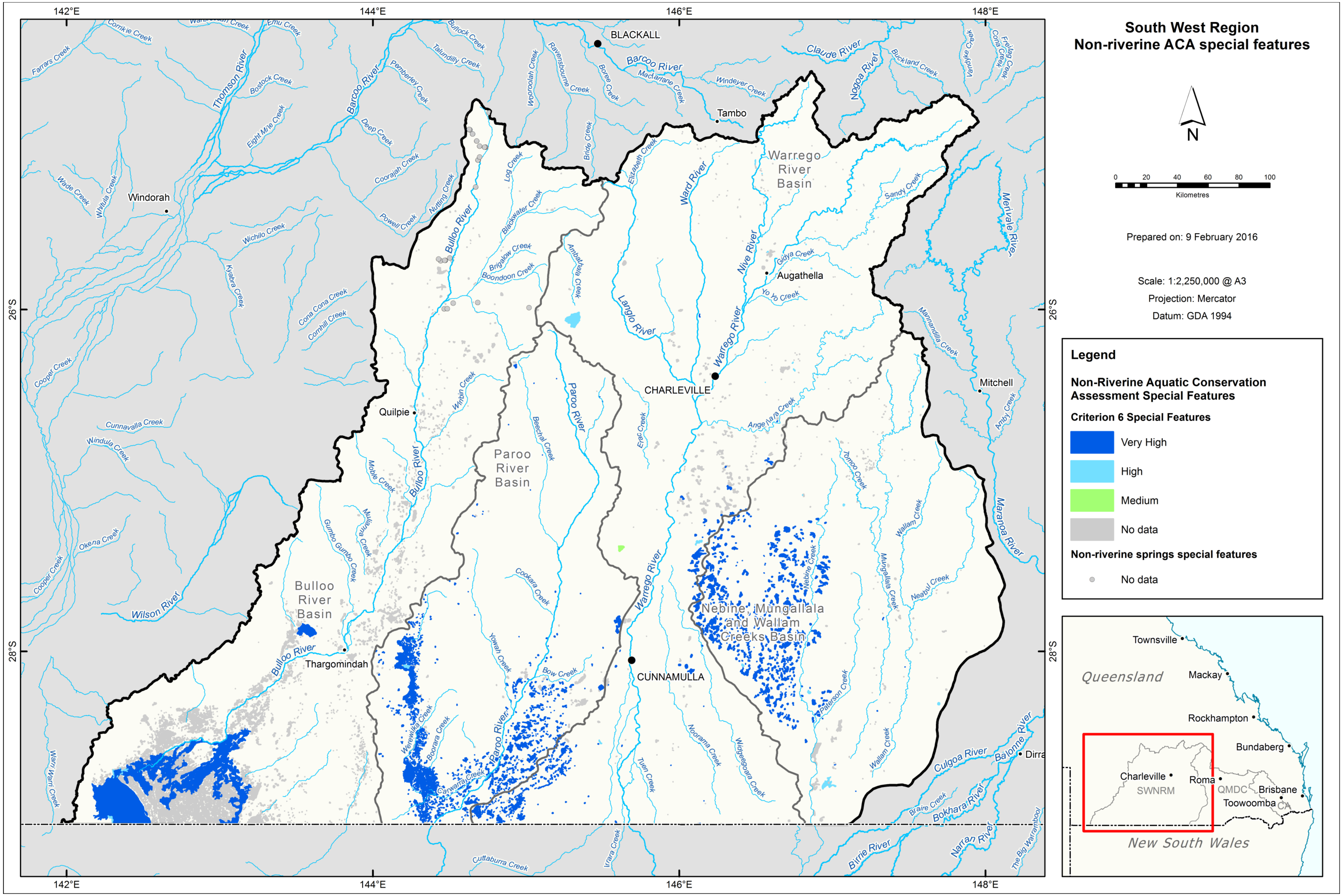

Figure 6: Non-Riverine Special Features contributing to the Aquatic Conservation Assessment for the Warrego, Paroo, Bulloo and Nebine drainage basins (Fielder et al., 2011; EHP, 2015).

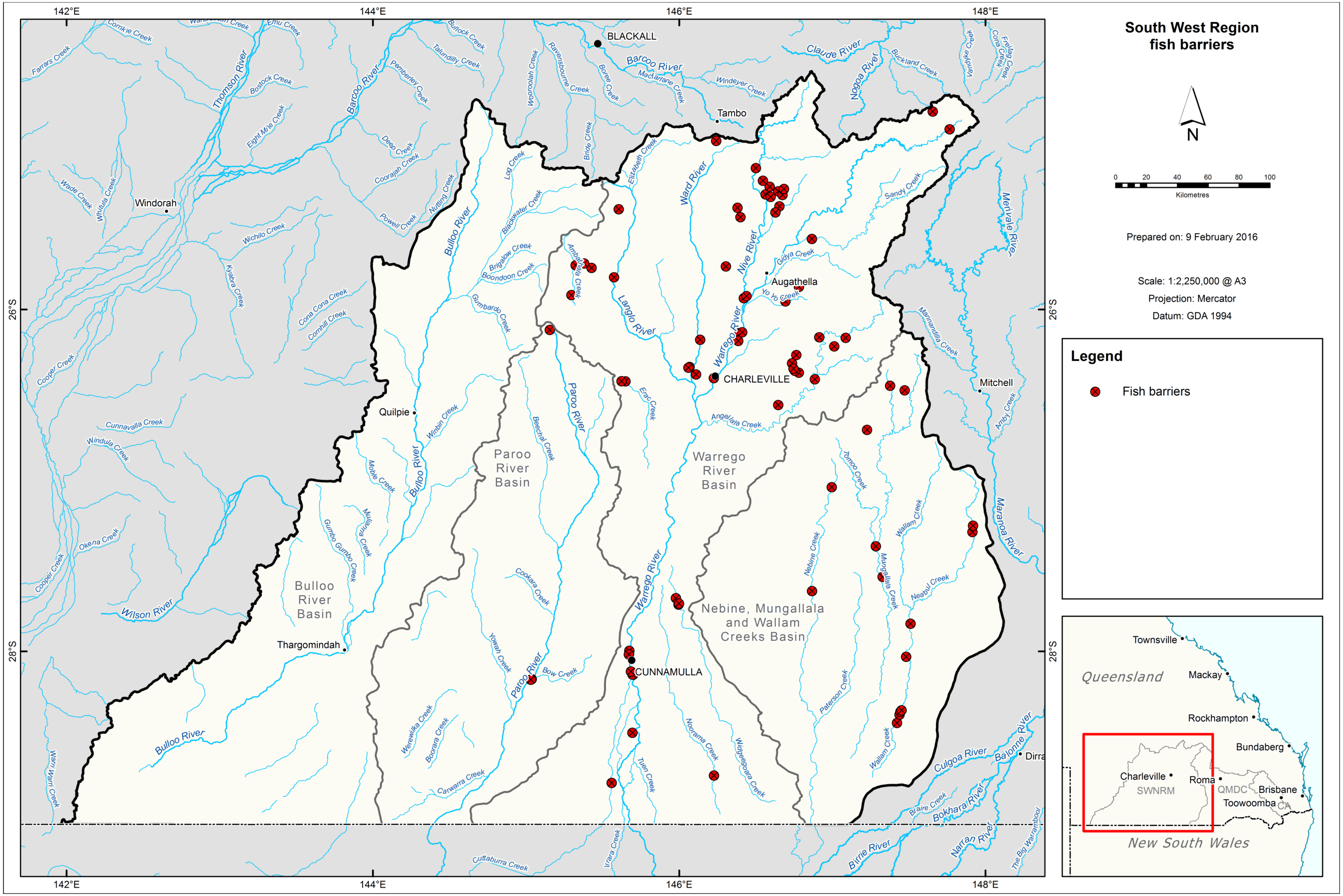

Figure 7: Barriers to fish passage, including weirs and road crossings, in the Warrego, Paroo, Bulloo and Nebine Plan area (Kerr et al., 2015).

1.4.3 Groundwater

Groundwater is present in the region in shallow alluvial and sandstone aquifers, and within the deeper confined strata of the Great Artesian Basin. The shallow aquifers are recharged locally during periods of above average rainfall. The Great Artesian Basin is recharged from infiltration occurring on the north-west slopes of the Great Dividing Range.

The Basin Plan identified three groundwater Sustainable Diversion Limit (SDL) resource units for the SW region:

- Sediments above the GAB: Warrego–Paroo–Nebine (GS60);
- St George Alluvium Warrego–Paroo-Nebine (GS63)[7]; and
- Warrego Alluvium (GS66).

Refer to Figure 8 for a map of the groundwater SDL resource units that intersect the SW region.

1.4.3.1 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Richardson et al., 2011). Ecosystem dependency on groundwater may vary temporally (over time) and spatially (depending on its location in the landscape). GDEs can include aquifers, caves, lakes, palustrine wetlands, lacustrine wetlands, rivers and vegetation[8]. It is important to note that not all groundwater dependent ecosystems are associated with a spring. Some groundwater dependent ecosystems will access groundwater that does not express at the surface, such as the roots of vegetation[9].

Refer to Figure 9 for a map of the groundwater dependent ecosystems in the plan area. A basic requirement for managing groundwater and GDEs is to understand where and how groundwater moves through the landscape. Potential GDE aquifer mapping seeks to achieve this through identifying the extent and key characteristics of GDE aquifers in a landscape. Potential GDE aquifer mapping incorporates a range of criteria including, but not limited to, confinement, geology, porosity, groundwater flow system, salinity, pH and recharge processes[10]. Figure 10 displays the potential GDE aquifers across the plan area.

[7] Note: The Basin Plan recognises the St George Alluvium groundwater aquifers in the plan area as a single SDL resource unit termed the St George Alluvium Warrego–Paroo-Nebine (GS63). However, under Queensland water resource planning, this resource unit is managed as the St George Alluvium (shallow) and the St George Alluvium (Deep).

[8] Groundwater dependent ecosystems, WetlandInfo 2014, Queensland Government, Queensland, viewed 2 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/groundwater-dependent/>.

[9] Groundwater dependent ecosystem FAQs, WetlandInfo 2012, Queensland Government, Queensland, viewed 2 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/gde-background/gde-faq/>.

[10] Potential groundwater dependent ecosystem aquifer mapping background, WetlandInfo 2013, Queensland Government, Queensland, viewed 2 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/potential-aquifer-background/>.

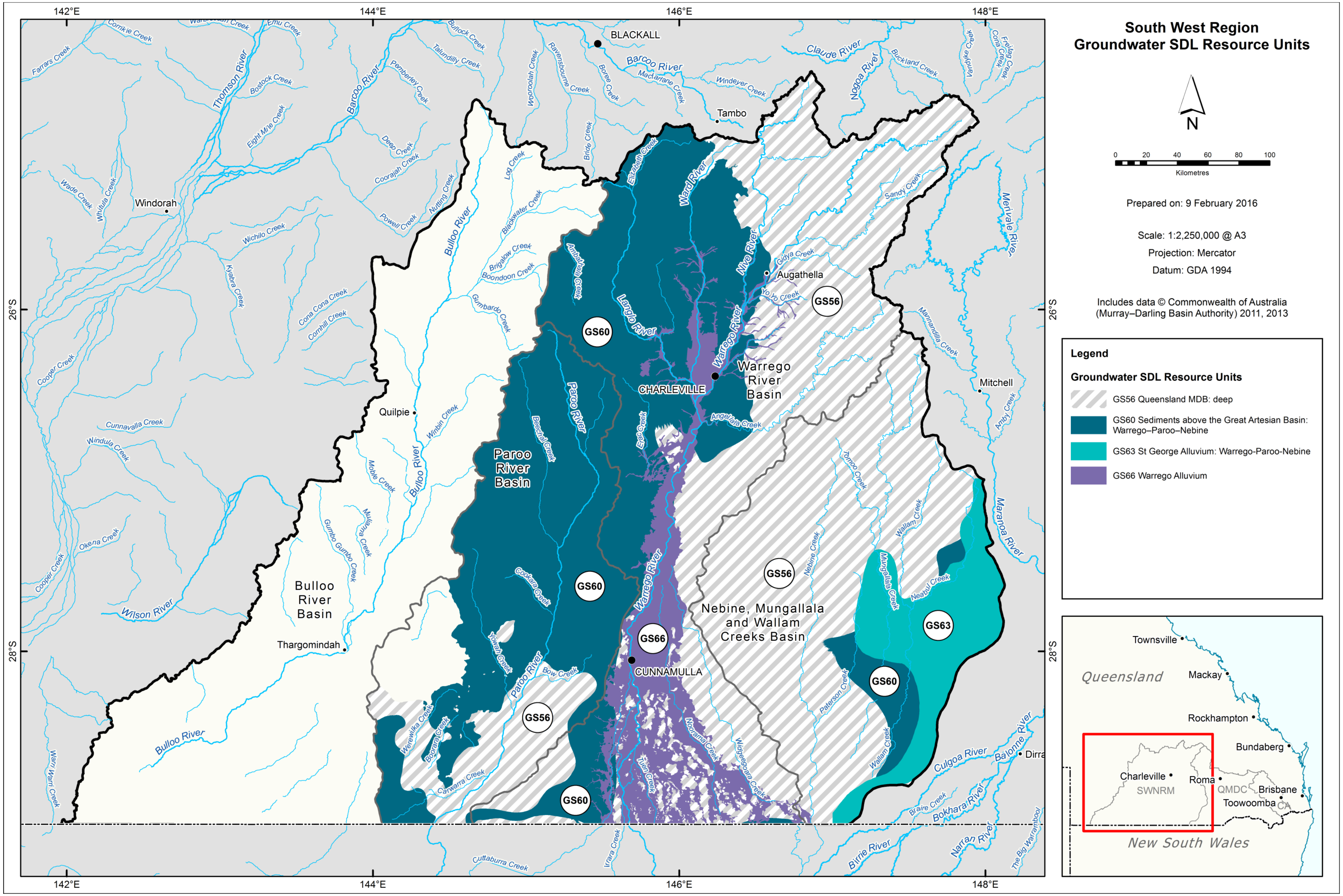

Figure 8: Groundwater Sustainable Diversion Limit resource units identified under the Basin Plan. The Groundwater Sustainable Diversion Limit resource units that apply to the plan area are the Sediments above the GAB: Warrego–Paroo–Nebine (GS60), St George Alluvium Warrego–Paroo-Nebine (GS63) and Warrego Alluvium (GS66).

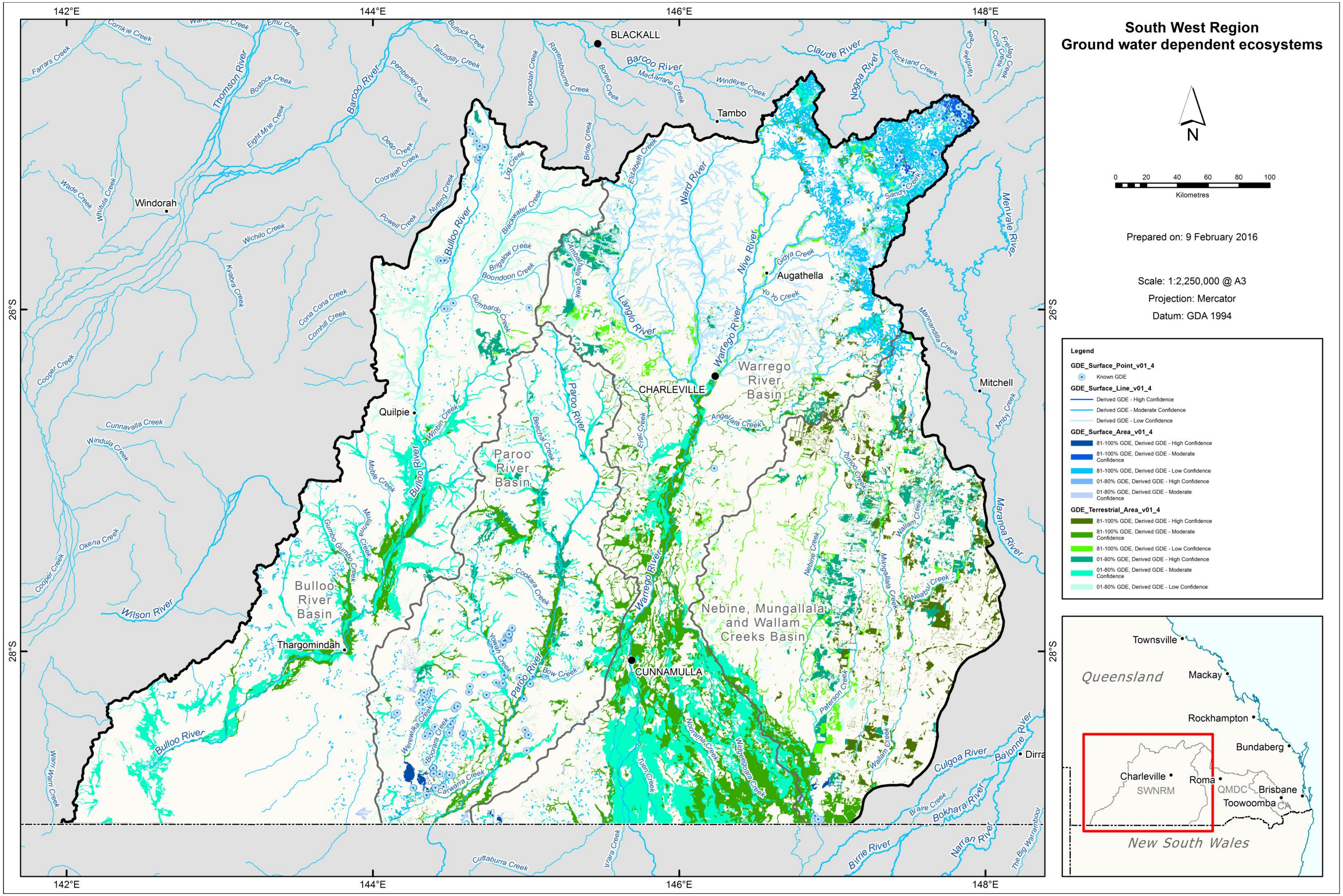

Figure 9: Groundwater dependent ecosystems in the Warrego, Paroo, Bulloo and Nebine plan area.

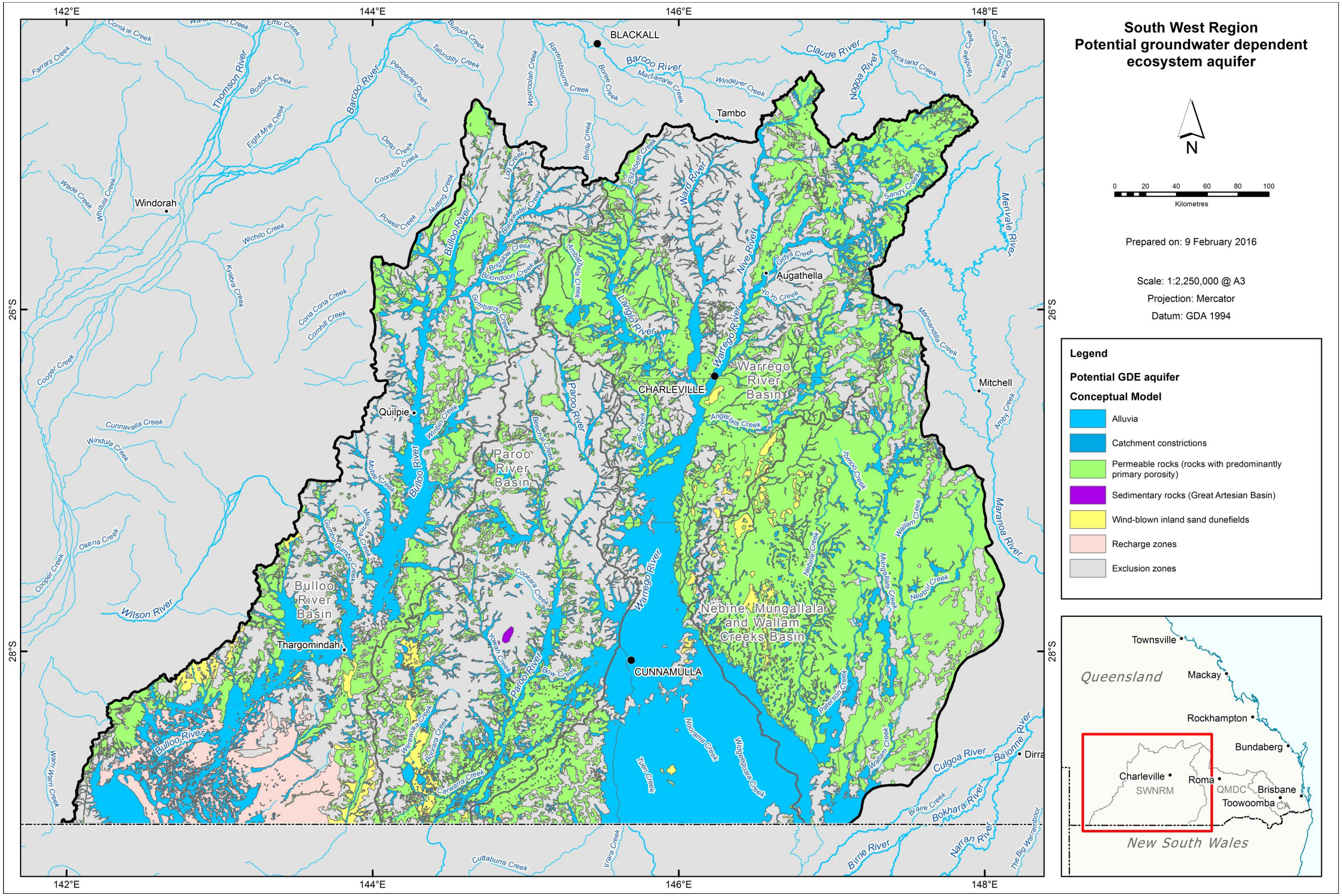

Figure 10: Potential GDE aquifer mapping within the Warrego, Paroo, Bulloo and Nebine plan area.

1.5 Queensland water resource planning

The allocation and sustainable management of water in Queensland is accomplished through the water resource planning process. This process involves the preparation of statutory water resource plans under the *Water Act 2000* (Qld.) and accompanying resource operations plans. The statutory water resource plan under the *Water Act 2000* (Qld.) for this plan area is the Water Resource (Warrego, Paroo, Bulloo and Nebine) Plan 2016*.* The Water Resource (Warrego, Paroo, Bulloo and Nebine) Plan 2016 states the outcomes, objectives and strategies for achieving a sustainable balance between water for industry, irrigators, town water supply, the community and environment. This includes the economic, social and ecological outcomes that apply to the plan area, as well as water allocation security objectives and environmental flow objectives.

As described in the introduction to this report, the Basin Plan requires Commonwealth Water Resource Plans to be submitted to the Murray–Darling Basin Authority for accreditation by the Commonwealth Minister responsible for water. The Commonwealth Water Resource Plans referred to under the Basin Plan are different from Queensland's existing statutory water resource plans. Commonwealth Water Resource Plans for Queensland Murray-Darling Basin drainage basins will comprise a package of existing State instruments and other relevant documents that meet the requirements of the Basin Plan. A key component of the Commonwealth Water Resource Plans will be Queensland water resource plans and resource operations plans prepared under the *Water Act 2000* (Qld.). There are four Queensland water resource plan areas that intersect the Murray-Darling Basin—Warrego, Paroo, Bulloo[11] and Nebine, Condamine and Balonne, Moonie and Queensland Border Rivers.

Refer to the Department of Natural Resources and Mines catchments and resource planning website for further information on Queensland water resource planning.

1.5.1 Great Artesian Basin

The Great Artesian Basin underlies the South West Region. The allocation and sustainable management of water from the Great Artesian Basin is managed separately under the Water Resource (Great Artesian Basin) Plan 2006*.* The declared Great Artesian Basin management areas within the Warrego, Paroo, Bulloo and Nebine plan area include Warrego East, Warrego West, Central and the western part of the Surat.

1.5.2 Intersecting streams

The Paroo River Intergovernmental Agreement 2003*,* between the states of Queensland and New South Wales, recognises the important social, environmental, economic and cultural values of the Paroo River system that need to be conserved, promoted or restored. The agreement provides for the development and implementation of policies and strategies concerning water resources, which affect the management of the quantity or quality of water in the river system (and associated catchment, floodplains, overflow channels, lakes, wetlands and sub-artesian waters dependent on surface flows) or the aquatic ecosystems, to avoid or eliminate adverse cross-border impacts.

Water quality monitoring data is collected from sites downstream of the State border through a joint arrangement between the Queensland and New South Wales Governments. This monitoring data was considered in developing the local water quality targets for fresh water-dependent ecosystems presented in this report.

1.6 State Planning Policy

The State Planning Policy (SPP) defines the Queensland Government's policies about matters of state interest in land use planning and development (a state interest is defined under the *Sustainable Planning Act 2009*).

1.6.1 State interest—water quality

Water quality is a state interest. The SPP (state interest—water quality) seeks to ensure that 'the environmental values and quality of Queensland waters are protected and enhanced'. It includes provisions to integrate the state interest—water quality when making or amending a planning scheme and designating land for community infrastructure. This includes the consideration of receiving waters, acid sulphate soils and development in water

[11] Although the Bulloo drainage basin is not connected to the Murray-Darling Basin, it is included in the Queensland water resource plan area with the Warrego, Paroo and Nebine drainage basins for State planning purposes.

supply buffer areas.

The provisions of the SPP are operationalised through the SPP code— water quality (Appendix 3 of the SPP, July 2014). The purpose of the code is to 'ensure development is planned, designed, constructed and operated to manage stormwater and wastewater in ways that support the protection of environmental values identified in the Environmental Protection (Water) Policy 2009*'.* The code contains detailed performance outcomes for planning schemes, development applications and land use activities to implement the code's purpose. These include stormwater management design objectives by climatic region (construction and post-construction phases).

The SPP (state interest–water quality) is supported by the State Planning Policy: state interest guideline—water quality (August 2014 and as updated). Environmental values and water quality objectives under the Environmental Protection (Water) Policy 2009 are core concepts under this guideline.

The SPP (including SPP Code) and supporting guideline are available from the Department of Infrastructure, Local Government and Planning website.

1.6.2 State Planning Policy: state interest—biodiversity

Biodiversity is a state interest. The SPP (state interest—biodiversity) seeks to ensure that 'matters of environmental significance are valued and protected and the health and resilience of biodiversity is maintained or enhanced to support ecological integrity'. It includes provisions to integrate the state interest—biodiversity when making or amending a planning scheme and designating land for community infrastructure. This includes considering matters of national, state and local environmental significance.

The SPP (state interest—biodiversity) is supported by the State Planning Policy: state interest guideline—biodiversity (August 2014 and as updated). Appendix 1 of this guideline describes the ecological value assessment methods that can be used to define specific ecological values (and condition or threats) of an area containing matters of state environmental significance, and the corresponding ecological requirements for development assessment. Environmental values and water quality objectives under the Environmental Protection (Water) Policy 2009 should be considered when assessing wetland condition and threats.

The SPP and supporting guideline are available from the Department of Infrastructure, Local Government and Planning website.

1.6.3 State Planning Policy: state interest—cultural heritage

Cultural heritage is a state interest. The SPP (state interest—cultural heritage) seeks to ensure that 'the cultural heritage significance of heritage places and heritage areas, including places of Indigenous cultural heritage, is conserved for the benefit of the community and future generations'. It includes provisions to integrate the state interest—cultural heritage when making or amending a planning scheme and designating land for community infrastructure. This includes considering and integrating matters of Aboriginal cultural heritage and Torres Strait Islander cultural heritage to support the requirements of the *Aboriginal Cultural Heritage Act 2003* and the *Torres Strait Islander Cultural Heritage Act 2003*[12]. World heritage properties, national heritage places and non-Indigenous cultural heritage places are additional considerations under the state interest—cultural heritage.

The SPP (state interest—cultural heritage) is supported by the State Planning Policy: state interest guideline—cultural heritage (July 2014 and as updated). The SPP and supporting guideline are available from the Department of Infrastructure, Local Government and Planning website.

[12] The *Aboriginal Cultural Heritage Act 2003* (ACHA) and *Torres Strait Islander Cultural Heritage Act 2003* (TSICHA) provide for the recognition, protection and conservation of Aboriginal and Torres Strait Islander cultural heritage and impose a duty of care in relation to the carrying out of activities. The requirements of the ACHA and TSICHA apply separately and in addition to the SPP.

SECTION 2: EXISTING CONDITION AND EXTENT

2 Existing condition and extent

2.1 Condition

The Queensland Government Q-catchments Program assessed the condition of the Warrego, Paroo, Nebine and Bulloo riverine ecosystems in 2012 (Negus et al, 2013a-d). Priority threats were identified for each riverine ecosystem and field assessments were conducted to determine condition. The Q-catchments Program assessed the Warrego, Paroo and Nebine riverine ecosystems as moderately disturbed and the Bulloo drainage basin as slightly disturbed. The priority threats were the same for each catchment (deposited sediment—high priority threat; introduced aquatic fauna (Table 1)—high priority threat; introduced riparian fauna—medium priority threat). Introduced riparian fauna affecting all drainage basins in the South West region include feral pig, European red fox, feral cat, wild dog, rabbit, feral goat and cane toad (Negus et al, 2012; South West NRM Ltd. consultation, 2015). The impacts and consequences of these pest fauna on aquatic ecosystems will vary, particularly in relation to the size of the animal and the numbers in a single location (Negus et al, 2012). In-stream watering of livestock is also a key threat to the stability of riparian areas and permanent waterholes in the South West region (Negus et al, 2012). Consultation with South West NRM Ltd (2015) has identified that uncontrolled grazing pressure through overstocking and concentration of stock in riparian areas and waterways is causing land erosion, sedimentation of rivers, pollution of water resources and degradation of environmental assets.

Preserving the Bulloo river system from invasion by European carp and Redclaw crayfish is of very high importance for natural resource management in the South West region. The Bulloo river system is the only drainage basin in the South West region that does not have carp (Table 1).

Table 1: Presence of instream pest fauna in the Warrego, Paroo, Bulloo and Nebine drainage basins acquired through expert opinion and field assessment (Negus et al, 2012; South West NRM Ltd. consultation, 2015).

Species	Bulloo	Paroo	Warrego	Nebine
European carp	× (High potential)	✓	✓	✓
Eastern mosquitofish	✓ (Expert review)	✓	✓	✓ (Expert review)
Goldfish	✓ (Expert review)	✓	✓	✓ (Expert review)
Redclaw crayfish	× (High potential)	×	×	×

The Q-catchments report indicated additional information is required to further assess the extent and impact of deposited sediment in the Bulloo, Paroo, Warrego and Nebine drainage basins (Negus et al, 2012). Some work on the impacts of sedimentation on wetlands has been conducted at the Currawinya Lakes Ramsar site in the lower Paroo. Timms (1997) found that:

Lake Karatta has shallowed 42cm and that about 200,000m^3 of sediment has been deposited in the lake, largely in the last few decades. The water is also very turbid, whereas it once was probably clear.

In addition, a subsequent report by Timms (2005) identified the following:

Gidgee Lake on Bloodwood Station has been infilled by almost 25 cm during the last 50 years[13], and in Lake Wyara in the Currawinya National Park, deltaic deposits threaten to connect islands to the shore.

These reports highlight the significant risk to downstream lakes, waterholes and the Currawinya Ramsar site of suspended and deposited sediment in the South West region. Timms (2005) cautions that if unmanaged, the lakes

[13] Located in New South Wales.

may become unable to fill due to the volume of sediment. The stream deltas entering Lake Wyara have grown to engulf a large area of the lake, and are likely to connect islands to the shoreline (Timms, 2005).

This could eventually threaten the safety of bird breeding islands from terrestrial predators and compromise the values of the Currawinya Lakes Ramsar site. Bartley et al. (2006) and South West NRM Ltd have acknowledged the importance of maintaining ground cover to reduce sedimentation in Australian rangelands.

Permanent waterholes along the river systems in South West region are important aquatic habitats during extended periods of low or no flow and, as a result, are referred to as 'refugial waterholes'. Research on refugial waterholes in other catchments in the Murray-Darling Basin has shown that the persistence of these waterholes is being very significantly impacted by increases in sedimentation over the past 50 years (Lobegeiger, 2010). Sedimentation is reducing the volume of these refugia, causing the waterholes to dry out more quickly. It is likely that the same processes are occurring in the refugial waterholes of the South West region. If left unmanaged, these processes will eventually reduce the persistence of critical refugia such that they will completely dry out during prolonged droughts. This would have very major impacts on the distribution of aquatic biota across South West drainage basins.

The riparian forest loss from pre-European settlement to 2013 was determined through remote sensing and spatial analysis as 17.4% for the Bulloo River catchment, 15.7% for the Paroo River catchment, 23.1% for the Warrego River catchment and 34.4% for the Nebine catchment (Clark et al., 2015). Riparian vegetation, including grasses, is important for the movement of water, nutrients, sediment and species (Naiman and Decamps, 1997). Riparian vegetation stabilises riverbanks and captures sediment, nutrients and other contaminants contained in run-off before it reaches waterways. Clearing of riparian vegetation can result in increased sedimentation of aquatic ecosystems as the riparian vegetation is no longer present to perform these functions. Clearing of riparian vegetation also reduces connectivity of plant and animal habitats. The Nebine/Wallam creek catchment had the highest rates of riparian forest loss between 2005 and 2009 in comparison to other catchments in Queensland (EHP, 2012).

The Water Quality Technical Panel (Refer to section 4.1) assessed water quality in the South West region using best available data. The panel noted that data is limited at some locations in the South West region and is a key knowledge gap. Good water quality occurs in the upper headwaters of the drainage basins in the South West region. As described above, the mid/lower reaches are impacted by sediment run-off, primarily due to lack of groundcover and loss of riparian vegetation. The Water Quality Technical Panel suggested that high copper and aluminium levels in some South West region drainage basins (including Nebine, Upper Bulloo and Paroo) are likely due to natural causes as land-use based inputs of copper and aluminium in these drainage basins were assessed as minimal (DSITIA, 2012). Local data indicates that nutrient levels in the South West region are highly variable depending on flow. Additional data is required to assess the levels of pesticides in South West drainage basins. At present, in-stream salinity is not high compared to other areas of the Murray-Darling Basin. However, it has the potential to become a water quality issue if land uses that increase salinity levels are not managed appropriately into the future.

Land-based Weeds of National Significance and other exotic weeds of concern in the South West region include the following:

1. Paroo drainage basin: Parkinsonia, Noogoora Burr and Bathurst Burr
2. Bulloo drainage basin: Mesquite and Parkinsonia
3. Warrego drainage basin: African Boxthorn, Mesquite, Mimosa Bush, Mother of Millions, Noogoora Burr, Parkinsonia, Parthenium, Prickly Pear and Coral Cactus
4. Nebine/Mungallala/Wallam drainage basin: Bathurst Burr, Harrisia Cactus, Mimosa Bush, Mother of Millions, Parkinsonia, Parthenium, Prickly Pear (South West NRM, 2012 and 2014).

Land-based weeds compete with native plants and reduce the quality of habitat for native animals.

Aquatic weeds have a range of impacts on South West drainage basins, including reducing in-stream dissolved oxygen levels. Water lettuce is well-established in the Nebine/Mungallala/Wallam and Warrego drainage basins due to favourable conditions (DEEDI, 2012). These drainage basins are also at a high risk of Hymenachne becoming established (DEEDI, 2011). The Water Quality Technical Panel identified that the Paroo and Bulloo drainage basins are at risk of water lettuce becoming established. The Allan Tannock Weir at Cunnamulla experienced high growth rates of the Azolla fern in 2015.

Water resource development is minimal in the South West region. There is an end-of-system mean annual flow of 99% for the Bulloo and Paroo drainage basins, 89% for the Warrego drainage basin and 87% for the Nebine drainage basin (DNRM, 2014). A review of water resource planning in the Warrego, Paroo, Bulloo and Nebine drainage basins indicated that there is a low risk to surface water ecological assets from water resource management activities in the South West region (DSITIA 2013). The State of Environment 2011 report identified that the Bulloo drainage division has one of the greatest area and density of wetlands in Queensland (EHP, 2012).

The HWMP for the Warrego, Paroo, Bulloo and Nebine basins seeks to maintain and where necessary, improve the condition of water resources and address, where appropriate, the matters identified above.

2.2 Extent

The extent and distribution of freshwater wetlands is the most important indicator of the state of wetland resources in Queensland, as any loss will mean that the services provided by that wetland will be diminished. Different wetland systems provide different values to society. These values can vary throughout the State and can be affected by changes in extent.

Freshwater wetlands include:

Riverine wetlands[14]: Systems that are contained within a channel (e.g. river, creek or waterway) and their associated streamside vegetation.
Lacustrine wetlands (lakes)[15]: Systems that are dominated by open water. Although lakes may have fringing vegetation, the majority of the wetland area is open water. Lacustrine systems in Queensland, particularly in arid and semi-arid areas, are highly variable. Some are known to dry out and to support species adapted to these conditions, while others stay wet for long periods and provide a refuge for many species during dry times.
Palustrine wetlands[16]: Systems traditionally considered as a wetland. They are vegetated, non-riverine or non-channel systems and include billabongs, swamps, bogs, springs, soaks etc. They have more than 30% emergent vegetation and are an important part of the landscape, providing habitat and breeding areas for a wide variety of species.

The tables below specify the area of freshwater wetlands (by system) in the plan area as a whole, as well as within each individual drainage basin.

Table 2: Wetland area by system (2013): Whole of plan area

System	Area (km^2)	Wetlands area (%)	Total area (%)
Artificial and highly modified	47.5	0.9	0.0
Lacustrine	694.3	13.6	0.4
Palustrine	3776	74.0	2.0
Riverine	585	11.5	0.3
Total	**5102.8**	**100.0**	**2.7**

Note: Areas are approximate and calculated using the GDA94/Australian Albers projection. Areas may change over time as mapping approaches improve. Totals may not match the sum of individually displayed figures due to the rounding of displayed figures.

Source: Warrego, Paroo, Bulloo and Nebine water resource planning area — facts and maps, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 1 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/water-resource-planning-area-warrego-paroo-bulloo-and-nebine/>.

[14] Riverine ecology, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 1 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/riverine/>.

[15] Lacustrine ecology, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 1 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/lacustrine/>.

[16] Palustrine ecology, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 1 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/palustrine/>.

Table 3: Wetland area by system (2013): Water resource plan basins

System	Area (km²)	Wetlands area (%)	Total area (%)
Warrego			
Artificial and highly modified	27.0	3.4	0.0
Lacustrine	126.1	15.9	0.2
Palustrine	296.4	37.3	0.4
Riverine	344.7	43.4	0.5
Total	**794.2**	**100.0**	**1.2**
Paroo			
Artificial and highly modified	2.4	0.3	0.0
Lacustrine	313.7	43.0	1.0
Palustrine	340.3	46.6	1.1
Riverine	73.6	10.1	0.2
Total	**730.0**	**100.0**	**2.3**
Bulloo			
Artificial and highly modified	4.0	0.1	0.0
Lacustrine	232.7	8.6	0.4
Palustrine	2440.1	90.1	4.7
Riverine	31.2	1.2	0.1
Total	**2708.0**	**100.0**	**5.2**
Nebine			
Artificial and highly modified	14.1	1.6	0.0
Lacustrine	21.7	2.5	0.1
Palustrine	699.2	80.3	1.9
Riverine	135.6	15.6	0.4
Total	**870.6**	**100.0**	**2.3**

Note: Areas are approximate and calculated using the GDA94/Australian Albers projection. Areas may change over time as mapping approaches improve. Totals may not match the sum of individually displayed figures due to the rounding of displayed figures.

Source: Warrego, Paroo, Bulloo and Nebine water resource planning area — wetland extents (2016), WetlandInfo, Department of Environment and Heritage Protection, Queensland.

Wetlands can also be described by type of habitat that occurs within the system. The table below specifies the wetland area by habitat for the plan area. Refer to the Queensland WetlandInfo website for conceptual models that describe each habitat type in terms of its hydrology, geomorphology, fauna and flora.

Table 4: Wetland area by habitat (2013): Whole of plan area

Habitat	Area (km^2)	Wetlands area %	Total area (%)
Coastal and sub-coastal non-floodplain tree swamp—Melaleuca spp. and Eucalypus spp.	1.0	0.0	0.0
Coastal and sub-coastal non-floodplain grass sedge and herb swamp	0.1	0.0	0.0
Coastal and sub-coastal floodplain tree swamp—Melaleuca spp. and Eucalypus spp.	1.9	0.0	0.0
Coastal and sub-coastal floodplain grass, sedge, herb swamp	0.1	0.0	0.0
Arid and semi-arid saline swamp	45.7	0.9	0.0
Arid and semi-arid tree swamp (floodplain)	109.3	2.1	0.1
Arid and semi-arid lignum swamp (floodplain)	1397.1	27.4	0.7
Arid and semi-arid grass, sedge and herb swamp (floodplain)	520	10.2	0.3
Arid and semi-arid tree swamp (non-floodplain)	24	0.5	0.0
Arid and semi-arid lignum swamp (non-floodplain)	621.2	12.2	0.3
Arid and semi-arid grass, sedge and herb swamp (non-floodplain)	1054.6	20.7	0.6
Arid and semi-arid non-floodplain spring swamp	1.0	0.0	0.0
Arid and semi-arid saline lake	89.6	1.8	0.0
Arid and semi-arid floodplain lake	236.7	4.6	0.1
Arid and semi-arid non-floodplain lake	189.4	3.7	0.1
Arid and semi-arid non-floodplain lake—claypans	178.5	3.5	0.1
Artificial and highly modified wetlands (dams, ring tanks, irrigation channels)	47.5	0.9	0.0
Riverine	585	11.5	0.3
Total	**5102.8**	**100.0**	**2.7**

Note: Areas are approximate and calculated using the GDA94/Australian Albers projection. Areas may change over time as mapping approaches improve. Totals may not match the sum of individually displayed figures due to the rounding of displayed figures.

Source: Warrego, Paroo, Bulloo and Nebine water resource planning area — facts and maps, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 1 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/water-resource-planning-area-warrego-paroo-bulloo-and-nebine/>.

The extent of wetlands in Queensland is affected primarily by drainage, clearing or levelling in lowland parts of catchments due to intensive agriculture and urbanisation. The greatest losses have occurred in the palustrine and riverine systems. At a statewide scale, an estimated 94% of pre-clear extent of freshwater wetland remains. Estimated historical loss of wetlands is unevenly distributed across drainage divisions and catchments with:

- 84% remaining in the Queensland Murray-Darling division
- 50% remaining in the North East Coast (non-Great Barrier Reef (GBR)) division
- 80% remaining in the North East Coast—GBR division
- close to 100% remaining in the other divisions (including the Bulloo drainage basin).

Of the three freshwater wetland systems (lacustrine, palustrine, riverine) in Queensland, one of the greatest ongoing losses has occurred in palustrine and riverine systems in the Murray-Darling drainage division. Within this division, historical loss of freshwater wetland extent is unevenly distributed. The Macintyre, Weir and the Dumaresq have less than, or equal to, 50% remaining. Historical loss of palustrine wetlands in the Moonie, Macintyre and Weir catchments has resulted in less than 25% remaining.

Ongoing net loss of wetlands in the Queensland Murray-Darling drainage division over the 2001-05, 2005-09 and 2009-13 periods has continued to decrease from an initial high rate of over 1500 hectares (ha) to 291ha (2009-13)—a rate of 72ha per year. Most of this loss is due to broad acre land clearing of riverine and palustrine wetlands, primarily in the Warrego drainage basin. In the Bulloo drainage division, ongoing loss over the 2001-05, 2005-09 and 2009-13 periods has been loss of palustrine wetlands and remained constant between 15ha and 20ha over each period (a rate of 4-5ha per year).

There are 40,901ha of freshwater wetlands within protected areas in the Queensland Murray-Darling drainage division. This amounts to 9% of the total 432,603ha of freshwater wetlands in the division and 0.7% across the state. The majority (78%) of freshwater wetlands that are in protected areas are contained within national parks. The rest are mostly within nature refuges (19%). Both lacustrine and palustrine wetlands are reasonably well represented in protected areas, at 14% and 11% respectively, however only 1% of riverine wetlands are contained within protected areas.

In the Bulloo drainage division, there are 116,427ha of freshwater wetlands in protected areas, which equates to 43% of freshwater wetlands in the division and 2.1% across Queensland. Proportionally, it is the most protected drainage division in the state. Freshwater wetlands are only represented in the nature refuges protected area type in Bulloo, with none in national parks or regional parks. While there are more palustrine wetland systems contained in protected areas (over 98,080ha, or 40%), the largest represented system is lacustrine wetlands, with up to 77% protected. The opposite can be said for riverine systems, with only 5% protected.

The tables below specify the change in wetland extent (by system) in the plan area as a whole, as well as within each individual drainage basin.

Table 5: Wetland extent change by system: Whole of plan area

System	2013 area (km^2)	2009 area (km^2)	2005 area (km^2)	2001 area (km^2)	2013/pre-clear (%)
Artificial and highly modified	47.5	47.1	46.2	43.9	n/a
Lacustrine	694.3	694.3	694.3	694.2	99.8
Palustrine	3776.0	3776.4	3779.0	3787.8	97.7
Riverine	585.0	587.1	589.8	599.2	93.1
Total	**5102.8**	**5104.9**	**5109.3**	**5125.1**	**95.7**

Note: Areas are approximate and calculated using the GDA94/Australian Albers projection. Areas may change over time as mapping approaches improve. Totals may not match the sum of individually displayed figures due to the rounding of displayed figures.

Source: Warrego, Paroo, Bulloo and Nebine water resource planning area — facts and maps, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 1 February 2016, <http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/water-resource-planning-area-warrego-paroo-bulloo-and-nebine/>.

Table 6: Wetland extent change by system: Water resource plan basins

System	2013 area (km^2)	2009 area (km^2)	2005 area (km^2)	2001 area (km^2)	2013/pre-clear (%)
Warrego					
Artificial and highly modified	27.0	26.7	25.9	24.2	n/a
Lacustrine	126.1	126.1	126.1	126.1	99.7
Palustrine	296.4	296.5	298.3	302.3	92.4
Riverine	344.7	346.7	349.3	354.0	86.2
Total	**794.2**	**796.1**	**799.7**	**806.6**	**87.9**
Paroo					
Artificial and highly modified	2.4	2.4	2.4	2.1	n/a
Lacustrine	313.7	313.7	313.7	313.7	100.0
Palustrine	340.3	340.3	340.3	341.4	97.5
Riverine	73.6	73.6	73.6	77.1	97.1
Total	**730.0**	**730.0**	**730.1**	**734.3**	**97.5**
Bulloo					
Artificial and highly modified	4.0	3.9	3.9	3.8	n/a
Lacustrine	232.7	232.7	232.7	232.7	99.6
Palustrine	2440.1	2,440.2	2,440.4	2,440.6	99.8
Riverine	31.2	31.2	31.2	31.2	97.4
Total	**2708.0**	**2,708.0**	**2,708.2**	**2,708.2**	**99.0**
Nebine					
Artificial and highly modified	14.1	14.1	14.0	13.8	n/a
Lacustrine	21.7	21.7	21.7	21.7	100.0
Palustrine	699.2	699.3	699.9	703.4	93.0
Riverine	135.6	135.6	135.7	137.0	97.6
Total	**870.6**	**870.8**	**871.4**	**875.9**	**94.4**

Note: Areas are approximate and calculated using the GDA94/Australian Albers projection. Areas may change over time as mapping approaches improve. Totals may not match the sum of individually displayed figures due to the rounding of displayed figures.

Source: Warrego, Paroo, Bulloo and Nebine water resource planning area — wetland extents (2016), WetlandInfo, Department of Environment and Heritage Protection, Queensland.

SECTION 3: OBJECTIVES AND OUTCOMES FOR WATER RESOURCES

3 Objectives and outcomes for water resources

The objectives and outcomes for water resources[17] are stated below. Specific objectives and outcomes apply to the waters of the Murray-Darling Basin as a whole and the waters of the Warrego, Paroo, Bulloo and Nebine drainage basins. The relevant section numbers are listed for objectives and outcomes derived from the Basin Plan.

3.1 Objectives and outcomes for Murray-Darling Basin water resources (whole system)

The following objectives and outcomes apply to the drainage basins in the South West region that are connected to the Murray-Darling Basin, specifically the Paroo and Warrego river basins and the Nebine, Mungallala and Wallam creek catchments.

3.1.1 Objectives and outcome to contribute to the achievement of the Murray-Darling Basin Plan

The relevant objectives for **water quality** are:

a. to give effect to relevant international agreements through the integrated management of Basin water resources
b. to establish a sustainable and long-term adaptive management framework for Basin water resources, that takes into account the broader management of natural resources in the Murray-Darling Basin
c. to optimise social, economic and environmental outcomes arising from the use of water resources.

(Reflects Basin Plan Section 5.02, 1a-c)

The outcome for the Basin Plan as a whole is a healthy and working Murray-Darling Basin that includes:

a. communities with sufficient and reliable water supplies that are fit for a range of intended purposes, including domestic, recreational and cultural use; and
b. productive and resilient water-dependent industries, and communities with confidence in their long-term future; and
c. healthy and resilient ecosystems with rivers and creeks regularly connected to their floodplains and ultimately, the ocean.

(Reflects Basin Plan Section 5.02, 2a-c)

3.1.2 Objectives and outcome in relation to environmental outcomes

The objectives in relation to environmental outcomes are, within the context of a working Murray-Darling Basin:

a. to protect and restore water-dependent ecosystems of the Murray-Darling Basin; and
b. to protect and restore the ecosystem functions of water-dependent ecosystems; and
c. to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats.

(Reflects Basin Plan Section 5.03, 1a-c)

The outcome in relation to objectives (a) to (c) is the restoration and protection of water-dependent ecosystems and ecosystem functions in the Murray-Darling Basin with strengthened resilience to a changing climate.

(Reflects Basin Plan Section 5.03, 2)

[17] Reflects the terminology used in the Basin Plan. 'Objectives and outcomes for water resources' are equivalent to 'Management Goals' under the National Water Quality Management Strategy. The EPP Water provides for the development of Management Goals that are long-term management objectives used to assess whether corresponding Environmental Values are being maintained. Management Goals for aquatic ecosystems reflect the management intent described in Section 14 of the EPP Water.

3.1.3 Objective and outcome in relation to water quality and salinity

The objective in relation to water quality and salinity is to maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Warrego, Paroo, Bulloo and Nebine drainage basins.

The outcome in relation to water quality and salinity is that water resources in the Warrego, Paroo, Bulloo and Nebine drainage basins remain fit for purpose.
(Reflects Basin Plan Section 5.04, 1-2)

3.2 Objectives and outcomes for the Warrego, Paroo, Bulloo and Nebine basins

The following objectives and outcomes apply to the Warrego, Paroo and Bulloo river basins and the Nebine, Mungallala and Wallam creek catchments.

3.2.1 Objective to maintain good levels of water quality

If the value of a water quality indicator (for example, salinity, nutrients, pH, turbidity etc.) is at a level that is better than the target value for water quality (set out in section 11 of this report), the objective is to maintain that level.
(Reflects Basin Plan Section 9.08)

3.2.2 Objective to maintain the extent of natural wetlands and riparian forested areas

The objective is to maintain and, where possible, enhance the extent of natural wetlands (palustrine, lacustrine and riverine) and riparian forested areas across the Warrego, Paroo, Bulloo and Nebine drainage basins.

3.2.3 Objective for declared Ramsar wetlands aquatic ecosystems

The objective is that the quality of water in the Currawinya Lakes Ramsar site is sufficient to maintain the ecological character[18] of the wetlands. (Reflects Basin Plan Section 9.04, 1)

3.2.4 Objective for aquatic ecosystems other than declared Ramsar wetlands

The objective is that the quality of water is sufficient:

a. to protect and restore the ecosystems, and
b. to protect and restore the ecosystem functions of the ecosystems, and
c. to ensure that the ecosystems are resilient to climate change and other risks and threats.

(Reflects Basin Plan Section 9.04, 2a-c)

3.2.5 Objective and outcome for Aboriginal cultural, spiritual and ceremonial values and uses of water

The objective is to ensure the suitability of water to support the identified cultural, ceremonial and spiritual values and uses of waters across the SW region.

The outcome is that SW region water resources remain fit for purpose in relation to cultural, spiritual and ceremonial values and uses of water.

(Reflects Basin Plan Section 10.52, 1a-b)

3.2.6 Objectives for raw water for treatment for human consumption

The objectives for raw water treatment for human consumption are:

a. to minimise the risk that the quality of raw water taken for treatment for human consumption results in the

[18] At time of print, the Ecological Character Description for Currawinya Lakes Ramsar site is under development by the Queensland Government.

adverse human health effects; and

b. to maintain the palatability rating of water taken for treatment for human consumption at the level of good as set out in the Australian Drinking Water Guidelines; and
c. to minimise the risk that the quality of raw water taken for treatment for human consumption results in the odour of drinking water being offensive to consumers.

(Reflects Basin Plan Section 9.05, a-c)

3.2.7 Objective for irrigation water

The objective for irrigation water is that the quality of surface water, when used in accordance with the best irrigation and crop management practices and principles of ecologically sustainable development, does not result in crop yield loss or soil degradation.

Soil degradation means reduced permeability and soil structure breakdown caused by the level of sodium in the irrigation water, and is assessed using the sodium adsorption ratio[19].

(Reflects Basin Plan Section 9.06)

3.2.8 Objective for recreational water quality

The objective for recreational water quality is to achieve a low risk to human health from water quality threats posed by exposure through ingestion, inhalation or contact during recreational use of SW region water resources.

(Reflects Basin Plan Section 9.07)

3.2.9 Objective for waters under the *Environmental Protection (Water) Policy 2009*

It is the management intent for waters[20] that the decision to release waste water or contaminants to the waters must ensure the following for:

- high ecological value (HEV) waters—the measures for the indicators for all EVs are maintained
- slightly disturbed (SD) waters—the measures for the slightly modified physical or chemical indicators are progressively improved to achieve the water quality objectives (targets) for HEV waters
- moderately disturbed (MD) waters, if the measures for indicators of the EVs:
  - achieve the water quality objectives for the water— the measures for the indicators are maintained at levels that achieve the water quality objectives (targets) for the water
  - do not achieve the water quality objectives (targets) for the water—the measures for indicators of the EVs are improved to achieve the water quality objectives (targets) for the water.

Refer to Section 6 of this plan for further details.

[19] See Chapter 11 – Salinity Management Handbook (DNR, 1997); or Figure 4.2.1 of Chapter 4 of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

[20] Refer to Section 14 of the EPP Water.

SECTION 4: CONSULTATION AND ENGAGEMENT

4 Consultation and engagement

The development of the HWMP for the Warrego, Paroo, Bulloo and Nebine basins involved ongoing consultation in accordance with the requirements of the EPP Water and the Basin Plan. Engagement with stakeholders and the community was organised through local print media, mail-outs, emails, the South West NRM Ltd website and workshops. The consultation was open to participants from local government, natural resource management groups, industry groups, local Aboriginal Nations and the community. The facilitation of workshops was supported by South West NRM Ltd.

The stakeholder and community-based discussions indicated that water is a key regional asset, whether above or below ground. The major variances in discussion amongst the groups were the different uses and outcomes, the allocations to various sectors and the potential threats to the quantity and quality of both above ground or underground water supplies.

4.1 Water Quality Technical Panel

Throughout the development of the HWMP for the Warrego, Paroo, Bulloo and Nebine basins, the Water Quality Technical Panel was consulted on matters where skilled expertise or technical input was required. The panel was comprised of technical staff from Queensland Government departments, South West NRM Ltd and external water quality experts, and utilised a range of State and Commonwealth information resources.

The Water Quality Technical Panel initially met to divide the Warrego, Paroo, Bulloo and Nebine basins into sub-regions through GIS mapping, to enable more targeted discussions and establishment of environmental values at stakeholder and community workshops (Refer to Figures 12 and 13).

The Water Quality Technical Panel further met to discuss the development of water quality targets based on local data to protect environmental values (Section 11) and for the risk assessment (Section 8).

The Water Quality Technical Panel group meetings included:

- Toowoomba 25 October 2010
- Toowoomba 9 December 2010
- Charleville 3 March 2011
- Roma 25 May 2011
- Toowoomba 9 November 2012 (Risk Assessment), and
- Toowoomba 20 February and 21 March 2013.

4.2 Consultation—First round

Personnel from the Queensland Government and South West NRM Ltd facilitated the first round of stakeholder and community consultation at the following locations:

- Mungallala 11 April 2011
- Bollon 11 April 2011
- Cunnamulla 12 April 2011
- Eulo 12 April 2011
- Thargomindah 13 April 2011
- Quilpie 14 April 2011
- Charleville 14 April 2011
- Augathella 15 April 2011.

The primary purpose of the first round of consultation was to review the sub-regions established by the Water Quality Technical Panel and determine the range of environmental values applicable to each sub-region. The workshop series was promoted in local media and through emails to South West NRM Ltd contacts, industry and government networks. Input from community members at each location was sought as to the environmental values that members believed to be significant for each of the sub-regions—based on members' personal knowledge, experience, values and uses of water and future aspirations for their communities.

Comments and issues raised by participants at each workshop are presented in the Consultation Summary Report: Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins (EHP, 2016).

4.3 Consultation—Second round

Personnel from the Queensland Government and South West NRM Ltd facilitated the second round of stakeholder and community consultation at the following locations:

- Morven 12 June 2012
- Augathella 13 June 2012
- Charleville 14 June 2012
- Quilpie 15 June 2012
- Thargomindah 16 June 2012
- Eulo 17 June 2012
- Cunnamulla 18 June 2012
- Bollon 19 June 2012.

This consultation provided the community with an update of progress towards the Warrego, Paroo, Bulloo and Nebine HWMP and an opportunity to provide feedback on the draft environmental values, levels of aquatic ecosystem protection and sub-regional mapping. Draft local water quality target values to protect the draft environmental values in each sub-region were presented to the community for comment.

Comments and issues raised by participants at each workshop are presented in the Consultation Summary Report: Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins (EHP, 2016).

4.4 Consultation—Third round

This consultation was conducted jointly between the Department of Environment and Heritage Protection, Department of Natural Resources and Mines and South West NRM Ltd and addressed the Commonwealth Water Resource Plan package to be submitted to the Murray-Darling Basin Authority for accreditation under the Basin Plan. The HWMP for the Warrego, Paroo, Bulloo and Nebine basins contributes to the requirements of a Water Quality Management Plan under Chapter 10, Part 7 of the Basin Plan.

- Bollon 13 October 2014
- Toompine 14 October 2014
- Eulo 15 October 2014
- Cunnamulla 16 October 2014

Comments and issues raised by participants at each workshop are presented in the Consultation Summary Report: Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins (EHP, 2016).

4.5 Consultation with Aboriginal Nations

Workshops were organised to enable people of local Aboriginal Nations to specifically discuss Aboriginal values and uses of water at a series of dedicated forums. The Department of Environment and Heritage Protection would like to acknowledge and pay respect to the past and present Traditional Owners of the region and their Nations, and thank the representatives of the Aboriginal communities, including the Elders, who provided their knowledge of natural resource management throughout the consultation process. It is recognised that there are values and protocols of men’s and women’s business that relate to water which are culturally sensitive and were not discussed openly. It is acknowledged that only the commonly known places and stories can be discussed openly. It is also understood that places and stories can hold different cultural values and significance between each Aboriginal Nation.

The HWMP for the Warrego, Paroo, Bulloo and Nebine basins was undertaken in consultation with Aboriginal Nations with an expressed interest in water planning for this region. These Aboriginal Nations included:

- Bidjara
- Budjiti
- Gunggari (Kungarri)
- Kooma (Guwamu)
- Kullilli
- Kunja
- Mardigan
- Murrawarri
- Mandandanji[21]

Workshops and meetings were held to enable representatives from the local Aboriginal community to identify objectives, outcomes, values and uses of water, risks, and opportunities to strengthen the protection of Aboriginal values and uses, for inclusion in both the Healthy Waters Management Plan and Queensland water resource plan for Warrego, Paroo, Bulloo and Nebine basins.

Initial workshops were organised through the former Far South West Aboriginal Natural Resource Management Group. Representatives from the following Nations comprised the Far South West Aboriginal Natural Resource Management Group: Kooma (Guwamu), Bidjara, Kunja, Mardigan, Budjiti, and Kullilli Nations. Two representatives from each local Aboriginal Nation participated. The representatives were either Native Title claimants or community members nominated by claimants to represent their Nation.

The following workshops and meetings were held to ensure the views of the Aboriginal community in relation to water quality were included in the development of the Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins.

• Longreach ‘Salt 2 Dust’ workshop	16 July 2011
• Charleville workshop	2 December 2011
• Cunnamulla workshop	17 October 2014
• Warwick, Northern Basin Aboriginal Nations Gathering	30 April 2014
• Toowoomba, Northern Basin Aboriginal Nations Board Meeting and Gathering	19–20 May 2015
• Bollon, Cunnamulla, Eulo, Charleville, Quilpie, Augathella Toowoomba and Roma meetings	13 October 2015 – 29 October 2015

A key outcome from these workshops was the refinement of ‘cultural and spiritual’ environmental value to also include ‘ceremonial’ values. Cultural, spiritual and ceremonial values cover the whole region, especially groundwater.

In addition to the consultation opportunities listed above, draft versions of the Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins were available on the South West NRM Ltd website for comment between meetings.

[21] Note: The Mandandanji Nation was identified in the Murray-Darling Basin Authority map endorsed by NBAN that shows the Aboriginal Nations for each water resource plan area. In further consultation it was noted by Traditional Owners that Mandandanji’s interest was in the Condamine-Balonne plan area and no comments were received from the Mandandanji Nation on the Warrego, Paroo, Bulloo and Nebine plan area.

The HWMP for the Warrego, Paroo, Bulloo and Nebine basins was also informed by the outcomes of the 'Caring for Water on Country in South West Queensland' report (South West NRM Ltd, 2012b). This report was based on a workshop attended by representatives from the Kooma (Guwamu), Bidjara, Kunja, Mardigan, Budjiti, Kullilli, Murrawarri and Boonthamurra Nations. The report states:

Every water site located in the landscape was considered as being special to Aboriginal people, and it was not possible to prioritise or select some water sites as having a higher value than others' (South West NRM Ltd, 2012b).

This concept was also reflected in the workshops listed above, resulting in the cultural, spiritual and ceremonial environmental value applying to all surface and groundwaters across the Warrego, Paroo, Bulloo and Nebine basins.

A presentation on the HWMP for Warrego, Paroo, Bulloo and Nebine basins was conducted to representatives from the Northern Murray-Darling Basin Aboriginal Nations (NBAN) in Warwick, 30 April 2014, by the Department of Environment and Heritage Protection. NBAN representatives were provided with the opportunity to comment on the draft Aboriginal values and uses determined through previous workshops with the Far South West Aboriginal Natural Resource Management Group. Participants were supportive of the recommendation that the cultural, spiritual and ceremonial environmental value applies to all surface and groundwaters within the SW region. This is reflected in the objective and outcome for Aboriginal cultural, spiritual and ceremonial values and uses of water. The intent of the objective is that the quality of water in the SW region will be suitable to support cultural, spiritual and ceremonial values and uses across all surface and groundwaters, with the outcome that water quality will be fit-for- purpose for Aboriginal people. Opportunities to strengthen the protection of Aboriginal values and uses were also presented to the NBAN Gathering for comment.

A hardcopy of the draft Healthy Waters Management Plan for Warrego, Paroo, Bulloo and Nebine basins was provided to the NBAN Board for comment at the Board Meeting in Toowoomba on 19 May 2015. A presentation on the approach of the Healthy Waters Management Plan to address the requirements of Chapter 10, Part 14 of the Basin Plan was conducted to the NBAN Board, as well as at the NBAN Community Meeting on 20 May 2015.

Water planning information sessions for people of the Aboriginal Nations in the Warrego, Paroo, Nebine and Bulloo catchments were held in Bollon, Cunnamulla, Eulo, Charleville, Quilpie, Augathella, Toowoomba and Roma between 13–29 October 2015. The information sessions were held collaboratively between the Department of Natural Resources and Mines and the Department of Environment and Heritage Protection, and were facilitated by representatives nominated by NBAN. The information sessions provided people from the Bidjara, Budjiti, Gunggari (Kungarri), Kooma (Guwamu), Kullilli, Kunja, Mandandanji, Mardigan and Murrawarri Aboriginal Nations with an opportunity to review and comment on the objectives, outcomes, values and uses of water, risks, and opportunities to strengthen the protection of Aboriginal values and uses captured through previous workshops and meetings.

Comments and issues related to water quality that were raised by participants at each workshop are presented in the Consultation Summary Report: Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins (EHP, 2016).

For further information on Aboriginal values and uses in the plan area, refer to the Warrego, Paroo, Bulloo and Nebine water resource plan and resource operations plan—Aboriginal values and uses report (DNRM, 2016).

4.6 Consultation—Climate variability

South West NRM Ltd undertook community workshops with the local community and Traditional Owners in late 2013 on the topic of planning for climate variability. Climate 'variability' considers the fluctuation in weather that would be experienced over the short term (10 years). These workshops resulted in two reports (available on the South West NRM Ltd website):

- Planning for climate variability in South West Queensland:
  - Don't camp in the creek bed (South West NRM Ltd, 2014a)
  - Yarning with Traditional Owners in South West Queensland (South West NRM Ltd, 2014b).

4.7 Consultation with the New South Wales Government

The Warrego, Paroo and Nebine drainage basins are cross-border river systems that form part of the 'Intersecting Streams' with New South Wales. Consultation with the New South Wales Government on the HWMP and WQM

Plan for the Warrego, Paroo, Bulloo and Nebine basins was undertaken by the Queensland Department of Environment and Heritage Protection to consider any cross-border impacts that may result from the management of water quality in these drainage basins. The consultation was conducted in accordance with sections 10.05, 10.32 and 10.35 of the Basin Plan.

The draft HWMP for the Warrego, Paroo, Bulloo and Nebine basins was presented to water quality representatives from the New South Wales Department of Primary Industries on 14 April 2015 for comment on:

- proposed alternative water quality target values based on local data analysis
- the impact of Queensland measures on the ability of New South Wales to meet water quality targets
- any adverse impacts measures may have on New South Wales water resources.

The feedback provided by the Department of Primary Industries to the Department of Environment and Heritage Protection was taken into consideration to better meet cross-border outcomes. The key improvements to the HWMP for the Warrego, Paroo, Bulloo and Nebine basins, based on the initial feedback from the New South Wales Government, were:

- Proposed alternative water quality target values were reviewed and updated based on the availability of additional local data.
- Text boxes were included throughout the document to assist the reader understand how the HWMP for the Warrego, Paroo, Bulloo and Nebine basins contributes to meeting the requirements of a Water Quality Management Plan under the Basin Plan.
- The updated HWMP distinguished between sections of the document that were recommended for accreditation under the Basin Plan, and sections that were recognised to support them. This approach was taken to ensure that the WQM Plan encapsulated the overall framework for the management of water quality in Queensland Murray-Darling Basin catchments.

In addition to direct correspondence with the New South Wales Government, the Department of Environment and Heritage Protection attended a Water Quality Management—Inter-Jurisdictional Group meeting on 4 November 2015 to discuss the development of Water Quality Management Plans. The meeting was attended by government representatives from New South Wales, Victoria, South Australia and the Australian Capital Territory, as well as the Murray-Darling Basin Authority. There was general endorsement of Queensland's approach to addressing the water quality provisions of the Basin Plan at this meeting.

The Department of Environment and Heritage Protection submitted the final draft of the WQM Plan for the Warrego-Paroo-Nebine basins to the New South Wales Department of Primary Industries on 11 January 2016 for their formal response. Refer to Section 13 of this report for information on the outcome of this submission.

SECTION 5: SOCIAL, ECONOMIC, CULTURAL AND ENVIRONMENTAL VALUES AND USES

5 Social, economic, cultural and environmental values and uses

The social, economic, cultural and environmental values and uses of water for the Warrego, Paroo, Bulloo and Nebine drainage basins were established through the environmental values framework under the EPP Water. Environmental Values are the qualities of water that make it suitable for supporting aquatic ecosystems and identified human uses. Setting environmental values through community and stakeholder consultation reflects how a local region values and uses water.

Under the EPP Water, and as depicted by Figure 11, environmental values include:

- aquatic ecosystem[22]
- agriculture (including irrigation, stock and domestic)
- aquaculture
- human consumption of aquatic foods
- drinking water (suitable for treatment before supply as drinking water[23])
- industrial use
- recreation (primary, secondary and visual/aesthetic), and
- cultural and spiritual values (modified to ‘cultural, spiritual and ceremonial values’ for the purposes of this HWMP at the request of Traditional Owners).

For the purpose of establishing environmental values, the Warrego, Paroo, Bulloo and Nebine drainage basins were separated into more manageable units termed ‘sub-catchments’ to encourage locally relevant discussion around the values and uses of water. The environmental values sub-catchments were developed on the basis of:

a. likely geological influences on soil type and water quality
b. recognition of existing defined sub-regional natural resource management planning areas.

The sub-catchments were generated from Queensland Government and South West NRM Ltd datasets, public domain information and community consultation.

The environmental values that apply to each sub-catchment were determined through stakeholder and community consultation (Refer to Section 4). The environmental values that apply to the Warrego, Paroo, Bulloo and Nebine drainage basins are presented in Tables 7-10 and mapped for each surface water and groundwater sub-catchment (Refer to Figures 12 and 13).

The economic and social impacts of protecting environmental values are considered through consultation. At the completion of consultation and consideration of all submissions, finalised environmental values and water quality objectives (water quality target values) will be subsequently recommended for inclusion under Schedule 1 of the EPP Water[24]. Under the EPP Water, environmental values and associated water quality objectives (water quality target values) inform statutory and non-statutory water quality management planning and decision-making.

[22] The Australian and New Zealand Water Quality Guidelines (ANZECC/ARMCANZ 2000) and the EPP Water outline how aquatic ecosystems can be subdivided into different levels of protection, depending on condition. The EPP Water recognises four possible levels of ecosystem condition and corresponding management intent; namely high ecological value (effectively unmodified) systems; slightly disturbed, moderately disturbed and highly disturbed systems. Section 14 of the EPP Water states the management intent for waters subject to an activity that involves the release of wastewater or contaminants to waters.

[23] For drinking water guidelines that apply to water after it has been treated or is to be used for drinking—see the Australian Drinking Water Guidelines developed by the National Health and Medical Research Council.

[24] If the environmental values and associated water quality objectives are not listed in schedule 1 of the EPP Water, the environmental values are stated under section 6 (2) of the EPP Water and the water quality objectives are the set of water quality guidelines for all indicators that protect all the environmental values for the water.

Aquatic ecosystem

- The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways, waterholes and riparian areas, for example, biodiversity, ecological interations, plants, animals, key species (such as turtles, yellowbelly, cod and yabbies) and their habitat, food and drinking water.

Irrigation

- Suitability of water supply for irrigation, for example, irrigation of crops, pastures, parks, gardens and recreational areas.

Farm water supply/use

- Suitability of domestic farm water supply, other than drinking water. For example, water used for laundry and produce preparation.

Stock watering

- Suitability of water supply for production of healthy livestock.

Aquaculture

- Health of aquaculture species and humans consuming aquatic foods (such as fish and prawns) from commercial ventures.

Human consumers of aquatic foods

- Health of humans consuming aquatic foods, such as fish and prawns, from natural waterways.

Primary recreation

- Health of humans during recreation which involves direct contact and a high probability of water being swallowed, for example, swimming, diving and water-skiing.

Secondary recreation

- Health of humans during recreation which involves indirect contact and a low probability of water being swallowed, for example, wading, boating, rowing and fishing.

Visual recreation

- Amenity of waterways for recreation which does not involve contact with water. For example, walking and picnicking adjacent to a waterway.

Drinking water supply

- Suitability of raw drinking water supply. This assumes minimal treatment of water is required, for example, coarse screening and/or disinfection.

Industrial use

- Suitability of water supply for industrial use, for example, food, beverage, paper, petroleum and power industries, mining and minerals refining/processing. Industries usually treat water supplies to meet their needs.

Cultural, spiritual and ceremonial values

- Cultural, spiritual and ceremonial values of water means its aesthetic, historical, scientific, social or other significance, to the past, present or future generations.

Figure 11: Environmental values icons and definitions

5.1 Environmental values per sub-region

Notes:

1. Refer to the accompanying maps in Figures 12 and 13 for the sub-regions where Environmental Values apply.
2. ✓ means the Environmental Value is selected for protection. Blank indicates that the Environmental Value is not selected for protection.
3. Refer to section 11 for the water quality target values that apply to protect the Environmental Values in Tables 7-10.

Table 7: Environmental values for the Nebine drainage basin surface waters and groundwaters

Nebine Drainage Basin	Environmental Values[1–3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural, spiritual and ceremonial values
Water												
SURFACE FRESH WATERS (rivers, creeks, streams)												
Upper Mungallala/Wallam Creeks	✓		✓	✓		✓	✓	✓	✓	✓		✓
Lower Mungallala/Wallam Creeks	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Nebine Creek	✓		✓	✓		✓	✓	✓	✓	✓		✓
Western Nebine Catchment	✓		✓	✓		✓		✓	✓	✓		✓
GROUNDWATERS												
Upper Mungallala/Wallam Creeks Groundwater	✓		✓	✓						✓		✓

Nebine Drainage Basin	Environmental Values[1–3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural, spiritual and ceremonial values
Water												
Lower Mungallala/Wallam Creeks Groundwater	✓		✓	✓	✓					✓	✓	✓
Nebine Creek Groundwater	✓		✓	✓						✓		✓

Table 8: Environmental Values for the Warrego drainage basin surface waters and groundwaters

Warrego Drainage Basin	Environmental Values[1–3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural, spiritual and ceremonial values
Water												
SURFACE FRESH WATERS (rivers, creeks, streams)												
Nive River	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Upper Warrego/Hoganthulla Creek	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Yo Yo Creek	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ward River	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Langlo River/Middle Creek	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Warrego River—Charleville vicinity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Angellala Creek	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Middle Warrego River—Wyandra vicinity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cuttaburra Creek	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lower Warrego River	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Warrego Drainage Basin	Environmental Values[1–3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural, spiritual and ceremonial values
Water												
GROUNDWATERS												
Nive River Groundwater	✓		✓	✓						✓		✓
Upper Warrego River Groundwater	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Middle Warrego River Groundwater	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lower Warrego River Groundwater	✓	✓	✓	✓	✓		✓			✓	✓	✓

Table 9: Environmental Values for the Paroo drainage basin surface waters and groundwaters

Paroo Drainage Basin	Environmental Values[1–3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural, spiritual and ceremonial values
Water												
SURFACE FRESH WATERS (rivers, creeks, streams)												
Beechal Creek	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Paroo River/Quilberry Creek	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Paroo River/Cookara Creek	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓
Paroo River/Bow Creek	✓	✓		✓		✓	✓	✓	✓		✓	✓
Yowah Creek	✓			✓		✓	✓	✓	✓		✓	✓
Western Creeks	✓			✓		✓	✓	✓	✓	✓	✓	✓
Eulo Springs Supergroup (surface waters)	✓		✓	✓					✓			✓
Lower Paroo River	✓			✓		✓	✓	✓	✓		✓	✓
GROUNDWATERS												

Paroo Drainage Basin	Environmental Values[1–3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural, spiritual and ceremonial values
Water												
Upper Paroo River Groundwater	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lower Paroo River Groundwater	✓		✓	✓			✓		✓	✓	✓	✓
Eulo Springs Supergroup (groundwater)	✓		✓	✓			✓		✓	✓	✓	✓

Table 10: Environmental Values for the Bulloo drainage basin surface waters and groundwaters

Bulloo Drainage Basin	Environmental Values[1–3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural, spiritual and ceremonial values
Water												
SURFACE FRESH WATERS (rivers, creeks, streams)												
Blackwater Creek	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Upper Bulloo River	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wimbin Creek	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goorie Goorie Creek	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Gumbo Gumbo Creek	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dewalla Creek	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pitteroo Creek	✓		✓	✓		✓	✓	✓	✓	✓		✓
Mirintu Creek	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓
Bulloo River—Main Channel	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Bulloo Drainage Basin	Environmental Values[1–3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural, spiritual and ceremonial values
Water												
OTHER FRESH WATERS												
Bulloo Lakes	✓		✓	✓		✓	✓	✓	✓	✓		✓
GROUNDWATERS												
Upper Bulloo River Groundwater	✓		✓	✓	✓	✓				✓	✓	✓
Middle Bulloo River Groundwater	✓		✓	✓	✓	✓				✓	✓	✓
Lower Bulloo River Groundwater	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓

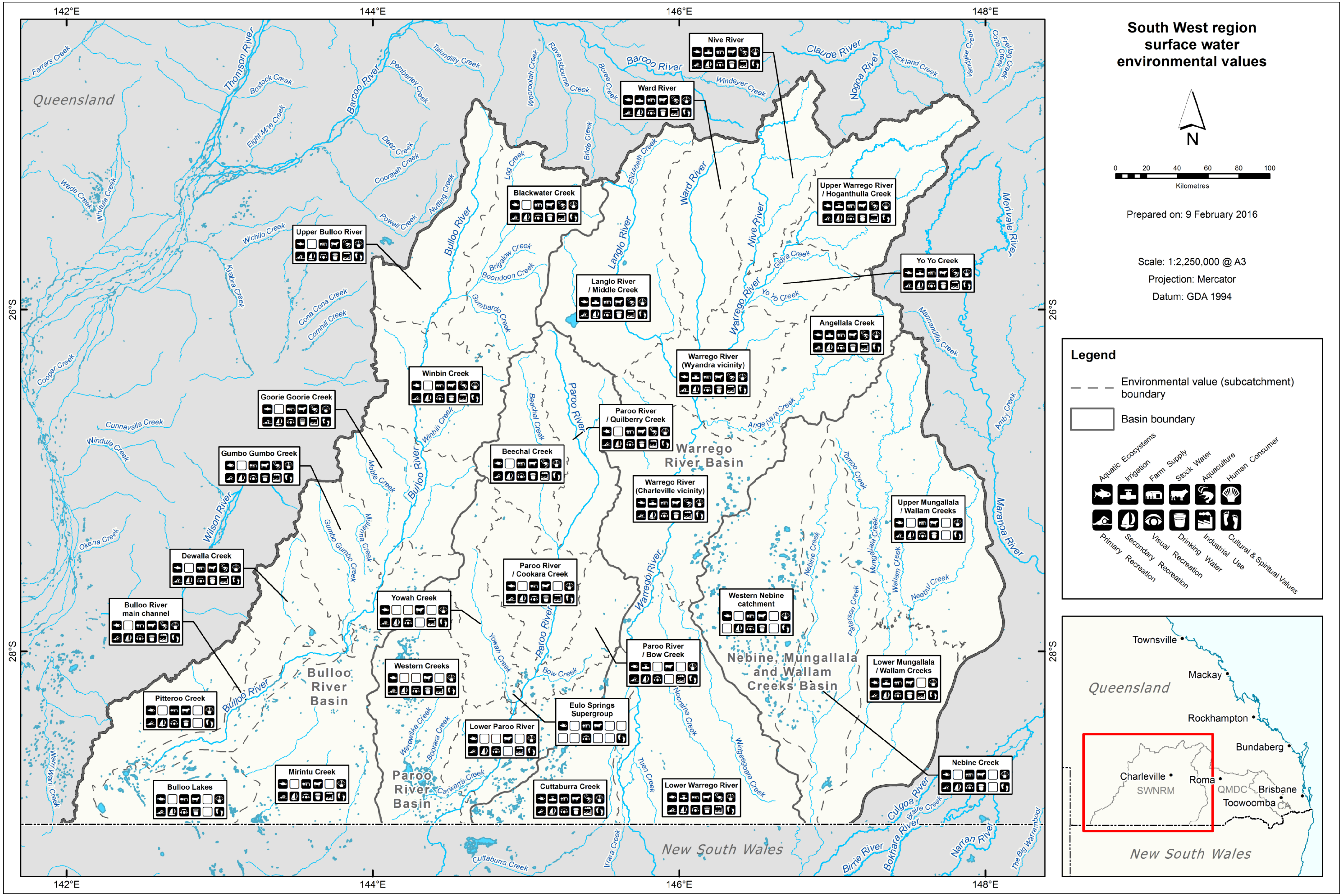

Figure 12: Environmental Values that apply to the surface waters in each sub-region within the Warrego, Paroo, Bulloo and Nebine drainage basins.

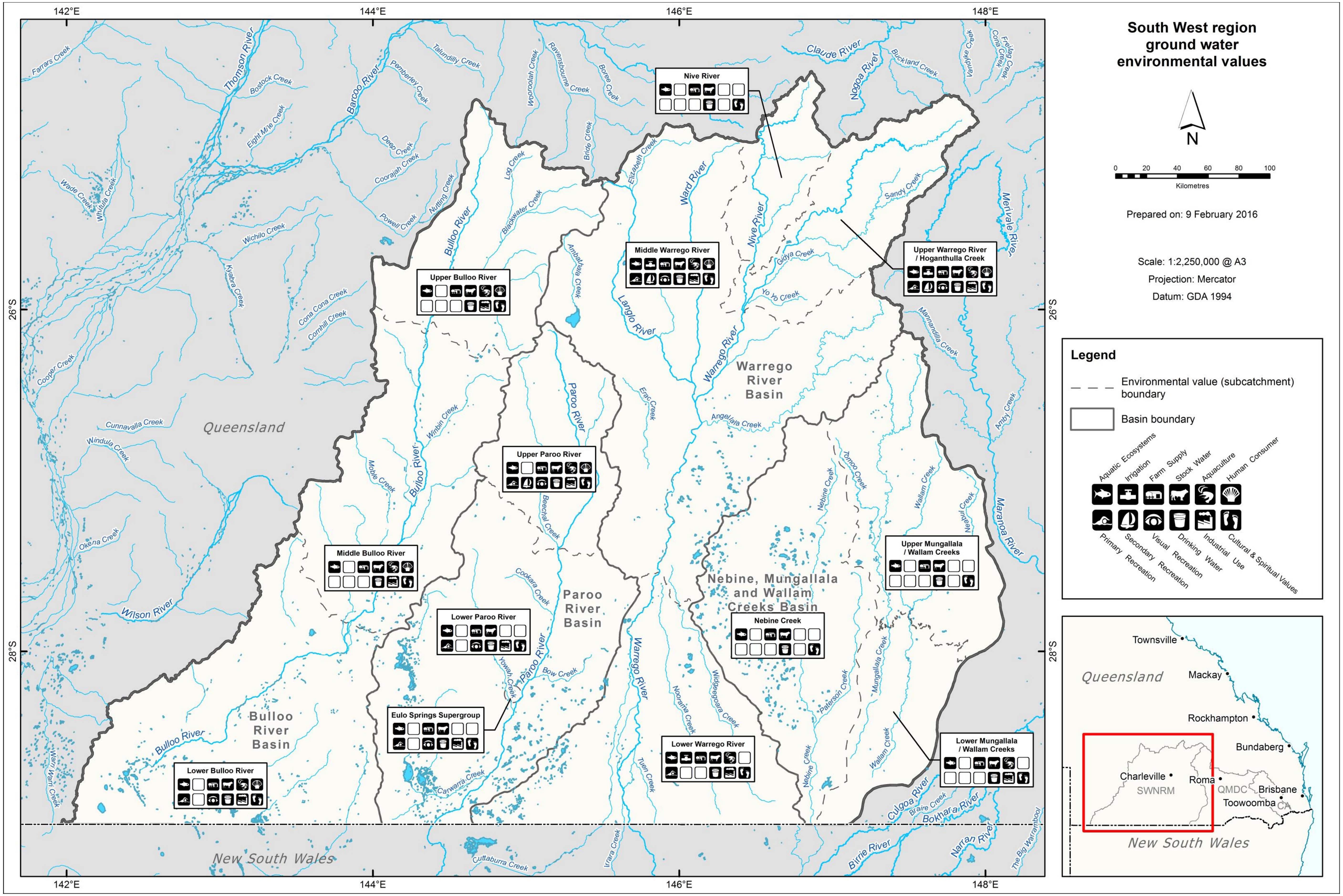

Figure 13: Environmental Values that apply to the groundwaters in each sub-region within the Warrego, Paroo, Bulloo and Nebine drainage basins.

SECTION 6: LEVELS OF AQUATIC ECOSYSTEM PROTECTION

6 Levels of aquatic ecosystem protection

For the aquatic ecosystem environmental value, the EPP Water identifies four levels of protection according to the current condition of waters. The four levels of protection are high ecological value, slightly disturbed, moderately disturbed and highly disturbed (Refer to Table 11). Each level of protection is assigned a specific management intent under the EPP Water, as described in Section 6.3 of this report.

Table 11: Levels of aquatic ecosystem protection

Ecosystem condition	Definition
Level 1 High ecological value (HEV) ecosystems	Waters in which the biological integrity of the water is effectively unmodified or highly valued.
Level 2 Slightly disturbed ecosystems	Waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators.
Level 3 Moderately disturbed ecosystems	Waters in which the biological integrity of the water is adversely affected by human activity to a relatively small but measurable degree.
Level 4 Highly disturbed ecosystems	Waters that are significantly degraded by human activity and have lower ecological value than high ecological value waters or slightly or moderately disturbed waters.

Source: EPP Water, Schedule 2.

A multi-reference approach was used to identify the levels of aquatic ecosystem condition across the Warrego, Paroo, Bulloo and Nebine drainage basins. Priority aquatic ecosystems were assigned the two highest levels of protection—High Ecological Value aquatic ecosystems or Slightly Disturbed aquatic ecosystems.

6.1 High Ecological Value and Slightly Disturbed Aquatic Ecosystems

High Ecological Value and Slightly Disturbed Aquatic Ecosystems are presented in Figure 14. The High Ecological Value and Slightly Disturbed waters designations apply only to the waters within the identified boundaries.

The information and datasets considered in the identification and mapping of High Ecological Value waters included:

- protected estates (primarily national parks)
- Currawinya Lakes Ramsar site
- Wetlands of High Ecological Significance
- the list of permanent waterholes considered as critical refugia, tabulated at Appendix 6 (Silcock, 2009)
- Matters of National Environmental Significance
- Matters of State Environmental Significance
- South West NRM Ltd biodiversity mapping
- Aquatic Conservation Assessments for the plan area[25]
- stakeholder consultation and expert opinion through the Water Quality Technical Panel.

The information and datasets for the Slightly Disturbed waters mapping included:

- nature refuges and state forests
- Queensland floodplain assessment overlay

[25] Aquatic Conservation Assessments (ACA), using AquaBAMM, for the wetlands of the Queensland Murray–Darling Basin (Fielder et al., 2011) and Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Lake Eyre and Bulloo basins (EHP, 2015).

- stakeholder consultation and expert opinion through the Water Quality Technical Panel.

6.2 Moderately Disturbed Aquatic Ecosystems

All other areas of the Warrego, Paroo, Bulloo and Nebine drainage basins that are not identified as High Ecological Value or Slightly Disturbed Aquatic Ecosystems are classed as Moderately Disturbed waters, the most common level of protection.

6.3 Management intent under the EPP Water

Section 14 of the EPP Water states how waters in the different levels of protection described above should be managed. These matters must be considered when decisions are being made about the release of waste water into receiving waters.

For the matters to be complied with for environmental management decisions, including consideration of the management intent, refer to the Environmental Protection Regulation 2008, section 51.

Table 12: Management intent under the EPP Water for levels of aquatic ecosystem protection

Level of protection	Management intent
High ecological value (HEV) waters	The measures for the indicators for all Environmental Values are maintained i.e. maintain water quality objectives (target values) for HEV waters.
Slightly disturbed waters	The measures for the slightly modified physical or chemical indicators are progressively improved to achieve the water quality objectives (target values) for HEV waters.
Moderately disturbed waters	If the measures for indicators of the Environmental Values achieve the water quality objectives (target values) for the water—the measures for the indicators are maintained at levels that achieve the water quality objectives (target values) for the water, or If the measures for indicators of the Environmental Values do not achieve the water quality objectives (target values) for the water—the measures for indicators of the Environmental Values are improved to achieve the water quality objectives (target values) for the water.
Highly disturbed waters	The measures for the indicators of all Environmental Values are progressively improved to achieve the water quality objectives (target values) for the water.

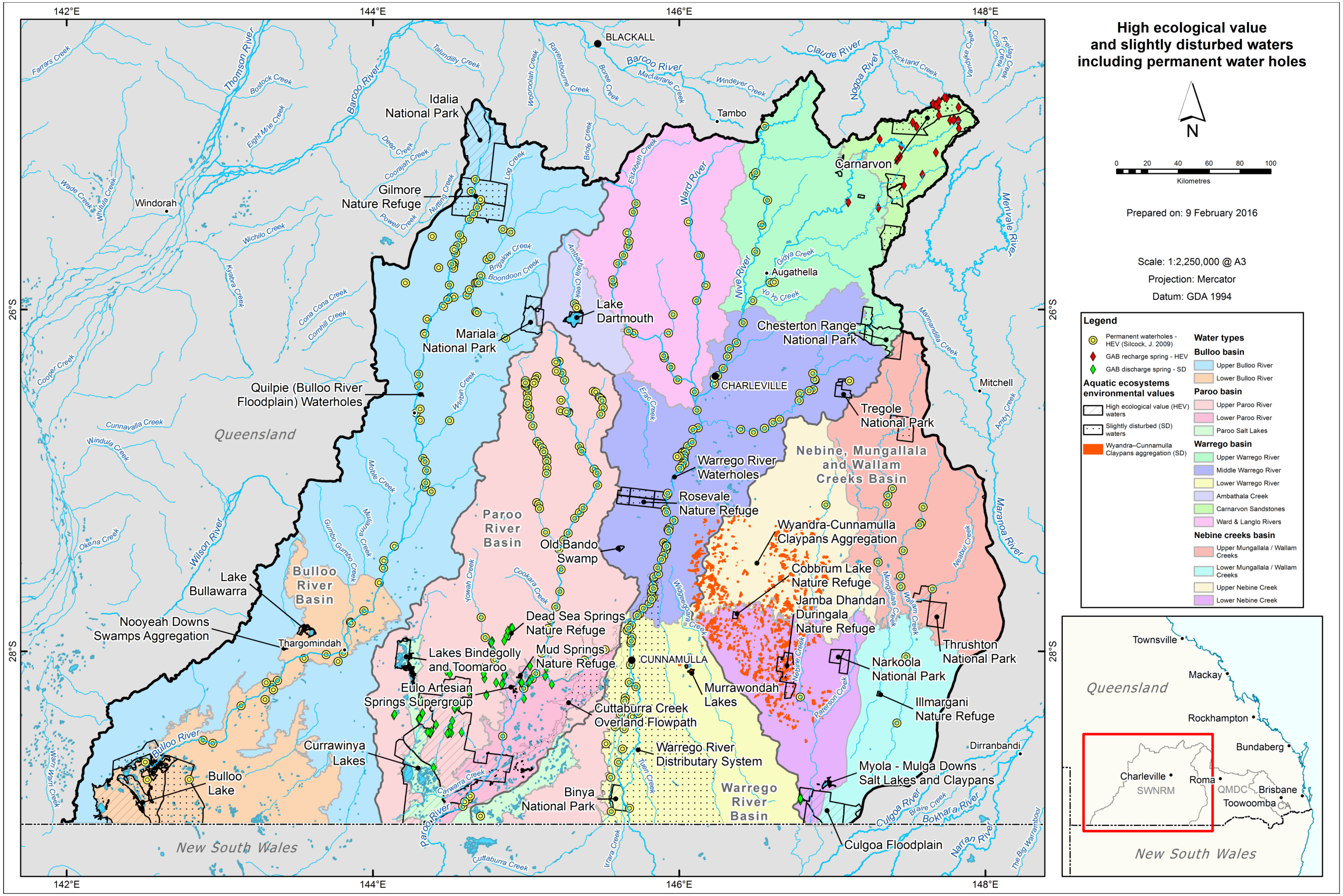

Figure 14: High Ecological Value and Slightly Disturbed waters. The permanent waterholes shown are High Ecological Value waters. A description of the water types in the Warrego, Paroo, Bulloo and Nebine plan area is provided in Appendix 3.

SECTION 7: KEY CAUSES OF WATER QUALITY DEGRADATION

7 Key causes of water quality degradation

Section 10.30 of the Basin Plan specifies that a WQM Plan must identify the causes, or likely causes, of water quality degradation in the water resource plan area having regard to the key causes of water quality degradation identified in the Basin Plan (Part 2 of Chapter 9 and Schedule 10).

Table 13 presents the key causes of water quality degradation in the Warrego, Paroo, Bulloo and Nebine drainage basins. Note that the Bulloo drainage basin is not subject to the Basin Plan, but is included for State planning purposes. The key causes of water quality degradation are derived from Chapter 9, Part 2 and Schedule 10 of the Basin Plan. The justifications for where the key causes of water quality degradation apply were sourced through consultation with the Water Quality Technical Panel (Refer to Section 4.1).

For details of the likelihood and consequence of the key causes of water quality degradation impacting on water resources in the plan area, refer to Section 8 and Appendix 5 of this document.

Table 13: Key causes of water quality degradation in the Warrego, Paroo, Bulloo and Nebine drainage basins

Type of water quality degradation	Key causes of water quality degradation for that type	Applicable drainage basins	Justification
Elevated levels of salinity	The process of mobilisation of salt stores in the landscape and geological redisposition to salinity development, including by: (a) the following processes and activities relating to water flow or water management: (i) saline groundwater and surface water discharges into surface water systems	All drainage basins, however Warrego drainage basin in particular.	Saline groundwater and surface water discharge into surface water systems have the potential to cause water quality degradation in all drainage basins in South West Queensland due to localised connectivity between the surface waters and the underlying aquifers. The Water Quality Technical Panel indicated that there is a possibility of saline groundwater discharge to the Warrego River near Cunnamulla associated with irrigation development. For further information, refer to the risk assessment (Section 8 and Appendix 5).
	(ii) increased deep drainage below irrigated agricultural land displacing saline groundwater to surface water systems	All drainage basins to a limited extent.	In each of the four drainage basins, livestock grazing represents at least 95% of the land use. As a result, the presence of irrigated agriculture is minimal. For the likelihood of increased deep drainage below irrigated agricultural land displacing saline groundwater to surface water systems presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).
	(iii) saline surface and shallow groundwater drainage from irrigated agricultural land into surface water systems	Warrego drainage basin only.	The Water Quality Technical Panel indicated that there is a possibility of saline groundwater discharge to the Warrego River near Cunnamulla associated with irrigation development. For the likelihood of this presenting a risk to water resources in the Warrego drainage basin, refer to the risk assessment (Section 8 and Appendix 5).

Type of water quality degradation	Key causes of water quality degradation for that type	Applicable drainage basins	Justification
	(iv) irrigation at high salinity risk locations without adequate drainage management; Example: Locations where there is a high risk of recharge to groundwater resulting in saline discharges to surface waters	Not applicable to any drainage basin.	There is a high risk salinity location in the Warrego drainage basin between Cunnamulla and Wyandra due to the presence of irrigated agriculture. As long as irrigators located in this area continue to implement water use efficient practices (e.g. trickle irrigation, lateral moves and pivot irrigation), the Water Quality Technical Panel advised that this type of water quality degradation will not apply.
	(v) de-watering of saline groundwater which mobilises salt into surface water systems	Not applicable to any drainage basin.	There are no licences issued for dewatering in the Warrego, Paroo, Bulloo and Nebine drainage basins (Based on the Queensland Water Management System database, January 2015).
	(vi) reduction in stream flows, limiting the dilution of salinity.	Not applicable to any drainage basin.	The plan area has minimal water resource development that would limit the dilution of salinity. There is an end-of-system mean annual flow of 99% for the Bulloo and Paroo drainage basins, 89% for the Warrego drainage basin and 87% for the Nebine drainage basin.
	(b) land management practices involving the replacement of deep-rooted vegetation with shallow-rooted crops and pastures, resulting in increased rainfall recharge displacing saline groundwater to surface water systems	All drainage basins.	In each of the four drainage basins, livestock grazing represents at least 95% of the land use. The presence of irrigated agriculture is minimal. For the likelihood of land management practices involving the replacement of deep-rooted vegetation with shallow-rooted crops and pastures presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).
	(2) The use of groundwater for irrigation purposes at locations where highly saline upper aquifer water drains to the lower aquifer.	St George Alluvium—Deep (WPBN) only.	There is potential for the highly saline upper aquifer to drain to the lower aquifer in the St George Alluvium. For the likelihood of this presenting a risk to water resources in the St George Alluvium (Deep), refer to the risk assessment (Section 8 and Appendix 5).
	(3) With respect to soil degradation, the use of water with a high ratio of sodium to calcium and magnesium for irrigation.	Nebine drainage basin only.	The Water Quality Technical Panel indicated application of high risk water is occurring between St George and Bollon. For the consequence of this on water resources in the Nebine drainage basin, refer to the risk assessment (Section 8 and Appendix 5).

Type of water quality degradation	Key causes of water quality degradation for that type	Applicable drainage basins	Justification
Elevated levels of suspended matter	Sediments entering Basin water resources, which is contributed to by: (a) the following land management practices: (i) inappropriate frequency, timing and location of cultivation; Example: Cultivation taking place at times of the year when the risk of erosion is high (e.g. during the high rainfall season), excessive frequency of cultivation, and cultivation of steep slopes	Not applicable to any drainage basin.	In each of the four drainage basins, grazing regimes (cattle and sheep) account for at least 95% of the land use. The upper head waters of the Bulloo, Paroo and Warrego contain hard landscapes with low infiltration potential from seasonal rainfall. Cultivation occurs to a minimal extent and typically consists of direct seeding or aerial dispersal of pasture on properties near Cunnamulla. Some weed control cultivation takes place around Cunnamulla in the table grape growing locations, but sedimentation runoff is very low. As a result, cultivation is not considered by the Water Quality Technical Panel to be a key cause of water quality degradation in the South West region.
	(ii) overgrazing of catchments and grazing of riverbanks and floodplains; Example: The riparian zone along watercourses kept in permanent vegetation can effectively mitigate the movement of sediment within farmlands and from farmlands	All drainage basins.	In each of the four drainage basins, livestock grazing represents at least 95% of the land use. For the likelihood of overgrazing occurring and causing degradation of the water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).
	(iii) poor soil conservation practices; Example: Practices that fail to use management strategies that prevent soil erosion, acidification, salinisation or other chemical soil contamination, or fail to adopt proven soil conservation technologies such as the construction of contour banks	Not applicable to any drainage basin.	Soil conservation practices, including trickle irrigation, lateral moves and pivot irrigation, are implemented in the Warrego drainage basin to prevent this becoming a cause of water quality degradation.
	(iv) practices that over the long-term cause decline of stream morphology, leading to near stream processes of gully erosion, side wall cut and head migration.	All drainage basins, particularly the Paroo and Bulloo.	Grazing, coupled with historical clearing, are practices that can cause declines in stream morphology—these practices have occurred in each drainage basin across the SW region. In addition, soil type and steep terrain can exacerbate the impacts of land management practices and lead to gully erosion, such as in the Paroo and Bulloo drainage basins. Side wall cut and head migration occurs naturally due to the ephemeral nature of river systems in South West Queensland. Practices that accelerate these causes of water quality degradation would be minimal due to the low levels of water resource development in the SW region. Refer to the risk assessment for further information (Section 8 and Appendix 5).

Type of water quality degradation	Key causes of water quality degradation for that type	Applicable drainage basins	Justification
	(b) the following water management practices: (i) rapid drawdown of water within a surface water resource; Example: Rapid drawdown of water in a dam (ii) the volume or manner of release of water, resulting in back or bed erosion.	Warrego drainage basin only.	The Allan Tannock Weir in the Warrego drainage basin is the only storage of sufficient volume in South West Queensland containing the necessary infrastructure to conduct releases. Although the water management practices specified by (i) and (ii) can be a potential cause of water quality degradation where a storage is present, the likelihood of this occurring in Allan Tannock Weir is low, as explained in the risk assessment (Section 8 and Appendix 5).
	(c) wave wash (for example, that caused by speedboats).	Warrego and Bulloo drainage basins only.	South West NRM Ltd. has indicated that recreational speedboats are often present in Allan Tannock Weir and the Ward River Recreational Area in the Warrego drainage basin and Lake Houdraman in the Bulloo drainage basin. For the likelihood of wave wash presenting a risk to water resources in these drainage basins, refer to the risk assessment (Section 8 and Appendix 5).
Elevated levels of nutrients	Nutrients entering Basin water resources through both point and diffuse sources. The key sources of nutrients are: (a) soil and organic matter (b) animal waste (c) fertilisers (d) sewage and industrial discharges (e) nutrients from water storages released as a result of storage management practices.	All drainage basins.	Each of these sources of nutrients has the potential to cause water quality degradation in each drainage basin in the South West region. For the likelihood of these causes presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).
Elevated levels of cyanobacteria cell counts or biovolume and toxins and odour compounds	The interaction of the following factors: (a) a water body with little or no flow (b) stratification in the water body (c) sunlight (d) the availability of phosphorus and nitrogen in the water (e) seeding from up-stream (although cyanobacteria blooms may occur without this factor).	All drainage basins.	The interaction of these factors has the potential to cause water quality degradation in all drainage basins in the South West region. For the likelihood of these causes presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).

Type of water quality degradation	Key causes of water quality degradation for that type	Applicable drainage basins	Justification
Water temperature outside natural ranges	(1) The key cause of water temperature of Basin water resources below natural ranges is the release of stored water from below the thermocline from large water storages in spring, summer and autumn.	Not applicable to any drainage basin.	There are no storages of sufficient size in the South West region to produce a thermocline that would result in the release of water of a temperature below natural ranges in spring, summer or autumn.
	(2) The key causes of water temperature of Basin water resources above natural ranges are the following: (a) the release of stored water from large water storages in winter	Not applicable to any drainage basin.	There are no storages of sufficient size in the South West region to produce a thermocline that would result in the release of water of a temperature above natural ranges in winter.
	(b) the removal of shading riparian vegetation	All drainage basins.	The riparian forest loss from pre-European settlement to 2013 was assessed via remote sensing and spatial analysis as 17.4% for the Bulloo River drainage basin, 15.7% for the Paroo River drainage basin, 23.1% for the Warrego River drainage basin and 34.4% for the Nebine drainage basin (Clark et al., 2015). For the likelihood of this clearing causing water quality degradation due to temperatures outside natural ranges, refer to the risk assessment (Section 8 and Appendix 5).
	(c) reduced flow.	Not applicable to any drainage basin.	The plan area has minimal water resource development that would result in reduced flow producing water temperature outside natural ranges. There is an end-of-system mean annual flow of 99% for the Bulloo and Paroo drainage basins, 89% for the Warrego drainage basin and 87% for the Nebine drainage basin.

Type of water quality degradation	Key causes of water quality degradation for that type	Applicable drainage basins	Justification
Dissolved oxygen outside natural ranges	(1) Micro-organisms consuming organic matter and depleting oxygen at a rate faster than it can be replenished. Example: This can arise when there is a discharge from sewage treatment plants or the flushing of natural organic material from the floodplain.	All drainage basins, particularly the Paroo and Bulloo.	The excess consumption of organic matter by micro-organisms and resulting oxygen depletion has the potential to occur in all drainage basins in the South West region where sewage treatment plants discharge to the river system. For the likelihood of these causes of water quality degradation presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5). The ability to increase flushing flows outside natural ranges due to water resource development is only applicable to the Allan Tannock Weir, where water releases are able to be made by the storage operator. As a result, the flushing of natural organic material from the floodplain due to the management of water flows is only addressed for the Warrego drainage basin in the risk assessment. The flushing of natural organic material from the floodplain as a result of high rainfall has been documented to cause blackwater events in the Paroo and Bulloo drainage basins. Refer to the risk assessment for further information on the likelihood and consequence of these events (Section 8 and Appendix 5).
	(2) Bottom release from, or overturn within, a stratified water storage.	Not applicable to any drainage basin.	There are no storages of sufficient size in the South West region to produce stratification.
	(3) Eutrophication leading to excessive plant growth causing high diurnal variations in dissolved oxygen levels, both above and below natural ranges.	All drainage basins.	Eutrophication has the potential to occur in all drainage basins in the South West region—depending on the level of nutrients discharged to the system. For the likelihood of this cause of water quality degradation presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).
Elevated levels of pesticides and other contaminants	Poor management practices including the following: (a) pesticide spray drift (b) allowing pesticides or other contaminants into surface water runoff (c) allowing pesticides or other contaminants to leach into groundwater	All drainage basins.	Each of the poor management practices that have been identified to result in elevated levels of pesticides and other contaminants has the potential to cause water quality degradation in each drainage basin in the South West region. For the likelihood of these causes of water quality degradation presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).

Type of water quality degradation	Key causes of water quality degradation for that type	Applicable drainage basins	Justification
	(d) allowing erosion of contaminated soil (e) inappropriate disposal of pesticides (f) inappropriate disposal and management of industrial and other waste (including from mining and coal-seam gas extraction).		
pH outside natural ranges	(1) The exposure to the air of soils containing iron sulphide minerals. Note: When iron sulphide minerals are exposed to air natural oxidation processes can result in the release of acid, which can be flushed into Basin water resources. (2) Agricultural practices that lead to the acidification of soils.	All drainage basins.	Iron sulphide is present in South West Queensland soils and has the potential to cause pH outside natural ranges if exposed to the air or disturbed through agricultural practices. For the likelihood of these causes of water quality degradation presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).
	(3) Eutrophication leading to excessive plant growth causing high diurnal variation in pH.	All drainage basins.	Eutrophication has the potential to occur in each drainage basin in the South West region—depending on the level of nutrients discharged to the system. For the likelihood of this cause of water quality degradation presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).
Elevated pathogen counts	Pathogens entering Basin water resources through both point and diffuse sources. The key sources of pathogens are: (a) human and animal waste (b) sewage discharges.	All drainage basins.	Human and animal waste, and sewage discharges are present in the South West region and have the potential to cause elevated pathogen counts in waterways. For the likelihood of these causes of water quality degradation presenting a risk to water resources in each drainage basin, refer to the risk assessment (Section 8 and Appendix 5).

SECTION 8: RISK ASSESSMENT OF WATER BEING OF A QUALITY UNSUITABLE FOR USE

8 Risk assessment of water being of a quality unsuitable for use

A water quality risk assessment was completed in accordance with the requirements of section 10.41 of the Basin Plan. The risk assessment assessed the risk to the condition, or continued availability, of Basin water resources as a result of water being of a quality unsuitable for use. For the purposes of the risk assessment, 'use' included:

- consumptive
- cultural, spiritual and ceremonial
- aquatic ecosystem
- economic.

The risk assessment was based on the 'Key causes of water quality degradation' derived from Schedule 10 of the Basin Plan and identified for the Warrego, Paroo, Bulloo and Nebine drainage basins in section 7 of this report. Issues of local significance in the region were also assessed (including pest flora and fauna), as well as the risk of climate change.

8.1 Risk assessment process

The risk assessment methodology is detailed in Appendix 5 of this report and is consistent with the AS/NZS ISO 31000:2009 Risk Management—Principles and Guidelines. The spatial scale of the surface water assessment was based on the Warrego, Paroo, Bulloo and Nebine drainage basins (Refer to Figure 2). The spatial scale of the groundwater assessment was based on the groundwater Sustainable Diversion Limit (SDL) resource units identified by the Murray-Darling Basin Authority[26] (Refer to Figure 8).

8.2 Risk assessment workshops

The initial risk assessment workshop was conducted in Toowoomba on 9 November 2012. The workshop was comprised of the Water Quality Technical Panel (Refer to section 4.1) and included local on-ground expertise from South West NRM Ltd staff. The scores from the initial risk assessment were revised as further consultation occurred between staff from the Queensland Government and South West NRM Ltd. The risk assessment was adjusted as follows:

- 'Degradation of aquatic habitat, riparian extent / connectivity, riparian condition' was included in the risk assessment to recognise impacts to the riparian zone in the South West region—as described in Clark et al. (2015).
- The risk rating in the Bulloo drainage basin for aquatic fauna was increased to very high to reflect the consequences of carp becoming introduced to this system (At time of publication, carp are currently absent in the Bulloo drainage basin but are a significant threat).
- The consequence score for climate change in the Bulloo drainage basin was raised to 'major'. South West NRM Ltd identified that the potential impacts of climate change in the Bulloo would cause a greater impact to community values than other drainage basins due to the largely undisturbed nature of the system.
- The risk rating for dissolved oxygen outside natural ranges was increased to a medium risk in the Paroo and Bulloo drainage basins. This was conducted to recognise additional information provided by South West NRM Ltd on the occurrence of blackwater events in the Paroo and Bulloo basins following periods of high rainfall. The term 'Dissolved oxygen outside natural ranges' was taken to mean dissolved oxygen outside natural ambient ranges, to recognise the influence of extreme rainfall events on dissolved oxygen concentrations.

[26] Refer to the Murray-Darling Basin Authority website for further information on Sustainable Diversion Limit resource units in the Murray-Darling Basin.

8.3 Risk assessment results

The results of the water quality risk assessment for the Warrego, Paroo, Bulloo and Nebine drainage basins are summarised in Table 14. The risk assessment identified a list of priority threats for the Warrego, Paroo, Bulloo and Nebine drainage basins, as follows:

1. elevated levels of suspended matter and deposited sediment as very high risk in the Paroo and Bulloo basins and high risk in the Warrego and Nebine basins
2. dissolved oxygen outside natural (ambient) ranges as medium risk in the Paroo and Bulloo basins
3. elevated levels of salinity a medium risk in the St George Alluvium (Deep) (WPBN).
4. pest fauna (land) as high risk in all four basins
5. pest fauna (aquatic) as high risk in the Warrego, Paroo and Nebine basins and very high risk in Bulloo basin
6. pest flora (land) as medium risk and pest flora (aquatic) as high risk in all four basins
7. degradation of aquatic habitat connectivity and condition within and between water-dependent ecosystems and the degradation of riparian extent, connectivity and condition as high risk in all four basins.

8.4 Risks to Aboriginal values and uses

The risk assessment results in Table 14 were presented at the Northern Murray-Darling Basin Aboriginal Nations (NBAN) gathering in Warwick, 30 April 2014. Meeting participants were supportive of the identified risks.

In addition, risks specifically to Aboriginal values and uses were described in further detail through consultation with Aboriginal people and organisations that represent Aboriginal Nations in the plan area. This consultation occurred throughout the development of the Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins between 2011 and 2015 (Refer to section 4.5). Where appropriate, the Department of Environment and Heritage Protection and the Department of Natural Resources and Mines conducted joint-consultation with the Aboriginal community to address both water use and water quality in a single forum. The October 2015 workshops were facilitated by representatives nominated by NBAN. Consultation conducted on the Basin Plan by the Murray-Darling Basin Authority was also considered.

The consultation with representatives from local Aboriginal Nations supported the view that:

Every water site located in the landscape was considered as being special to Aboriginal people, and it was not possible to prioritise or select some water sites as having a higher value than others' (South West NRM Ltd, 2012b).

The Aboriginal community described the way in which water is valued and used across the plan area, as listed below:

- natural springs and mound springs
- rivers and waterholes
- lakes, wetlands, claypans and gilgais
- fish traps
- earthen and stone arrangements
- scarred and carved trees
- middens
- hearths
- burial grounds
- plants and animals
- water quality
- riparian zone
- connectivity through the landscape

Consultation with the Aboriginal people and Traditional Owners in the WPBN plan area raised many issues that were seen as risks to Aboriginal values and uses arising from the use and management of water resources, as well as from land use and other non-water related activities. Although some of the risks to values and uses identified by local Aboriginal people cannot be managed specifically by the Healthy Waters Management Plan, they were included in order to understand the full range of issues affecting water related values and uses in the catchments.

The risks to Aboriginal values and uses in the plan area were as follows:

- erosion of river banks and the impacts on ceremonial and burial grounds, requiring areas to be fenced off, revegetated and maintained (Bollon, Cunnamulla, Charleville meetings)
- siltation build-up behind weirs and general siltation and turbidity of the waterways (Bollon, Cunnamulla,

Charleville, Toowoomba meetings)
- loss of river flows that support native fish and vegetation that are important for Aboriginal cultural practices (Cunnamulla, Toowoomba meetings)
- effect of droughts and erosion on permanent waterholes and the subsequent impacts on cultural sites such as scarred trees, middens and burial grounds (Bollon, Cunnamulla, Charleville meetings)
- loss of knowledge on the cultural and spiritual values of the area and the need for more cultural mapping of usage and occupancy (Bollon, Cunnamulla, Charleville meetings)
- impacts of aquatic weeds, fish barriers such as Allan Tannock Weir, introduced European carp, cane toads, litter, blue green algae outbreaks and overfishing on the waterways (Cunnamulla, Charleville, Quilpie, Augathella meetings)
- loss of wildlife and native vegetation, including river red gums, birdlife, water rats, native fish and shellfish (Cunnamulla, Augathella meetings)
- disturbance to fish traps
- inappropriate recreational activity at popular waterways/waterholes, particularly concerning disposal of human waste
- suspected illegal pumping and blocking of channels (Cunnamulla meeting)
- lack of easily accessible information on water use in catchments (Cunnamulla meeting)
- impact on rivers and waterholes from stock (Charleville meeting)
- suspected impacts from mining, coal seam gas exploration and uncapped bores (Quilpie meeting)
- positive and negative impacts of bore drain capping (Cunnamulla meeting)
- increase in chemical inputs to waterways via feral baiting programs, aerial spraying and herbicide runoff.

Table 14: Risk assessment of water being of a quality unsuitable for use in the Warrego, Paroo, Bulloo and Nebine drainage basins—Summary

Colour	Risk level		Colour	Risk level
Red	Very high risk		Yellow	Medium risk
Orange/tan	High risk		White	Low risk N/A

Risk Factor	Surface water drainage basin				Groundwater Sustainable Diversion Limit (SDL) Areas				
	Warrego	Paroo	Bulloo (not part of MDB)	Nebine	Sediments above the GAB (GS60)	Warrego Alluvium (GS66)—Above Wyandra	Warrego Alluvium (GS66) - Below Wyandra	St George Alluvium (Shallow) (WPBN) (GS63)[2]	St George Alluvium (Deep) (WPBN) (GS63)[2]
Elevated levels of salinity[1]	Low	Low	Low	Low	Low	Low	Low	Low	Medium
Elevated levels of suspended matter—including deposited sediment*	High	Very high	Very high	High	N/A	N/A	N/A	N/A	N/A
Elevated levels of nutrients, including phosphorus and nitrogen	Low	Low	Low	Low	Low	Low	Low	Low	Low
Elevated cyanobacteria cell counts or biovolume, toxins and odour compounds	Low	Low	Low	Low	N/A	N/A	N/A	N/A	N/A
Dissolved oxygen outside natural (ambient) ranges	Low	Medium	Medium	Low	N/A	N/A	N/A	N/A	N/A
Elevated levels of pesticides, heavy metals and other toxic contaminants*	Low	Low	Low	Low	Low	Low	Low	Low	Low
Elevated pathogen counts	Low	Low	Low	Low	Low	Low	Low	Low	Low
pH outside natural ranges	Low	Low	Low	Low	N/A	N/A	N/A	N/A	N/A
Water temperature outside natural ranges	Low	Low	Low	Low	N/A	N/A	N/A	N/A	N/A
Climate change	Low	Low	Low	Low	Low	Low	Low	Low	Low
Degradation of aquatic habitat, riparian extent / connectivity, riparian condition	High	High	High	High	N/A	N/A	N/A	N/A	N/A
Pest fauna - land	High	High	High	High	N/A	N/A	N/A	N/A	N/A
Pest fauna—aquatic	High	High	Very High	High	N/A	N/A	N/A	N/A	N/A
Pest flora—land	Medium	Medium	Medium	Medium	N/A	N/A	N/A	N/A	N/A
Pest flora—aquatic	High	High	High	High	N/A	N/A	N/A	N/A	N/A

Notes:
1. This risk factor includes consideration of impacts from resource activities (including mining and CSG).

2. The St George Alluvium Warrego–Paroo-Nebine (GS63) under Queensland water resource planning is managed as two separate units—the St George Alluvium (shallow) and the St George Alluvium (Deep).

SECTION 9: MANAGEMENT RESPONSES

9 Management responses

Section 10.33 of the Basin Plan specifies that a WQM Plan must specify measures to be undertaken in, or in relation to, the water resources of the water resource plan area that contribute to the achievement of objectives.

A measure is recommended for accreditation in a WQM Plan for Queensland Murray-Darling Basin catchments if the:

- **level of risk is medium, high or very high;**
- **relevant water quality and salinity target values are identified in section 11 of the HWMP;**
- **measure is an action within the scope of the *Water Act 2007* and Queensland *Water Act 2000***
- **measures are fit-for-purpose and cost effective.**

As a result of these criteria, the management responses listed in a Healthy Waters Management Plan are not flow-related accredited measures for the purposes of the Basin Plan. However, in order to encapsulate the overall framework for the management of water quality in the Queensland Murray-Darling Basin, the WQM Plan under the Basin Plan *recognises* that the following land management responses listed in Section 9 apply to improve water quality in the Warrego, Paroo, Bulloo and Nebine basins.

The management responses presented in this section have been developed to address the risks identified in Section 8 of this report and contribute to the achievement of objectives and outcomes for water resources specified in Section 3. Management responses listed in Tables 15-22 address risks to water quality in the Warrego, Paroo, Bulloo and Nebine drainage basins identified as being at a medium, high or very high level.

The management responses identify the existing natural resource management projects in the plan area, implemented primarily by South West NRM Ltd, the recognised Regional NRM Body for the region. The projects are supported by Queensland and Commonwealth Government funding and the voluntary adoption of Grazing BMP modules developed for the Fitzroy and Burdekin basins—funded by the Queensland Government. The existing natural resource management projects in the plan area include:

- Queensland Natural Resource Management Program
    - Enhancing Primary Production through Control of Total Grazing Pressure (TGP) and improved land management (70% Sustainable Agriculture, 30% Weeds and Pests)
- Australian Government—Caring for our Country[27]:
    - Sustainable Environment: Maintenance of ecosystem services
    - Sustainable Environment: Protecting Ramsar site and values
    - Sustainable Agriculture: Mulga Graze
    - Sustainable Agriculture: Landcare in the Mulga Lands
    - Enhancing capacity of Indigenous communities to conserve and protect natural resources

Existing projects being conducted across Queensland Murray-Darling Basin may inform future management responses and updates to this document. The implementation of future projects will be dependent on the allocation of funding and resources for natural resource management actions.

The extent and cost of the management responses is guided by the level of risk assigned to the type of water quality degradation the management response seeks to address. Management responses should also be fit-for-purpose and collaborative to increase cost efficiency. The projects underway address the medium, high and very high risks to water quality identified in the plan area.

The success of the management responses provided in this section will be assessed against the water quality target values specified in Section 11 of this report, where funded monitoring programs are available. The management responses have been designed to maintain and/or improve water quality to achieve these water quality targets.

[27] The Australian Government announced that Caring for our Country would be combined with the National Landcare Programme in 2013. The National Landcare Programme is continuing to deliver upon initiatives that were in place prior to 1 July 2014, including Caring for our Country 2013-2018 <http://www.nrm.gov.au/news-and-resources/resources/previous-programmes>.

Although impacts of climate change were assessed as a low risk (Refer to Section 8 of this report), proactive measures to address climate change, identified by South West NRM Ltd, are listed below:

- Improve community understanding of the impacts of climate change and variability using best available science for the SW region.
- Collaborate with landholders, industry, local government, scientific experts, Traditional Owners and other key stakeholders on methods to address and adapt to climate change.
- Encourage adoption of technology that improves energy efficiency.
- Utilise tree planting support from the Carbon Farming Initiative (carbon credits derived from natural resource management)—sequestering carbon through revegetation.
- Implement the Caring for our Country—Sustainable Agriculture: Mulga Graze project (Refer to Appendix 1).
- Implement the Caring for our Country—Sustainable Agriculture: Landcare in the Mulga Lands project (Refer to Appendix 1).

In addition, refer to the research described in Section 4.6 of this report.

9.1 Management responses to address risks (medium, high or very high risks)

9.1.1 Risk factor: Degradation of aquatic habitat, riparian extent/connectivity, riparian condition

Risk level	
Warrego River basin	High
Paroo River basin	High
Bulloo River basin	High
Nebine River basin	High
Not applicable to groundwater.	

Table 15: Management responses to address the degradation of aquatic habitat, riparian extent/connectivity, riparian condition

Key causes of water quality degradation to be addressed by measures	**Management responses**
Removal of riparian vegetation. Overgrazing of catchments and grazing of riverbanks and floodplains. Practices that over the long-term cause decline of stream morphology, leading to near stream processes of gully erosion, side wall cut and head migration. The implementation of poor management practices leading to elevated levels of pesticides and other contaminants.	<u>Current activities:</u> Implementation of the following projects: • 'Queensland NRM Project: Enhancing Primary Production through Control of Total Grazing Pressure (TGP) and improved land management' (Refer to Appendix 1) to manage riparian condition, extent and connectivity. Target the project to high ecological value water assets (such as permanent waterholes), critical flow paths (particularly across the distributary systems of the Paroo and Warrego), and floodplain wetlands to improve fencing and enhance grazing regimes. Utilise the riparian and groundcover mapping products (Clark et al., 2015; Van den berg et al., 2015) to identify and prioritise areas of the South West region for protection or remediation, in line with riparian targets and the maintenance of catchment groundcover (Section 11.2.8 of this report). • 'Enhancing capacity of Indigenous communities to conserve and protect natural resources' (Refer to Appendix 1 or Chapter 10 of this report)—to implement natural resource management by Traditional Owner groups. • 'Caring for our Country—Sustainable Agriculture: Landcare in the Mulga Lands' (Refer to Appendix 1) to educate the next generation on sustainable landscape practices. • 'Caring for our Country—Sustainable Agriculture: Mulga Graze' (Refer to Appendix 1) to protect and enhance perennial native pasture species. Queensland Government provided funding to support the development of the Grazing Best Management Practice (BMP) program in the Great Barrier Reef catchments and progressive roll-out of the program across Queensland. The voluntary and industry-led Grazing BMP program provides graziers across Queensland with the opportunity to improve productivity

and reduce soil run-off to waterways through the identification of improved practices. The Grazing BMP program is available to graziers online via the following website: <https://www.bmpgrazing.com.au>.

Under the Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin and an amended National Partnership Agreement, the Queensland Government received funding to support the 'Aerial Survey of wetlands and waterbirds in Queensland' from 2014-2017. This project monitors river and wetland health, including wetland condition at the Currawinya Lakes Ramsar site. The aerial surveys are conducted by the University of New South Wales.

<u>Future activities:</u>

- Address the following high priority knowledge gaps identified in the Bioregional Assessment Project—Phase 1 in South West Queensland (South West NRM Ltd, 2012a):
  - Conduct a hydrological study of the Currawinya Lakes to investigate overland flow paths and connectivity.
  - Research the effects on the hydrological regimes of the Currawinya Lakes resulting from linear infrastructure crossing flow paths.
  - Research the importance of non-potable aquifers to ecosystem function.
- Address other priority knowledge gaps and research opportunities identified in the Bioregional Assessment Project—Phase 1 (South West NRM Ltd, 2012a), where possible.
- Encourage best practice soil, water, nutrient and pesticide management for irrigated horticulture / cropping.
- Continue to prioritise significant floodplain wetlands for land care activities, including biological assessments and monitoring.
- Continue to implement management actions to ensure no net decline of in-stream habitat. Macroinvertebrate analysis can be used as indicators of in-stream condition and trend.
- Monitor and report key water quality indicators at South West monitoring sites in each water type area (Refer to Appendix 2 for potential sites).

9.1.2 Risk factor: Elevated levels of salinity

Risk level	
St George Alluvium (Deep) (WPBN)	Medium
All other surface waters and groundwaters	Low

Table 16: Management responses to address elevated levels of salinity

Key causes of water quality degradation to be addressed by measures	Management responses
The use of groundwater for irrigation purposes at locations where highly saline upper aquifer water drains to the lower aquifer (applicable to the St George Alluvium (Deep) only). Saline groundwater and surface water discharges into surface water systems. Increased deep drainage below irrigated agricultural land displacing saline groundwater to surface water systems. Saline surface and shallow groundwater drainage from irrigated agricultural land into surface water systems (Warrego drainage basin only). Irrigation at high salinity risk locations without adequate drainage management (between Cunnamulla and Wyandra only). Land management practices involving the replacement of deep-rooted vegetation with shallow-rooted crops and pastures.	<u>Current activities</u> The St George Alluvium is managed as two separate resource units (shallow and deep) under the Queensland water resource planning framework. Section 19 of the *Water Resource (Warrego, Paroo, Bulloo and Nebine) Plan 2016* limits any increase in groundwater take from the St George Alluvium (deep), to mitigate the risk of increased salinity in this resource unit. To maintain low risk scores for elevated levels of salinity across all surface waters and groundwaters, the following management responses are encouraged by South West NRM Ltd.: • Where implemented, continue existing efficient irrigation management practices. • Promote uptake of the Grazing BMP program by graziers in the plan area. The Queensland Government will continue to implement the Basin Salinity Management Strategy to 2030. The objective of the program is to monitor and report compliance with end-of-valley salinity targets associated with Queensland Murray-Darling Basin catchments. <u>Future activities</u> • Continue to support / promote water use efficiency in irrigation. • Maintain groundcover in sodic soil areas. • Promote and support native vegetation management—maintain/improve deep rooted vegetation in high salinity risk areas.

With respect to soil degradation, the use of water with a high ratio of sodium to calcium and magnesium for irrigation (Nebine drainage basin only).	

9.1.3 Risk factor: Elevated levels of suspended matter—including deposited sediment

Risk level	
Warrego River basin	High
Paroo River basin	Very High
Bulloo River basin	Very High
Nebine River basin	High
Not applicable to groundwater.	

Table 17: Management responses to address elevated levels of suspended matter—including deposited sediment

Key causes of water quality degradation to be addressed by measures	**Management responses**
Overgrazing of catchments and grazing of riverbanks and floodplains. Practices that over the long-term cause decline of stream morphology, leading to near stream processes of gully erosion, side wall cut and head migration. Wave wash (for example, that caused by speedboats).	<u>Current activities:</u> Implementation of the: • 'Queensland NRM Project: Enhancing Primary Production through Control of Total Grazing Pressure (TGP) and improved land management' (Refer to Appendix 1) to address total grazing pressure and groundcover loss to reduce erosion of the landscape and riparian zones, and resulting sedimentation of waterways. • 'Caring for our Country—Sustainable Environment: Maintenance of ecosystem services project' (Refer to Appendix 1) to reduce turbidity and silt deposition in critical drought refugia. • 'Caring for our Country—Sustainable Environment: Protecting Ramsar site and values' (Refer to Appendix 1) to reduce turbidity and silt deposition in the Currawinya Lakes Ramsar site and upstream in the Paroo River catchment. Queensland Government provided funding to support the development of the Grazing Best Management Practice (BMP) program in the Great Barrier Reef catchments and progressive roll-out of the program across Queensland. The voluntary and industry-led Grazing BMP program provides graziers across Queensland with the opportunity to improve productivity and reduce soil run-off to waterways through the identification of improved practices. The Grazing BMP program is available to graziers online via the following website: <https://www.bmpgrazing.com.au>.

	Under the Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin and an amended National Partnership Agreement, the Queensland Government received funding to support the development of a water quality model (eWater Source Modelling) for Queensland Murray-Darling Basin catchments – including the Warrego, Paroo, Bulloo and Nebine basins. The Source Catchment model will enable a greater understanding of the temporal and spatial variability in water quality loads and concentrations across the Warrego, Paroo, Bulloo and Nebine drainage basins, enabling better prioritisation of management responses. The water quality model assesses total suspended solids, as well as electrical conductivity and key nutrients. Water quality monitoring is also being conducted to validate and calibrate the model—for completion 2016-17. <u>Future activities</u> • Continue to work with landholders to maintain and improve riparian forest and catchment groundcover, in line with Section 11.2.8 of this report. Prioritise areas of bank instability or erosion for remediation. • Monitor and report suspended and deposited sediment at key surface water sites in the plan area. • Continue to monitor sedimentation at Caiwarro and other lakes within the Currawinya Ramsar site and devise cost-effective approaches to reduce sediment levels. • Determine impact of wave wash on elevated levels of suspended matter in the recreational areas of the Warrego and Bulloo drainage basins.

9.1.4 Risk factor: Dissolved oxygen outside natural ranges

Risk level	
Warrego River basin	Low
Paroo River basin	Medium
Bulloo River basin	Medium
Nebine River basin	Low
Not applicable to groundwater.	

Table 18: Management responses to address dissolved oxygen outside natural ranges

Key causes of water quality degradation to be addressed by measures	**Management responses**
Micro-organisms consuming organic matter and depleting oxygen at a rate faster than it can be replenished as a result of the flushing of natural organic material from the floodplain during high rainfall.	<u>Current activities:</u> • South West NRM Ltd. identifies blackwater events, to monitor frequency of occurrence in relation to natural resource management actions.

	Future activities: • As above.

9.1.5 Risk factor: Pest fauna—Land

Risk level	
Warrego River basin	High
Paroo River basin	High
Bulloo River basin	High
Nebine River basin	High
Not applicable to groundwater.	

Table 19: Management responses to address risks from land-based pest fauna

Key causes of water quality degradation to be addressed by measures	Management responses
Overgrazing of catchments and grazing of riverbanks and floodplains. Pugging, rooting, wallowing, bank slumping, increased nutrients, spread of weeds and the consumption of native plants and wildlife (e.g. freshwater mussels) (Negus et al., 2012a-d).	Current activities: Collaborative implementation of the: • 'Queensland NRM Project: Enhancing Primary Production through Control of Total Grazing Pressure (TGP) and improved land management' (Refer to Appendix 1) to address increased pest species throughout the region including wild dogs, pigs, foxes and cats. These pest fauna are causing significant animal predation and degradation of landscape and riparian areas. • 'Caring for our Country—Sustainable Environment: Maintenance of ecosystem services project' (Refer to Appendix 1) to manage predation of endangered and threatened ground dwelling and migratory species. • 'Caring for our Country—Sustainable Environment: Protecting Ramsar site and values' (Refer to Appendix 1) to prevent degradation of the Currawinya Lakes Ramsar site by feral pigs. • Sub-cluster landscape baiting supported by the Department of Agriculture and Fisheries (Qld.) and Federal Government drought assistance package to manage feral animals. • Biannual baiting programs to control feral animals under the *Land Protection (Pest and Stock Route Management) Act 2002*. Future activities:

	• Continue to implement collaborative approaches to pest control with land managers and identify opportunities to value-add through the alignment and timing of pest management programs.

9.1.6 Risk factor: Pest fauna—Aquatic

Risk level	
Warrego River basin	High
Paroo River basin	High
Bulloo River basin	Very High
Nebine River basin	High
Not applicable to groundwater.	

Table 20: Management responses to address risks from aquatic pest fauna

Key causes of water quality degradation to be addressed by measures	**Management responses**
Predation of native species. Competition with native fish populations for food, habitat and spawning locations. Increase in suspended sediment and nutrients. (Negus et al., 2012a-d).	<u>Current activities:</u> • Prevent increase in relative abundance of carp and other pest species through trapping, electrofishing and other successful measures undertaken by South West NRM Ltd. Conduct on-going public awareness events for native fish and pest management, such as carp fishing days in major waterholes. Prevent spread of carp into the Bulloo drainage basin through ongoing awareness and education. <u>Future activities:</u> • Manage stocking programs to support all native fish species. • Mitigate existing barriers to fish movements, where possible. • Negotiate for new developments to include fish passage at stream crossings, where possible.

9.1.7 Risk factor: Pest flora—Land

Risk level	
Warrego River basin	Medium
Paroo River basin	Medium
Bulloo River basin	Medium
Nebine River basin	Medium
Not applicable to groundwater.	

Table 21: Management responses to address risks from land-based pest flora

Key causes of water quality degradation to be addressed by measures	**Management responses**
Competition with native plants and reduction in the quality of habitat for native animals.	<u>Current activities:</u> Implementation of the: • ‘Queensland NRM Project: Enhancing Primary Production through Control of Total Grazing Pressure (TGP) and improved land management’ (Refer to Appendix 1) to reduce invasive weed species across grazing lands in the plan area. • ‘Caring for our Country—Sustainable Environment: Protecting Ramsar site and values’ to prevent the spread of invasive weeds into Currawinya Lakes Ramsar site (Refer to Appendix 1). • ‘Caring for our Country—Sustainable Environment: Maintenance of ecosystem services’ (Refer to Appendix 1) to reduce core infestations of Weeds of National Significance. <u>Future activities:</u> • Continue to prioritise riparian, floodplain and wetland areas for weed management to minimise erosion and provide increased sediment filtering.

9.1.8 Risk factor: Pest flora—Aquatic

Risk level	
Warrego River basin	High
Paroo River basin	High
Bulloo River basin	High
Nebine River basin	High
Not applicable to groundwater.	

Table 22: Management responses to address risks from aquatic pest flora

Key causes of water quality degradation to be addressed by measures	Management responses
Competition with native plants. Reduction in the quality of habitat for native animals. Dissolved oxygen outside natural ranges. Water temperature outside natural ranges. Heavy infestations can inhibit recreational and aesthetic values.	Current activities: Implementation of the: • 'Caring for our Country—Sustainable Environment: Maintenance of ecosystem services' to reduce core infestations of Weeds of National Significance. • 'Caring for our Country—Sustainable Environment: Protecting Ramsar site and values' to prevent the spread of invasive weeds into Currawinya Lakes Ramsar site (Refer to Appendix 1). Identify the priority aquatic flora species for control under relevant Regional or Local Pest Management Plans, with eradication or mitigation coordinated by Local Government. Future activities: • Continue to prioritise high ecological value areas (such as waterholes) for aquatic weed management.

SECTION 10: OPPORTUNITIES TO STRENGTHEN THE PROTECTION OF ABORIGINAL VALUES AND USES OF WATER

10 Opportunities to strengthen the protection of Aboriginal values and uses of water

Section 10 of the Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins presents opportunities to strengthen the protection of Aboriginal values and uses of water. The opportunities to strengthen the protection of Aboriginal values and uses are primarily related to the protection of water quality and aquatic ecosystems. The opportunities were developed to address risks to Aboriginal values and uses identified through consultation with the former Far South West Aboriginal Natural Resource Management Group, the Northern Murray-Darling Basin Aboriginal Nations (NBAN) and the local Aboriginal community (Refer to section 4.5 and the Consultation Summary Report: Healthy Waters Management Plan for the Warrego, Paroo, Bulloo and Nebine basins (EHP, 2016) for further information).

The Aboriginal values and uses of water in the plan area that were identified through consultation are as follows:

- natural springs and mound springs
- rivers and waterholes
- lakes, wetlands, claypans and gilgais
- fish traps
- earthen and stone arrangements
- scarred and carved trees
- middens
- hearths
- burial grounds
- plants and animals
- water quality
- riparian zone
- connectivity through the landscape.

The opportunities to strengthen the protection of Aboriginal values and uses of water were developed for consistency with the objective and outcome for Aboriginal cultural, spiritual and ceremonial values and uses of water. The intent of the objective is that the quality of water in the Warrego, Paroo, Bulloo and Nebine drainage basins will be suitable to support cultural, spiritual and ceremonial values and uses across all surface and groundwaters, with the outcome that water quality will be fit for purpose for Aboriginal people.

The opportunities to strengthen the protection of Aboriginal values and uses of water were identified and recorded in the Healthy Waters Management Plan to guide future projects across the South West region. Future projects will be dependent on available funding and resources. A key opportunity to strengthen the protection of Aboriginal values and uses in the plan area would be an expansion of the Federal Working on Country program or Queensland Indigenous Land and Sea Ranger program to the Warrego, Paroo, Bulloo and Nebine drainage basins. Land and sea rangers work closely with Traditional Owners, local authorities, pastoralists, schools and community groups to achieve environmental outcomes and raise awareness of the importance of looking after country.

South West NRM Ltd (2014b) and the former Far South West Aboriginal NRM Group also identified the following improvements, in relation to how natural resource management is conducted in the plan area:

- increase employment, training or economic opportunities for Aboriginal people
- continued involvement and decision making from the Aboriginal people in the region
- all work in each Traditional Owner's area needs to be done in close collaboration with the correct local group
- aim to protect cultural, spiritual, ceremonial and economical values of water
- increase Traditional Owner representation in monitoring of water
- mentor local youth through natural resource management activities, overseen by Elders.

The National Cultural Flows Research Project is also underway in the Murray-Darling Basin and due for completion by the end of 2017. The National Cultural Flows Research Project is driven by Aboriginal People, for Aboriginal people. It combines scientific methodologies and generations of cultural knowledge to strengthen the evidence for recognition of Aboriginal rights and interests relating to water[28]. The Queensland Government is a member of the National Cultural Flows Research Project Committee and will provide advice to the committee on state water planning processes and promote the results of the research project to its stakeholders. The outcomes of the project may also inform future updates to the HWMP upon its review.

Table 23: Opportunities to strengthen the protection of Aboriginal values and uses in the plan area

Risk to Aboriginal values and uses	Opportunities to strengthen the protection of Aboriginal values and uses
Erosion of river banks and the impacts on ceremonial and burial grounds, requiring areas to be fenced off, revegetated and maintained (Bollon, Cunnamulla, Charleville meetings)	Refer to the 'Caring for our Country - Enhancing capacity of Aboriginal communities to conserve and protect natural resources' project below (Section 10.1), or discuss opportunities to protect ceremonial and burial grounds with South West NRM.
Siltation build-up behind weirs and general siltation and turbidity of the waterways (Bollon, Cunnamulla, Charleville, Toowoomba meetings)	Implement the management responses for addressing ‘Elevated levels of suspended matter—including deposited sediment’ (Refer to Section 9 of this report).
Loss of river flows that support native fish and vegetation that are important for Aboriginal cultural practices (Cunnamulla, Toowoomba meetings)	As part of the water planning process, the Department of Natural Resources and Mines (DNRM) undertakes extensive environmental assessments that look at the flow-related risks to ecological assets, such as native fish and vegetation. The assessment determined that the risk to assets in this plan area was low.
Effect of droughts and erosion on permanent waterholes and the subsequent impacts on cultural sites such as scarred trees, middens and burial grounds (Bollon, Cunnamulla, Charleville meetings)	The effect of droughts on permanent waterholes is addressed by DNRM through the water planning process, and specifically through the use of environmental flow objectives (EFOs). The long-term watering plan for the Warrego, Paroo and Nebine catchment explains how the EFOs are applied to protect waterhole values. Refer to the 'Caring for our Country - Enhancing capacity of Aboriginal communities to conserve and protect natural resources' project below (Section 10.1), or discuss opportunities to protect cultural sites with South West NRM.
Loss of knowledge on the cultural and spiritual values of the area and the need for more cultural mapping of usage and occupancy (Bollon, Cunnamulla, Charleville meetings)	Refer to the 'Caring for our Country - Enhancing capacity of Aboriginal communities to conserve and protect natural resources' project below (Section 10.1), or discuss opportunities to protect cultural sites with South West NRM.
Impacts of aquatic weeds, fish barriers such as Allan Tannock Weir, introduced European carp, cane toads, litter, blue green algae outbreaks and overfishing on the waterways (Cunnamulla, Charleville, Quilpie, Augathella meetings)	Investigate feasibility of the installation of a fish ladder at the Allan Tannock weir. Implement the management responses for addressing pest fauna (aquatic) (Refer to Section 9 of this report) in consultation with local Traditional Owner representatives. Identify economic opportunities for carp harvesting. Record blue-green algae outbreaks. Compare results to water quality targets.
Loss of wildlife and native vegetation, including river red gums, birdlife, water rats, native fish and shellfish (Cunnamulla, Augathella meetings)	Risks to aquatic ecosystems, including vegetation, are assessed as part of DNRM’s environmental assessments. The risk to these assets from the alteration of flows was assessed as low in this plan area.

[28] National Cultural Flows Research Project (2016). Refer to: http://culturalflows.com.au/

	Refer to the management responses in Section 9 of this report for on-ground projects that seek to improve conditions for wildlife and vegetation in the plan area.
Disturbance to fish traps	Identify priority fish traps for restoration and inform South West NRM.
Inappropriate recreational activity at popular waterways/waterholes, particularly concerning disposal of human waste	Discuss with local government and relevant agencies improvements to recreational areas. For example: • Encourage and provide facilities for the increasingly popular destinations for caravan tourists • Bollards may be required to guide vehicles. • Bins and signs placed in appropriate places to discourage littering. Address riparian/bank impacts, where identified (Refer to the management responses in Section 9 of this report).
Suspected illegal pumping and blocking of channels (Cunnamulla meeting)	Issues of non-compliance such as illegal take are referred to and handled by the local DNRM office. Illegal take of water is addressed in the *Water Act 2000*.
Lack of easily accessible information on water use in catchments (Cunnamulla meeting)	Information on water use, including permitted take and available water, is readily available on the SunWater website. SunWater is the irrigator infrastructure operator for the plan area.
Impact on rivers and waterholes from stock (Charleville meeting)	Refer to the management responses in Section 9 of this report. The Queensland NRM Project: Enhancing Primary Production through Control of Total Grazing Pressure (TGP) and improved land management addresses total grazing pressure and groundcover loss from stock to control increased erosion /sedimentation in the plan area.
Suspected impacts from any future mining, coal seam gas exploration (Quilpie meeting)	In Queensland, public notification is required for certain development applications to ensure that the public is aware of the development and they have the opportunity to make submissions about it. Public submissions should be made to address any concerns associated with any future mining and coal seam gas activity.
Positive and negative impacts of bore drain capping (Cunnamulla meeting)	The Great Artesian Basin Sustainability Initiative (GABSI) program has been extended to 30 June 2017. GABSI is a joint program between the Australian, New South Wales, Queensland, South Australian and Northern Territory governments to provide funding support to repair uncapped bores that threaten the long-term sustainability of the Great Artesian Basin. Refer to the Australian Government website for a list of contact details for local state officers involved in the GABSI program.
Increase in chemical inputs to waterways via feral baiting programs, aerial spraying and herbicide runoff.	Identify priority waterholes where there is potential pollution due to chemical inputs.

10.1 Caring for our Country—Enhancing capacity of Aboriginal communities to conserve and protect natural resources

This project is funded by the Commonwealth Government for five years, commencing in July 2013 and concluding June 2018. The project is managed by South West NRM Ltd.

The project acts to enhance the capacity of the Aboriginal communities of south-west Queensland, to conserve and protect natural resources, in particular those species and ecosystems within the areas of national, state and regional environmental significance within the SW region. Through engagement with Traditional Owners, the project will demonstrate and promote methods for enhancing the condition and resilience of critical drought refugia, threatened ecological communities, and other vulnerable ecosystems, to allow for a return to a Traditional landscape.

The project will identify and promote Traditional Culture and Values that underpin biodiversity conservation, heritage conservation and the sustainable use of natural resources. The project encompasses the Aboriginal Nations of the Kooma (Guwamu), Bidjara, Kunja, Mardigan, Budjiti, and Kullilli people within the Warrego, Paroo, Bulloo and Nebine catchments. The project specifically focuses on the implementation of aspirational natural resource management change on the Indigenous Protected Areas and Nature Refuges of Murra Murra and Bendee Downs (49,974 hectares; Kooma (Guwamu) Nation) and Mount Tabor (70,574 hectares; Bidjara Nation). Additionally, the project works with other Aboriginal communities to strategize and implement opportunities for enhancing culture and opportunity. The project will leverage off and value-add to the experience and success of previous cooperative projects with Aboriginal people; further enhancing the strategic relationships of South West NRM Ltd. with respect to the education and adoption of natural resource management strategies within Aboriginal communities. Contact South West NRM Ltd for further information on this project.

SECTION 11: WATER QUALITY TARGET VALUES

11 Water quality target values

Water quality target values[29] are quantitative measures of water quality indicators that protect a stated environmental value (Refer to section 5 of this report). The targets can be concentrations, loads or a biological measure, e.g. macroinvertebrate diversity. Where there are multiple water quality target values for a particular indicator to protect different environmental values at a location, the most stringent water quality target value applies.

Section 10.32 of the Basin Plan specifies that a WQM Plan is to identify water quality target values for fresh water-dependent ecosystems, irrigation water and water used for recreational purposes. Default water quality target values are provided in the Basin Plan (Chapter 9 and Schedule 11) for these matters. Subsections 10.32 (3) and (4) enables the WQM Plan to specify alternative water quality target values if they are developed in accordance with stated requirements.

Where available, alternative local water quality targets to those specified in Chapter 9 and Schedule 11 of the Basin Plan have been included in Section 11 of the HWMP for the Warrego, Paroo, Bulloo and Nebine basins. The application of the default Basin Plan water quality targets is considered inappropriate where local water quality target values have been developed. The default Basin Plan targets under Chapter 9 and Schedule 11 were developed for a broad spatial scale that does not reflect the variation in water types across Warrego, Paroo, Bulloo and Nebine drainage basins (Refer to the waters types in Figure 15 and described in Appendix 3). Where data was available at a finer spatial scale, local water quality target values were developed for the water types within the Warrego, Paroo, Bulloo and Nebine drainage basins. Further information on the development of alternative water quality target values is provided in Appendix 2.

Refer to the following sections of the Healthy Waters Management Plan for the water quality target values for accreditation under section 10.32 of the Basin Plan:

- **section 11.2.1: Water quality targets for fresh water-dependent ecosystems (moderately disturbed aquatic ecosystems)**
- **section 11.2.2: Water quality targets for the Currawinya Lakes Ramsar site**
- **section 11.3.1: Water quality targets for the protection of the Primary Industry Environmental Value—Suitability for irrigation**
- **section 11.3.5: Water quality targets for the protection of the Primary, Secondary and Visual Recreation Environmental Values.**

11.1 Targets for managing water flows

Water quality in relation to the management of water flows in the Warrego, Paroo, Bulloo and Nebine basins is addressed through the Department of Natural Resources and Mines water resource planning framework. Refer to the Department of Natural Resources and Mines—Water Management website for further information.

[29] 'Water quality target values' under the Basin Plan are equivalent to 'Water Quality Objectives' under the EPP Water.

11.2 Water quality targets for the protection of the Aquatic Ecosystem Environmental Value

The water quality targets in this section apply where the Aquatic Ecosystem Environmental Value has been identified in the Warrego, Paroo, Bulloo and Nebine drainage basins (Refer to Section 5 of this report).

11.2.1 Water quality targets for fresh water-dependent ecosystems (moderately disturbed aquatic ecosystems)

Section 10.32 of the Basin Plan requires a WQM Plan to identify water quality targets for fresh water-dependent ecosystems other than declared Ramsar wetlands.

Under the Healthy Waters Management Plan, water quality targets for the protection of the Aquatic Ecosystem Environmental Value were developed for each water type[30] in the Warrego, Paroo, Bulloo and Nebine plan area based on local data. A sub-set of these water quality targets are relevant to meeting the requirements of section 10.32 of the Basin Plan for fresh water-dependent ecosystems other than declared Ramsar wetlands. The water quality target values for accreditation under section 10.32 of the Basin Plan are the water quality target values in:

- **Table 24A for Nebine basin surface waters**
- **Table 25A for Warrego basin surface waters**
- **Table 26A for Paroo basin surface waters.**

While not accredited under the Basin Plan, the water quality target values in Tables 24B, 25B and 26B, which were developed under the Queensland legislative water quality framework, are recognised to support the accredited water quality target values to protect and restore water-dependent ecosystems.

Note: The water quality target values for the Bulloo drainage basin are not accredited under the Basin Plan as the Bulloo drainage basin is a closed system that is not connected to the Murray-Darling Basin.

Local water quality targets for fresh water-dependent ecosystems were developed for each water type identified in Figure 15. A description of water types in the Warrego, Paroo, Bulloo and Nebine plan area is provided in Appendix 3. Where local data was unavailable, the regional water quality targets for fresh water-dependent ecosystems listed in Schedule 11 of the Basin Plan apply for the B1—Upland Water Quality Zone and the A1—Lowland Water Quality Zone[31] (also portrayed on Figure 15).

NOTE: The purpose of the targets provided in this section is to assist those involved in managing water resources to ensure that moderately disturbed aquatic ecosystems are adequately protected (Refer to Section 6: Levels of aquatic ecosystem protection). The local water quality targets presented below are applicable to baseflow conditions, unless otherwise indicated. Water quality target values for event (high) flows are included for key indicators where available. Additional water quality monitoring and modelling is required to derive additional local water quality target values for other flow scenarios.

[30] Water types for the Warrego, Paroo, Bulloo and Nebine drainage basins are mapped in Figure 15 and are described in Appendix 3.

[31] Refer to the Murray-Darling Basin Authority website for spatial information on Water Quality Zones.

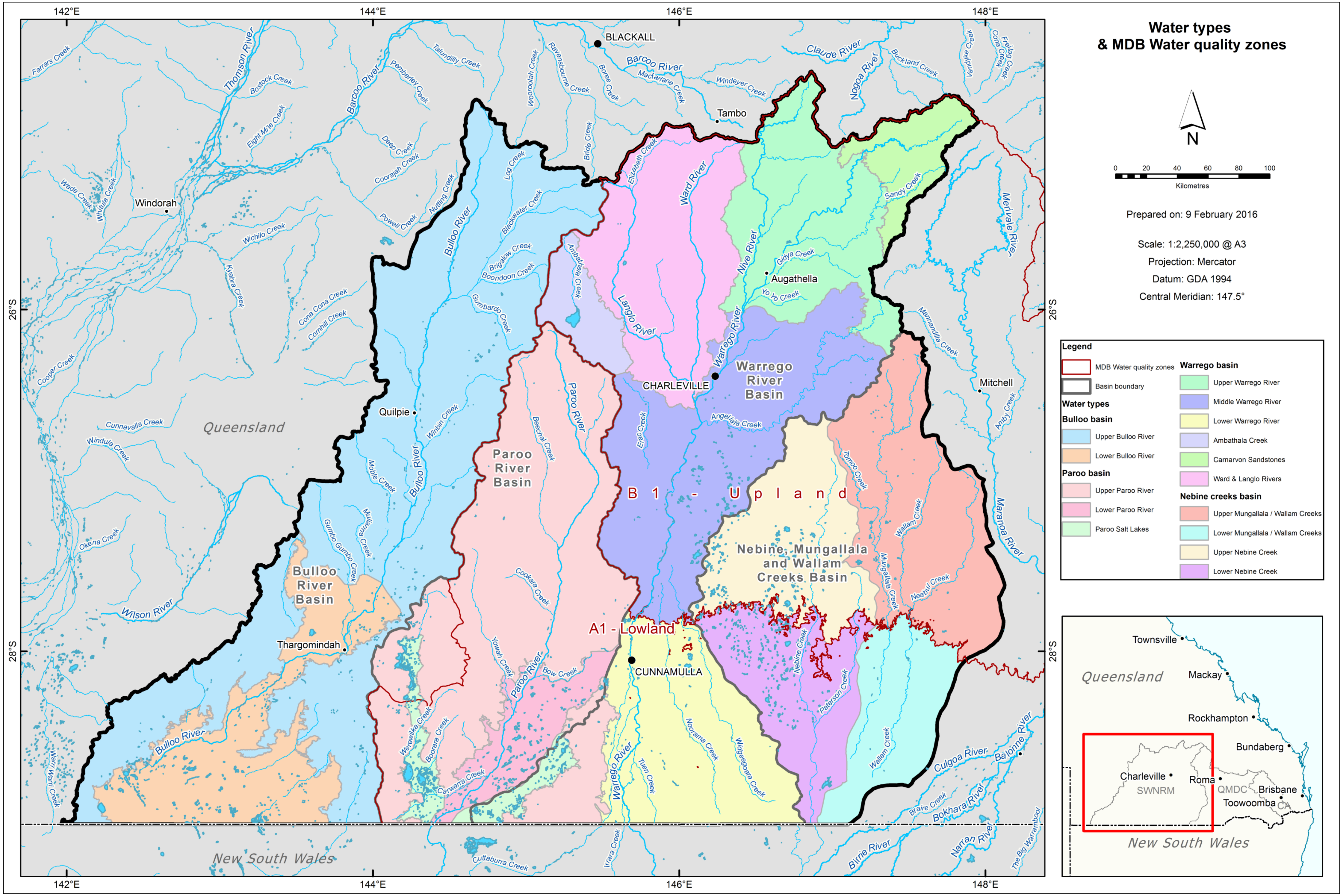

Figure 15: Water types developed for the Warrego, Paroo, Bulloo and Nebine drainage basins where local water quality target values for fresh water-dependent ecosystems apply (Refer to Tables 19-22). See Appendix 3 for a description of each water type.

NEBINE DRAINAGE BASIN SURFACE WATERS

Table 24A—Water quality target values for event (high) flows and baseflows[32]

Notes:

1. Water quality targets for indicators are shown as single values representing 50th percentiles (median), unless otherwise indicated. These water quality targets are applicable to baseflow conditions only, unless otherwise stated.

2. MD: Moderately disturbed.

3. ID: Insufficient data to develop a target value.

4. *Basin Plan Schedule 11 target value for B1 (Condamine and Warrego valleys; Upland zone)—Other water-dependent ecosystems.

5. # Basin Plan Schedule 11 target value for A1 (Condamine, Paroo and Warrego valleys; Lowland zone)—Other water-dependent ecosystems.

6. ♦ In South West drainage basins, turbidity is naturally high (range = 200 to over 1000 NTU) when electrical conductivity measurements are <200µS/cm. Turbidity is typically <30NTU when conductivity is >200µS/cm, except during major flow events (Refer to Appendix 4).

Water area/type	Management intent/ level of protection	Turbidity♦ (NTU) (Annual median)	Total Phosphorus (µg/L) (Annual median)	Total Nitrogen (µg/L) (Annual median)	DO (Annual median within the range)		pH (Annual median within the range)	Salinity (End-of-valley targets)	Temperature (Monthly median within the range)	Pesticides, heavy metals and other toxic contaminants
					mg/L	% sat				
NEBINE DRAINAGE BASIN SURFACE WATERS										
Upper Mungallala/ Wallam Creeks Catchment Waters	MD	50	50	830	N/A*	60-110*	6.5-8.0	Not applicable.	Between the 20%ile and the 80%ile of natural monthly water temperature*.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.
Lower Mungallala/ Wallam Creeks	MD	50	50	830	>5.0#	60-110#	6.5-8.0#	Not applicable	Between the 20%ile and the 80%ile of natural monthly water	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed

[32] Water quality target values in Table 24A are accreditable water quality target values for fresh water-dependent ecosystems (other than declared Ramsar wetlands) under section 10.32 of the Basin Plan.

Catchment Waters									temperature#.	systems must not be exceeded.
Upper Nebine Creek Catchment Waters	MD	660	390	1020	N/A*	60-110*	6.5-8.0	Not applicable	Between the 20%ile and the 80%ile of natural monthly water temperature*.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.
Lower Nebine Creek Catchment Waters	MD	660	390	1020	>5.0#	60-110#	6.5-8.0#	Not applicable	Between the 20%ile and the 80%ile of natural monthly water temperature#.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.

Water area/type	Management intent/ level of protection	**NEBINE DRAINAGE BASIN SURFACE WATERS:** **Table 24B—Additional water quality target values for event (high) flows and baseflows[33]**								
		Notes: 1. Water quality targets for indicators are shown as single values representing 50th percentiles, unless otherwise indicated. These water quality targets are applicable to baseflow conditions only, unless otherwise stated. 2. MD: Moderately disturbed. 3. ID: Insufficient data to develop a target value. 4. ◊ Value derived from the ANZECC Guidelines (2000).								
		EC (µS/cm)	TSS (mg/L)	Alkalinity (mg/L as CaCO3)	SAR	NOx (µg-N/L)	NH4 (µg-N/L)	FRP (µg-P/L)	SO4 (mg/L)	Chl-a (µg/L)
NEBINE DRAINAGE BASIN SURFACE WATERS										
Upper Mungallala and Wallam Creeks	MD	130	10	94	ID	2	9	1	0.5	7
Lower Mungallala and Wallam Creeks	MD	130	10	94	ID	2	9	1	0.5	7
Upper Nebine Creek	MD	70	60	37	ID	83	12	8	3.0	5◊
Lower Nebine Creek	MD	70	60	37	ID	83	12	8	3.0	5◊

[33] While not accreditable under the Basin Plan, water quality target values in Table 24B are recognised to support the accreditable water quality target values in Table 24A to protect and restore fresh water-dependent ecosystems.

<table>
<tr><th rowspan="3">Water area/type</th><th rowspan="3">Management intent/ level of protection</th><th colspan="10">WARREGO DRAINAGE BASIN SURFACE WATERS
Table 25A—Water quality target values for event (high) flows and baseflows[34]</th></tr>
<tr><td colspan="10">Notes:
1. Water quality targets for indicators are shown as single values representing 50th percentiles (median), unless otherwise indicated. These water quality targets are applicable to baseflow conditions only, unless otherwise stated.
2. MD: Moderately disturbed.
3. ID: Insufficient data to develop a target value.
4. * Basin Plan Schedule 11 target value for B1 (Condamine and Warrego valleys; Upland zone)—Other water-dependent ecosystems.
5. # Basin Plan Schedule 11 target value for A1 (Condamine, Paroo and Warrego valleys; Lowland zone)—Other water-dependent ecosystems.
6. ♦ In South West drainage basins, turbidity is naturally high (range = 200 to over 1000 NTU) when electrical conductivity measurements are <200µS/cm. Turbidity is typically <30NTU when conductivity is >200µS/cm, except during major flow events (Refer to Appendix 4).
7. High flow: Water quality target value applicable to high flow conditions only. High flow conditions are defined as: Upper Warrego: >0.7 cumecs at Augathella gauging station; Middle Warrego: >20 cumecs at Wyandra gauging station; Lower Warrego: >9.2 cumecs at Cunnamulla gauging station.</td></tr>
<tr><td>Turbidity♦
(NTU) (Annual median)</td><td>Total Phosphorus (µg/L) (Annual median)</td><td>Total Nitrogen (µg/L) (Annual median)</td><td colspan="2">DO
(Annual median within the range)
mg/L | % sat</td><td>pH (Annual median within the range)</td><td>Salinity (End-of-valley targets)</td><td>Temperature (Monthly median within the range)</td><td colspan="2">Pesticides, heavy metals and other toxic contaminants</td></tr>
<tr><td colspan="12">WARREGO DRAINAGE BASIN SURFACE WATERS</td></tr>
<tr><td>Carnarvon Sandstones</td><td>MD</td><td>15</td><td>170</td><td>720</td><td>N/A*</td><td>60-110*</td><td>7.0-8.0</td><td>Refer to Lower Warrego River Catchment Waters.</td><td>Between the 20%ile and the 80%ile of natural monthly water temperature*.</td><td colspan="2">Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.</td></tr>
</table>

[34] Water quality target values in Table 25A are accreditable water quality target values for fresh water-dependent ecosystems (other than declared Ramsar wetlands) under section 10.32 of the Basin Plan.

Upper Warrego River Catchment Waters	MD	25	170	720	N/A*	60-110*	7.0-8.0	Refer to Lower Warrego River Catchment Waters.	Between the 20%ile and the 80%ile of natural monthly water temperature*.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.
Ward and Langlo Rivers Catchment Waters	MD	410	170	720	N/A*	60-110*	7.0-8.0	Refer to Lower Warrego River Catchment Waters.	Between the 20%ile and the 80%ile of natural monthly water temperature*.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.
Ambathala Creek Catchment Waters	MD	210	190	910	N/A*	60-110*	7.0-8.0	Refer to Lower Warrego River Catchment Waters.	Between the 20%ile and the 80%ile of natural monthly water temperature*.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.
Middle Warrego River Catchment Waters	MD	Baseflow: 210 High flow: 650	Baseflow: 190 High flow: 850	Baseflow: 910 High flow: 2100	N/A*	60-110*	7.0-8.0	Refer to Lower Warrego River Catchment Waters.	Between the 20%ile and the 80%ile of natural monthly water temperature*.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.
Lower Warrego River Catchment Waters	MD	Baseflow: 210 High flow: 760	Baseflow: 180 High flow: 320	Baseflow: 620 High flow: 1100	>5.0[#]	60-110[#]	7.0-8.0	Refer to Appendix 1 of Schedule B to the Murray-Darling Basin Agreement.	Between the 20%ile and the 80%ile of natural monthly water temperature#.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.

WARREGO DRAINAGE BASIN SURFACE WATERS:

Table 25B—Additional water quality target values for event (high) flows and baseflows[35]

Notes:

1. Water quality targets for indicators are shown as single values representing 50th percentiles, unless otherwise indicated. These water quality targets are applicable to baseflow conditions only, unless otherwise stated.
2. MD: Moderately disturbed.
3. ID: Insufficient data to develop a target value.
4. ◊ Value derived from the ANZECC Guidelines (2000).
5. High flow: Water quality target value applicable to high flow conditions only. High flow conditions were defined as: Carnarvon Sandstones: >1.6 cumecs at Maranoa River at Forest Vale gauging station; Upper Warrego: >0.7 cumecs at Augathella gauging station; Middle Warrego: >20 cumecs at Wyandra gauging station; Lower Warrego: >9.2 cumecs at Cunnamulla gauging station.

Water area/type	**Management intent/ level of protection**	EC (µS/cm)	TSS (mg/L)	Alkalinity (mg/L as CaCO3)	SAR	NOx (µg-N/L)	NH4 (µg-N/L)	FRP (µg-P/L)	SO4 (mg/L)	Chl-a (µg/L)
WARREGO DRAINAGE BASIN SURFACE WATERS										
Carnarvon Sandstones	MD	Baseflow: 180 High flow: 110	Baseflow: 40 High flow: 615	Baseflow: 70 High flow: 37	ID	ID	ID	ID	Baseflow: 4.5 High flow: 2.5	5◊
Upper Warrego River Catchment Waters	MD	Baseflow:180 High flow: 130	25	88	1.5	2	3	25	2.0	10
Ward and Langlo Rivers Catchment Waters	MD	135	ID	88	1.5	2	3	25	2.0	10

[35] While not accreditable under the Basin Plan, water quality target values in Table 25B are recognised to support the accreditable water quality target values in Table 25A to protect and restore fresh water-dependent ecosystems.

Ambathala Creek Catchment Waters	MD	115	30	44	0.7	187	7	58	5.5	1
Middle Warrego River Catchment Waters	MD	Baseflow: 115 High flow: 100	Baseflow: 30 High flow: 1030	44	0.7	187	7	58	5.5	1
Lower Warrego River Catchment Waters	MD	Baseflow: 145 High flow: 80	Baseflow: 50 High flow: 380	Baseflow: 45 High flow: 27	1.3	2	5	2	Baseflow: 4.5 High flow: 5.5	10

PAROO DRAINAGE BASIN SURFACE WATERS

Table 26A—Water quality target values for event (high) flows and baseflows[36]

Notes:

1. Water quality targets for indicators are shown as single values representing 50th percentiles (median), unless otherwise indicated. These water quality targets are applicable to baseflow conditions only, unless otherwise stated.
2. MD: Moderately disturbed. HEV: High Ecological Value.
3. ID: Insufficient data to develop a target value.
4. # Basin Plan Schedule 11 target value for A1 (Condamine, Paroo and Warrego valleys; Lowland zone)—Other water-dependent ecosystems.
5. ♦ In South West drainage basins, turbidity is naturally high (range = 200 to over 1000 NTU) when electrical conductivity measurements are <200µS/cm. Turbidity is typically <30NTU when conductivity is >200µS/cm, except during major flow events (Refer to Appendix 4).
6. High flow: Water quality target value applicable to high flow conditions only. High flow conditions were defined as >20 cumecs at Caiwarro gauging station.

Water area/type	**Management intent/ level of protection**	Turbidity♦ (NTU) (Annual median)	Total Phosphorus (µg/L) (Annual median)	Total Nitrogen (µg/L) (Annual median)	DO (Annual median within the range)		pH (Annual median within the range)	Salinity (End-of-valley targets)	Temperature (Monthly median within the range)	Pesticides, heavy metals and other toxic contaminants
					mg/L	% sat				
PAROO DRAINAGE BASIN SURFACE WATERS										

[36] Water quality target values in Table 26A are accreditable water quality target values for fresh water-dependent ecosystems (other than declared Ramsar wetlands) under section 10.32 of the Basin Plan.

Upper Paroo River Catchment Waters	MD	310	180	930	>5.0[#]	60-110[#]	6.5-8.0[#]	Refer to Appendix 1 of Schedule B to the Murray-Darling Basin Agreement.	Between the 20%ile and the 80%ile of natural monthly water temperature#.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.
Lower Paroo River Catchment Waters	MD	Baseflow: 540 High flow: 580	Baseflow: 180 High flow: 170	Baseflow: 880 High flow: 680	>5.0[#]	60-110[#]	6.5-8.0[#]	Refer to Appendix 1 of Schedule B to the Murray-Darling Basin Agreement.	Between the 20%ile and the 80%ile of natural monthly water temperature#.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.
Paroo Salt Lakes	MD	Refer to section 11.2.3 of this report—Water quality targets for lakes other than declared Ramsar wetlands.						Refer to Appendix 1 of Schedule B to the Murray-Darling Basin Agreement.	Between the 20%ile and the 80%ile of natural monthly water temperature#.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.
Currawinya Lakes Ramsar Site	HEV	Refer to section 11.2.2 - Water quality targets for the Currawinya Lakes Ramsar site.								

Water area/type	Management intent/ level of protection	PAROO DRAINAGE BASIN SURFACE WATERS:

		Table 26B—Additional water quality target values for event (high) flows and baseflows[37]								
		Notes: 1. Water quality targets for indicators are shown as single values representing 50th percentiles, unless otherwise indicated. These water quality targets are applicable to baseflow conditions only, unless otherwise stated. 2. MD: Moderately disturbed. HEV: High Ecological Value. 3. ID: Insufficient data to develop a target value. 4. High flow: Water quality target value applicable to high flow conditions only. High flow conditions were defined as >20 cumecs at Caiwarro gauging station.								
		EC (µS/cm)	TSS (mg/L)	Alkalinity (mg/L as CaCO3)	SAR	NOx (µg-N/L)	NH4 (µg-N/L)	FRP (µg-P/L)	SO4 (mg/L)	Chl-a (µg/L)
PAROO DRAINAGE BASIN SURFACE WATERS										
Upper Paroo River Catchment Waters	MD	75	55	23	1.1	10	16	2	2.5	10
Lower Paroo River Catchment Waters	MD	Baseflow: 85 High flow: 70	Baseflow: 55 High flow: 90	21	1.4	84	27	13	Baseflow: 4.5 High flow: 3.5	9
Paroo Salt Lakes	MD	Refer to section 11.2.3 of this report—Water quality targets for lakes other than declared Ramsar wetlands.								
Currawinya Lakes Ramsar Site	HEV	Refer to section 11.2.2 - Water quality targets for the Currawinya Lakes Ramsar site								

Water area/type	Management intent/ level of protection	BULLOO DRAINAGE BASIN SURFACE WATERS Table 27A—Water quality target values for event (high) flows and baseflows[38]
		Notes: 1. Water quality targets for indicators are shown as single values representing 50th percentiles (median), unless otherwise indicated. These water quality targets are applicable to baseflow conditions only, unless otherwise stated.

		2. MD: Moderately disturbed. 3. ID: Insufficient data to develop a target value. 4. # Basin Plan Schedule 11 target value for A1 (Condamine, Paroo and Warrego valleys; Lowland zone)—Other water-dependent ecosystems, due to similarities between the Paroo and Bulloo drainage basins. 5. ♦ In South West drainage basins, turbidity is naturally high (range = 200 to over 1000 NTU) when electrical conductivity measurements are <200µS/cm. Turbidity is typically <30NTU when conductivity is >200µS/cm, except during major flow events (Refer to Appendix 4). 6. High flow: Water quality target value applicable to high flow conditions only. High flow conditions were defined as: Upper Bulloo: >16.3 cumecs at Quilpie gauging station; Lower Bulloo: >34.5 cumecs at Autumnvale gauging station.								
		Turbidity♦ (NTU) (Annual median)	Total Phosphorus (µg/L) (Annual median)	Total Nitrogen (µg/L) (Annual median)	DO (Annual median within the range)		pH (Annual median within the range)	Salinity (End-of-valley targets)	Temperature (Monthly median within the range)	Pesticides, heavy metals and other toxic contaminants
					mg/L	% sat				
BULLOO DRAINAGE BASIN SURFACE WATERS										
Upper Bulloo River Catchment Waters	MD	270	200	840	>5.0#	60-110#	6.5-8.0	Not applicable.	Between the 20%ile and the 80%ile of natural monthly water temperature#.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.

[37] While not accreditable under the Basin Plan, water quality target values in Table 26B are recognised to support the accreditable water quality target values in Table 26A to protect and restore water-dependent ecosystems.

[38] Accreditation of water quality target values under the Basin Plan does not apply to the Bulloo drainage basin as it is a closed drainage system, not connected to the Murray-Darling Basin.

Lower Bulloo River Catchment Waters	MD	780	390	1020	>5.0#	60-110#	6.5-8.0	Not applicable.	Between the 20%ile and the 80%ile of natural monthly water temperature#.	Trigger values for freshwater in Table 3.4.1 of the ANZECC Guidelines that apply to slightly-moderately disturbed systems must not be exceeded.

Water area/type	Management intent/ level of protection	**BULLOO DRAINAGE BASIN SURFACE WATERS:** **Table 27B—Additional water quality target values for event (high) flows and baseflows**								
		Notes: 1. Water quality targets for indicators are shown as single values representing 50th percentiles, unless otherwise indicated. These water quality targets are applicable to baseflow conditions only, unless otherwise stated. 2. MD: Moderately disturbed 3. ID: Insufficient data to develop a target value 4. ◊ Value derived from the ANZECC Guidelines (2000). 5. High flow: Water quality target value applicable to high flow conditions only. High flow conditions were defined as: Upper Bulloo: >16.3 cumecs at Quilpie gauging station; Lower Bulloo: >34.5 cumecs at Autumnvale gauging station.								
		EC (µS/cm)	TSS (mg/L)	Alkalinity (mg/L as CaCO3)	SAR	NOx (µg-N/L)	NH4 (µg-N/L)	FRP (µg-P/L)	SO4 (mg/L)	Chl-a (µg/L)
BULLOO DRAINAGE BASIN SURFACE WATERS										
Upper Bulloo River Catchment Waters	MD	100	55	32	0.9	28	17	14	3.5	2
Lower Bulloo River Catchment Waters	MD	95	110	27	0.9	ID	17	ID	5.0	5◊

11.2.2 Water quality targets for the Currawinya Lakes Ramsar site

As a Ramsar Convention signatory, Australia is expected to describe and maintain the ecological character of each of its current 65 Ramsar sites. An ecological character description (ECD) is a rigorously prepared assessment of the ecosystem components, processes and benefits/services of a site. The trigger levels contained in the ECD provide the benchmark against which ecological changes at the site are assessed for significance[39].

The Currawinya Lakes Ramsar site is located in the Paroo drainage basin. It is a High Ecological Value aquatic ecosystem (Refer to Figure 14 and the management intent in Section 6.3). The Currawinya Lakes Ramsar site contains a diverse range of waterbodies including freshwater and saline lakes, riverine channels and waterholes, saltpans, claypans, swamps, and freshwater springs. Table 28 outlines the diversity in water quality and flow characteristics of major and minor lake systems within the Currawinya Lakes Ramsar site.

The water quality target values in Tables 29A and 29B seek to protect and restore the streams, rivers, lakes and wetlands of the Currawinya Lakes Ramsar site and ensure no deterioration of the water quality range.

Section 10.32 of the Basin Plan requires a WQM Plan to identify water quality targets for fresh water-dependent ecosystems that are declared Ramsar wetlands.

Local water quality target values were developed to reflect the diverse range of waterbodies in the Currawinya Lakes Ramsar site, including saline and freshwater lakes. The water quality target values for accreditation under section 10.32 of the Basin Plan are water quality target values listed in Table 29A for the Currawinya Lakes Ramsar site. The accreditation of the water quality range determined through local data analysis (20th, 50th and 80th percentiles) seeks to ensure no deterioration of existing water quality to protect the Currawinya Lakes Ramsar site. Water quality target values for both baseflow and high flow conditions are included in Table 29A where available.

While not accredited under the Basin Plan, the water quality targets for the following matters, which were developed under Queensland legislative water quality framework, are recognised to support the accredited water quality target values in Table 29A to protect and restore the water-dependent ecosystems of the Currawinya Lakes Ramsar site:

- **water quality target values listed in Table 29B for the Currawinya Lakes Ramsar site**
- **water quality targets for permanent waterholes (Refer to section 11.2.5.1).**

[39] Refer to fact sheet titled Currawinya Lakes – a wetland of international importance at <http://wetlandinfo.ehp.qld.gov.au/>. The Ecological Character Description for Currawinya Lakes Ramsar site is under development by the Queensland Government.

Table 28: Key characteristics of lakes within Currawinya Lakes Ramsar site (Queensland Parks and Wildlife Service, 2014)

Lake	Key characteristics
Lake Numalla	Turbid Alkaline Fresh water Lake levels vary but are almost permanent. Inflows occur from local runoff. Additional inflows of flood water from the Paroo River in moderate to major flood events (above 2.4 metres at Caiwarro gauging station) via Carwarra Creek.
Lake Yumberarra	Generally clear Generally fresh (saline when drying) Alkaline Semi-permanent Connected to Kaponyee Lakes and Lake Karatta under certain flow conditions. Inflows from Paroo River occur during major flood events (above 4.25 metres at Caiwarro gauging station).
Lake Karatta	Very turbid Fresh Alkaline Semi-permanent Connected to Lake Yumberarra under certain flow conditions Sediment inflows occur via Stinking Well Creek.
Kaponyee Lakes	Turbid Generally fresh (saline when drying) Alkaline Semi-permanent Receives brackish inflows from Lake Wyara via Kaponyee Creek when water levels are high. Inflows from Paroo River occur during major flood events (above 4.25 metres at Caiwarro gauging station).
Lake Wyara	Clear Alkaline Saline Semi-permanent Inflows occur from local runoff. Almost no flood inflows occur from the Paroo River.

CURRAWINYA LAKES RAMSAR SITE SURFACE WATERS

Table 29A—Water quality target values

Notes:
1. Water quality targets for indicators are shown as single values representing 50th percentiles (median), unless otherwise indicated. These water quality targets are applicable to baseflow conditions only.

2. HEV: High Ecological Value

3. ID: Insufficient data to develop a target value

4. # Basin Plan Schedule 11 target value for A1 (Condamine, Paroo and Warrego valleys; Lowland zone)—Declared Ramsar wetlands.

5. ♦ In South West drainage basins, turbidity is naturally high (range = 200 to over 1000 NTU) when electrical conductivity measurements are <200µS/cm. Turbidity is typically <30NTU when conductivity is >200µS/cm, except during major flow events (Refer to Appendix 4).

6. ◊ Water quality target values shown as 20th, 50th and 80th percentiles (i.e. 20th-50th-80th) based on Timms (1997).

7. ▲ Water quality target value shown as the mean (average) based on Porter et al. (2007).

8. ¤ Upon inflows from Lower Paroo streams and rivers under event (high) flow conditions.

9. High flow: Water quality target value applicable to high flow conditions only. High flow conditions were defined as >20 cumecs at Caiwarro gauging station.

Water area/type	Management intent/ level of protection	Turbidity[♦] (Annual median)	Total Phosphorus (µg/L) (Annual median)	Total Nitrogen (µg/L) (Annual median)	DO (Annual median within the range)		pH (Annual median within the range)	Salinity (End of Valley Targets)	Temperature (Monthly median within the range)	Pesticides, heavy metals and other toxic contaminants
					mg/L	% sat				
CURRAWINYA LAKES RAMSAR SITE SURFACE WATERS										
Lower Paroo streams and rivers	HEV	Baseflow: 400-540-730 NTU	Baseflow: 140-180-260	Baseflow: 750-880-1100	>5.0[#]	60-110[#]	6.5-8.0[#]	Refer to Appendix 1 of Schedule B to the Murray-Darling Basin Agreement.	Between the 20%ile and 80%ile of natural monthly water temperature[#].	Values in table 3.4.1 of the ANZECC Guidelines for the protection of 99% of species must not be exceeded[#].
		High flow: 470-580-800 NTU	High flow: 140-170-210	High flow: 550-680-860						

Lake Numalla	HEV	55-100-180 FTU[◊]	High flow: 140-170-210[■]	High flow: 550-680-860[■]	N/A[#]	90-110[#]	8.3-9.1-9.2[◊]	-[#]	Between the 20%ile and 80%ile of natural monthly water temperature[#].	Values in table 3.4.1 of the ANZECC Guidelines for the protection of 99% of species must not be exceeded[#].
Lake Yumberarra	HEV	6-14-65 FTU[◊]	High flow: 140-170-210[■]	High flow: 550-680-860[■]	N/A[#]	90-110[#]	9.0-9.5-10[◊]	-[#]	Between the 20%ile and 80%ile of natural monthly water temperature[#].	Values in table 3.4.1 of the ANZECC Guidelines for the protection of 99% of species must not be exceeded[#].
Lake Karatta	HEV	35-190-600 FTU[◊]	High flow: 140-170-210[■]	High flow: 550-680-860[■]	N/A[#]	90-110[#]	7.9-8.8-9.1[◊]	-[#]	Between the 20%ile and 80%ile of natural monthly water temperature[#].	Values in table 3.4.1 of the ANZECC Guidelines for the protection of 99% of species must not be exceeded[#].
Kaponyee Lakes	HEV	55-100-180 FTU[◊]	High flow: 140-170-210[■]	High flow: 550-680-860[■]	N/A[#]	90-110[#]	6.5-9.0[#]	-[#]	Between the 20%ile and 80%ile of natural monthly water temperature[#].	Values in table 3.4.1 of the ANZECC Guidelines for the protection of 99% of species must not be exceeded[#].

Lake Wyara	HEV	10 FTU▲	High flow: 140-170-210▪	High flow: 550-680-860▪	N/A[#]	90-110[#]	9.8▲	-[#]	Between the 20%ile and 80%ile of natural monthly water temperature[#].	Values in table 3.4.1 of the ANZECC Guidelines for the protection of 99% of species must not be exceeded[#].

Water area/type	Management intent/ level of protection	CURRAWINYA LAKES RAMSAR SITE SURFACE WATERS: Table 29B—Water quality target values								
		Notes: 1. Water quality targets for indicators are shown as single values representing 80th percentiles, unless otherwise indicated. These water quality targets are applicable to baseflow conditions only, unless otherwise stated. 2. HEV: High Ecological Value 3. ID: Insufficient data to develop a target value 4. ◊ Water quality target values shown as 20th, 50th and 80th percentiles (i.e. 20th-50th-80th) based on Timms (1997). 5.▲ Water quality target value shown as the mean (average) based on Porter et al. (2007). 6. High flow: Water quality target value applicable to high flow conditions only. High flow conditions were defined as >20 cumecs at Caiwarro gauging station.								
		EC (µS/cm)	TSS (mg/L)	Alkalinity (mg/L)	SAR	NOx (µg/L)	NH4 (µg/L)	FRP (µg/L)	SO4 (mg/L)	Chl-a (µg/L)
CURRAWINYA LAKES RAMSAR SITE SURFACE WATERS										
Streams and rivers	HEV	Baseflow: 70-85-120 High flow: 55-70-85	Baseflow: 35-55-100 High flow: 60-90-185	18-21-30	1.1-1.4-2.1	52-84-136	15-27-43	8-13-18	Baseflow: 3.5-4.5-6.0 High flow: 3.0-3.5-5.5	3-9-15
Lake Numalla	HEV	2300-2800-3800◊	ID	ID	ID	ID	ID	ID	ID	ID
Lake Yumberarra	HEV	1300-3700-9900◊	ID	ID	ID	ID	ID	ID	ID	ID
Lake Karatta	HEV	640-1900-3500◊	ID	ID	ID	ID	ID	ID	ID	ID
Kaponyee Lakes	HEV	2300-2800-3800◊	ID	ID	ID	ID	ID	ID	ID	ID

Lake Wyara	HEV	27000▲	ID	ID	ID	ID	ID	ID	ID	ID

11.2.3 Water quality targets for lakes other than declared Ramsar wetlands

Lakes in dryland regions are diverse in their natural water conditions and biology. Local investigations of the natural range of water quality in all stages of inundation and drying are necessary to develop local water quality target values.

To protect the aquatic ecosystem values of lakes, they should be protected against threats of secondary salinity, sedimentation and disrupted hydrologic regime. Thus, there should be no change from historic hydrologic regime (i.e. no change in rainfall frequency, intensity required to inundate the lake), and loads of salt and sediments from upstream catchments should be managed in accordance with the management intent for the waters (Refer to section 6.3) and consistent with the Basin Salinity Management Strategy.

11.2.4 Water quality targets for Slightly Disturbed waters

The water quality target values for pesticides, heavy metals and other toxic contaminants for Slightly Disturbed waters in the Warrego, Paroo, Bulloo and Nebine drainage basins are that the values in Table 3.4.1 of the ANZECC guidelines (2000) for the protection of 99% of species must not be exceeded.

The water quality target values for Slightly Disturbed waters in the Warrego, Paroo, Bulloo and Nebine drainage basins for all other indicators are as follows:

1. if the measures for indicators achieve the water quality target values for High Ecological Value waters in the Warrego, Paroo, Bulloo and Nebine drainage basins, maintain the water quality to this standard
2. if the measures for indicators do not achieve the water quality target values for High Ecological Value waters in the Warrego, Paroo, Bulloo and Nebine drainage basins, progressively improve the water quality at the site towards achieving the High Ecological Value water quality target values for each indicator.

Refer to section 6.3 for a description of the management intent under the EPP Water for Slightly Disturbed waters in the Warrego, Paroo, Bulloo and Nebine drainage basins.

The Slightly Disturbed waters are mapped at Figure 14.

11.2.5 Water quality targets for High Ecological Value waters

The water quality targets for pesticides, heavy metals and other toxic contaminants for High Ecological Value waters is that the values in Table 3.4.1 of the ANZECC guidelines for the protection of 99% of species must not be exceeded.

The water quality target for High Ecological Value waters in the Warrego, Paroo, Bulloo and Nebine drainage basins for all other indicators is to maintain the existing water quality distribution (i.e. maintain the 20th, 50th and 80th percentile values for each indicator).

Refer to section 6.3 for a description of the management intent under the EPP Water for High Ecological Value waters in the Warrego, Paroo, Bulloo and Nebine drainage basins.

The High Ecological Value waters are mapped at Figure 14.

11.2.5.1 Permanent waterholes

Permanent waterholes, as mapped at Figure 14 and tabulated at Appendix 6, are important for their outstanding natural values in dryland river systems. In dryland regions, many rivers stop flowing for extended periods of time and become disconnected waterholes and wetlands. The waterholes are critical refugia for aquatic organisms, such as fish, turtles and invertebrates. Permanent waterholes also support birds, plants, reptiles and amphibians.

The refugial waterholes along the river systems in the SW region represent the only permanent aquatic habitat during extended periods of low or no flow and are critical components of a functioning ‘source and sink’ system for aquatic organisms in semi-arid landscapes.

Waterholes experience variable patterns of connection and disconnection. This is a fundamental driver of ecological processes in dryland riverine environments, vital for dispersal and survival of diverse populations of biota. Waterholes require careful management, both individually and as an integrated system of waterholes along the length of rivers and channels.

Waterhole persistence is associated with active river-forming processes (to provide deep waterhole habitat for biota) and bankfull discharge[40]. In-channel flows, or flow pulses, are important for connecting waterholes and improving water quality (Sheldon et al., 2010). As a result, the water quality of waterholes in the Warrego, Paroo, Bulloo and Nebine drainage basins will be largely influenced by the strategies for water resource development implemented through water resource planning instruments. It is recommended water resource development maintains the hydrological variability of waterholes and prevents extreme levels of water abstraction (Sheldon et al., 2010).

As the permanent waterholes mapped in Figure 14 are classified as High Ecological Value waters, refer to section 11.2.5 for the water quality target values that apply[41]. Additionally:

1. riparian vegetation surrounding identified waterholes should be maintained or, as necessary over time, restored
2. disturbance to beds and banks of waterholes should be minimised where possible to reduce sedimentation.

[40] Bankfull discharge is the point at which water overflows onto a floodplain.

[41] Note: Water quality target values for lakes in the Currawinya Lakes Ramsar site are listed in Table 24A and 24B.

11.2.6 Water quality targets to protect Groundwater Environmental Values

This section lists the water quality targets for various groundwater types to protect the aquatic ecosystem environmental values stated for the groundwaters of the Warrego, Paroo, Bulloo and Nebine basins (Refer to Section 5).

Water quality targets are provided according to their chemistry zone and depth category in Tables 31-47.

Where groundwaters interact with surface waters, groundwater quality should not compromise identified environmental values and water quality targets for those waters.

The ANZECC Guidelines (2000) recommend that the highest level of protection should be provided to underground aquatic ecosystems, given their high conservation value.

The management intent is to maintain the existing water quality distribution (20th, 50th and 80th percentiles).

11.2.6.1 Groundwater chemistry zones in the Warrego, Paroo, Bulloo and Nebine basins

The groundwater chemistry zones in the Warrego, Paroo, Bulloo and Nebine drainage basins are shown in Figure 16. The groundwater chemistry zones listed below are arranged under five major water chemistry groups and are labelled with relevant identification numbers:

1. Sodium bicarbonate:

ID No. 03 – Goora

ID No. 04 – Bankshire

2. Sodium chloride:

ID No. 07 – Redford

ID No.11 – Boondoon

ID No.13 – Blairmore

ID No.15 – Charleville

ID No.16 – Pingine

ID No.19 – Winbin

3. Relatively low sodium:

ID No.20 – Tinnenburra

ID No.23 – Armadilla

ID No.25 – Moorak

ID No.26 – Passchendale

4. Sulphate:

ID No.31 – Joe

ID No.33 – Amby

ID No.34 – Grenfield

5. Similar to surface water:

ID No.35 – Yoothappinna

ID No.36 – Carnarvon

The Groundwater Chemistry Zones that intersect the Groundwater Sustainable Diversion Limit resource units identified under the Basin Plan are identified in Table 30.

Table 30: The Groundwater Chemistry Zones that intersect the Groundwater Sustainable Diversion Limit resource units under the Basin Plan for the plan area (See Figure 8 for map).

Water Chemistry Group	Sodium bicarbonate		Sodium chloride						Relatively low sodium				Sulphate			Similar to surface water	
	03—Goora	**04—Bankshire**	**07—Redford**	**11—Boondoon**	**13—Blairmore**	**15—Charleville**	**16—Pingine**	**19—Winbin**	**20—Tinnenburra**	**23—Armadilla**	**25—Moorak**	**26—Passchendale**	**31—Joe**	**33—Amby**	**34—Grenfield**	**35—Yoothappinna**	**36—Carnarvon**
Sediments above the GAB: Warrego–Paroo–Nebine (GS60)	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
St George Alluvium: Warrego–Paroo-Nebine (GS63)[42]	✓	✓		✓	✓		✓	✓			✓						
Warrego Alluvium (GS66)	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓			✓

[42] Note: The Basin Plan recognises the St George Alluvium groundwater aquifers in the plan area as a single SDL resource unit termed the St George Alluvium Warrego–Paroo-Nebine (GS63). However, under Queensland water resource planning, this resource unit is managed as the St George Alluvium (shallow) and the St George Alluvium (Deep).

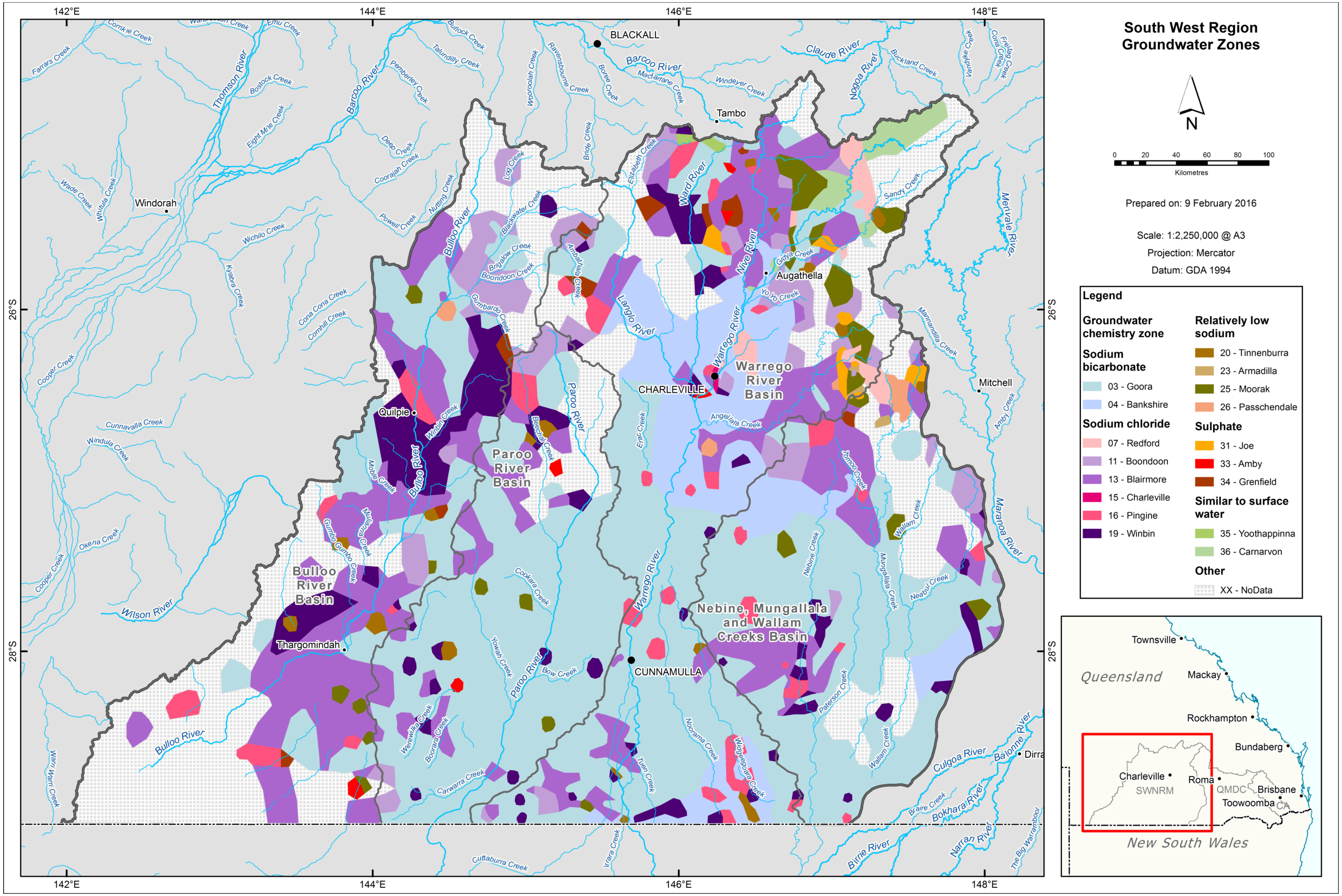

Figure 16: Groundwater chemistry zones in the Warrego, Paroo, Bulloo and Nebine drainage basins (DSITIA, 2015).

Note: This figure may be updated over time based on the availability of new information.

Table 31: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sodium Bicarbonate—03 Goora (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very shallow	20th	62	58	4	2	0	0	115	41	46	25	2	2	0.09	0	359	11	7.4	120.9	16.0	0.14	0.01	0.000	-	-	2.80	0.38
	50th	96	72	13	15	7	13	200	54	95	33	16	7	0.75	0	700	66	7.9	185.5	25.0	0.20	0.01	0.010	-	-	4.35	1.60
	80th	299	98	27	23	13	20	357	69	214	46	88	13	2.23	1	1623	113	8.5	456.7	45.7	0.57	0.04	0.028	-	-	25.85	5.89
Shallow	20th	76	70	4	3	1	1	0	44	49	26	9	3	0.00	0	420	16	7.6	146.2	14.9	0.10	0.00	0.000	-	-	3.85	1.40
	50th	187	82	13	7	4	7	234	55	96	33	44	9	0.75	0	860	62	8.1	203.0	21.0	0.25	0.01	0.000	-	-	12.10	2.42
	80th	352	95	39	15	22	17	580	66	330	49	88	18	2.88	0	1802	183	8.5	504.0	41.8	0.69	0.04	0.073	-	-	21.73	7.18
Medium	20th	68	79	5	3	0	0	144	47	49	31	11	3	0.00	0	590	22	7.5	150.0	17.3	0.20	0.00	0.000	-	-	4.95	1.59
	50th	265	82	13	5	6	10	385	52	170	40	23	5	0.50	0	1300	56	7.9	365.0	28.5	0.30	0.03	0.010	-	-	12.20	6.25
	80th	435	96	27	10	43	15	750	65	348	44	104	11	0.96	0	2170	240	8.4	624.0	49.6	0.49	0.29	0.017	-	-	23.40	7.64
Deep	20th	151	74	6	4	5	3	103	45	133	33	10	4	0.00	0	1056	36	7.4	253.9	30.5	0.10	0.01	0.001	-	-	7.11	1.24
	50th	239	81	19	8	16	12	397	52	180	41	44	7	0.25	0	1210	113	8.1	340.0	34.5	0.20	0.01	0.005	-	-	9.20	4.10
	80th	308	90	31	12	21	14	425	57	224	49	94	12	0.50	0	1710	175	8.5	388.0	53.5	0.79	0.05	0.010	-	-	16.39	5.89
Very deep	20th	183	82	3	1	0	0	0	38	98	27	5	1	0.00	0	817	12	7.5	203.2	13.0	0.12	0.00	0.000	-	-	11.50	3.22
	50th	271	95	7	3	3	2	258	55	166	39	26	5	0.50	0	1232	38	8.1	324.5	17.0	0.30	0.01	0.005	-	-	23.45	5.32
	80th	477	98	24	9	10	6	457	68	303	50	83	15	2.81	0	2166	105	8.5	510.6	21.0	0.70	0.05	0.010	-	-	38.85	9.61
Artesian	20th	170	97	2	1	0	0	317	68	54	16	0	0	0.00	0	730	6	8.1	276.0	19.0	0.47	0.00	0.000	0.000	0.000	22.21	5.31
	50th	210	98	3	2	0	0	418	76	70	22	1	0	0.00	0	880	10	8.3	360.0	22.0	0.60	0.01	0.010	0.005	0.010	28.40	6.90
	80th	262	99	5	2	1	1	524	83	98	30	5	1	0.90	0	1060	17	8.6	450.0	26.0	1.10	0.06	0.010	0.010	0.015	35.80	8.72

Table 32: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sodium Bicarbonate—04 Bankshire (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very shallow	20th	62	60	21	7	8	7	188	43	58	31	15	4	1.75	0	540	102	7.7	156.0	49.2	0.15	0.00	0.000	-	-	2.70	1.09
	50th	275	73	27	11	17	13	350	53	175	38	32	6	12.00	1	1400	122	8.0	290.0	62.0	0.20	0.01	0.010	-	-	6.70	3.21
	80th	398	85	44	27	30	16	549	60	360	50	71	9	25.50	4	2120	234	8.2	457.5	83.8	0.37	0.09	0.037	-	-	15.40	7.70
Deep	20th	87	80	3	1	1	1	0	44	63	32	20	9	-	-	455	12	-	112.5	-	0.29	-	-	-	-	6.32	1.34
	50th	126	86	7	7	4	6	55	49	81	40	34	11	-	-	606	38	-	221.0	-	0.33	-	-	-	-	7.00	3.06
	80th	333	98	17	14	6	10	184	60	197	44	93	13	-	-	1398	67	-	356.0	-	0.60	-	-	-	-	32.19	6.96
Very deep	20th	203	85	3	2	0	0	102	35	125	36	12	3	0.00	0	958	9	7.5	185.5	9.5	0.20	0.00	0.005	-	-	16.83	1.35
	50th	246	97	5	2	1	1	246	42	165	43	80	11	0.50	0	1117	15	8.0	230.0	18.0	0.30	0.01	0.010	-	-	28.35	3.95
	80th	355	98	20	8	7	5	339	56	297	55	115	19	2.06	0	1600	119	8.5	304.4	21.2	0.69	0.05	0.020	-	-	33.30	5.68
Artesian	20th	254	97	2	1	0	0	390	56	80	19	0	0	0.00	0	1050	7	8.0	339.1	20.0	0.50	0.00	0.000	0.000	0.000	28.50	6.50
	50th	296	98	4	1	1	0	532	63	145	32	14	2	0.00	0	1292	11	8.3	459.0	23.0	0.73	0.01	0.010	0.005	0.010	37.10	8.91
	80th	374	99	6	2	2	1	628	79	200	37	60	8	1.57	0	1597	20	8.6	534.8	27.3	1.20	0.06	0.010	0.010	0.015	51.73	10.35

Table 33: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sodium chloride—07 Redford (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very deep	20th	44	47	16	23	9	11	0	28	40	28	9	2	-	-	364	81	7.0	95.5	-	0.10	-	-	-	-	1.90	0.00
	50th	62	54	32	25	12	19	50	48	66	36	29	15	-	-	484	118	7.5	125.5	-	0.21	-	-	-	-	2.80	0.30
	80th	185	62	60	30	21	31	238	64	181	51	84	21	-	-	1517	335	7.9	236.8	-	0.40	-	-	-	-	3.99	1.00
Artesian	20th	16	35	3	1	0	0	62	43	28	33	9	9	0.00	0	215	8	7.0	53.0	13.0	0.10	0.00	0.000	-	-	0.90	0.00
	50th	39	50	7	21	6	28	173	48	61	40	34	13	0.10	0	507	45	8.1	158.0	15.0	0.20	0.02	0.010	-	-	1.25	4.75
	80th	268	99	22	31	12	34	304	54	173	42	92	16	0.50	0	1231	105	8.6	259.5	20.0	0.33	0.05	0.053	-	-	38.58	5.05

Table 34: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sodium chloride—11 Boondoona (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very shallow	20th	124	69	9	4	1	1	0	8	110	40	17	5	-	-	823	39	7.1	71.7	-	0.16	-	-	-	-	4.63	0.07
	50th	222	80	22	11	11	8	51	23	205	63	42	12	-	-	1059	116	7.5	138.0	-	0.45	-	-	-	-	8.60	0.94
	80th	660	95	59	19	23	18	172	43	901	76	185	19	-	-	2913	201	8.3	193.9	-	0.75	-	-	-	-	19.73	2.20
Shallow	20th	93	76	6	5	2	2	3	17	100	46	13	5	0.00	0	593	24	7.1	50.5	21.8	0.08	0.02	0.001	-	-	5.01	0.03
	50th	100	85	11	9	8	9	140	35	115	50	44	15	0.50	0	630	57	7.6	115.0	57.0	0.20	0.13	0.030	-	-	5.95	0.95
	80th	242	95	14	12	12	13	215	38	164	65	121	20	14.50	4	1117	72	8.7	193.5	64.5	0.42	40.52	0.040	-	-	23.30	3.51
Medium	20th	102	69	11	5	3	2	0	11	95	51	11	3	0.00	0	795	48	7.0	60.4	21.4	0.10	0.00	0.000	-	-	5.50	0.00
	50th	210	78	19	11	12	11	103	26	225	64	51	11	0.55	0	1100	115	7.7	148.0	44.0	0.23	0.01	0.010	-	-	8.40	0.57
	80th	522	91	58	18	31	15	208	37	607	72	149	19	8.68	2	2603	308	8.3	279.3	59.1	0.30	0.10	0.038	-	-	14.50	2.51
Deep	20th	145	71	11	4	8	3	0	12	174	53	18	3	0.00	0	848	58	7.4	74.5	32.5	0.20	0.00	0.000	-	-	5.70	0.00
	50th	180	80	23	10	16	13	130	20	245	66	49	11	0.50	0	1200	111	7.6	117.0	61.0	0.28	0.00	0.010	-	-	7.60	0.64
	80th	465	90	30	13	22	16	181	36	638	77	74	15	1.88	0	2132	175	8.2	189.0	73.5	0.39	0.23	0.020	-	-	22.70	1.99
Very deep	20th	145	75	8	3	1	1	0	9	135	45	10	3	0.00	0	809	35	7.3	87.1	16.0	0.11	0.00	0.000	-	-	6.50	0.00
	50th	268	86	21	8	7	4	15	24	270	62	74	11	0.50	0	1300	89	7.9	165.0	25.0	0.30	0.01	0.010	-	-	15.50	1.65
	80th	720	95	56	15	22	11	230	42	890	80	236	19	2.05	0	3257	222	8.3	255.2	49.0	0.58	0.33	0.074	-	-	29.15	3.42
Artesian	20th	152	93	3	2	0	0	0	25	81	34	0	0	0.05	0	600	9	7.6	132.5	16.0	0.20	0.00	0.000	-	-	15.00	2.00
	50th	242	96	6	3	1	1	202	37	209	51	37	12	0.50	0	1210	18	8.2	211.5	19.0	0.40	0.01	0.010	-	-	22.80	3.74
	80th	310	98	9	4	3	3	336	55	257	65	107	19	1.67	0	1355	37	8.3	282.0	24.4	0.75	0.07	0.012	-	-	33.30	5.14

Table 35: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sodium chloride—13 Blairmore (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very shallow	20th	261	75	3	1	0	0	0	7	143	32	22	4	0.00	0	1087	9	7.4	156.8	16.0	0.23	-	-	-	-	9.39	0.00
	50th	418	83	39	9	10	5	299	27	420	55	100	13	1.00	0	1830	151	8.0	377.0	16.0	0.43	-	-	-	-	20.20	1.40
	80th	1644	99	106	11	84	16	508	61	2170	77	607	17	30.10	2	7953	582	8.6	578.1	51.2	1.06	-	-	-	-	52.71	7.55
Shallow	20th	354	70	18	4	2	1	0	6	444	55	98	9	0.00	0	1639	87	6.8	118.1	-	0.19	0.00	-	-	-	9.87	0.00
	50th	594	78	66	12	27	8	0	18	711	64	257	15	0.50	0	3218	259	7.5	280.0	-	0.58	0.02	-	-	-	16.20	0.00
	80th	968	94	124	14	73	14	267	32	1381	79	423	21	4.91	0	4678	588	8.2	391.8	-	1.23	0.05	-	-	-	34.00	4.83
Medium	20th	400	67	31	6	21	7	0	9	463	66	82	9	0.60	0	1984	176	7.3	149.3	48.2	0.23	0.01	0.005	0.005	0.015	8.83	0.00
	50th	713	83	58	8	42	9	201	10	1050	76	190	11	2.50	0	3930	316	7.9	176.0	52.0	0.24	0.01	0.005	0.005	0.015	18.00	0.00
	80th	726	86	109	15	72	19	213	25	1082	80	288	16	2.50	0	4203	634	8.3	331.6	52.0	0.75	0.01	0.030	0.005	0.015	20.02	1.14
Deep	20th	340	74	14	3	6	2	0	7	375	60	24	3	0.00	0	1728	62	7.5	137.6	15.0	0.20	0.01	0.000	-	-	10.51	0.00
	50th	490	88	37	6	19	5	146	18	640	71	115	10	1.00	0	2559	162	8.0	216.0	51.0	0.50	0.01	0.010	-	-	19.30	1.88
	80th	860	94	85	14	67	13	351	28	1558	82	278	17	4.80	0	5480	582	8.3	335.2	68.6	1.00	0.16	0.020	-	-	31.49	5.38
Very deep	20th	365	77	13	3	3	1	0	7	371	57	17	2	0.00	0	1850	52	7.3	139.8	13.0	0.20	0.00	0.000	0.005	0.015	12.46	0.00
	50th	586	88	37	6	16	5	133	15	786	73	154	11	1.25	0	3000	172	7.8	203.0	18.0	0.40	0.01	0.005	0.005	0.015	21.00	1.33
	80th	871	95	86	13	40	10	328	28	1299	81	280	18	2.50	0	4261	382	8.4	349.1	51.0	0.64	0.04	0.029	0.020	0.015	33.90	4.50
Artesian	20th	308	93	4	1	0	0	254	16	199	36	0	0	0.00	0	1392	10	7.9	233.0	15.0	0.40	0.00	0.000	0.000	0.000	24.60	2.91
	50th	491	96	9	3	3	1	388	39	482	58	1	0	0.50	0	2280	37	8.2	350.5	18.0	0.60	0.01	0.010	0.005	0.010	31.80	6.53
	80th	707	99	25	4	10	3	581	57	980	83	10	1	2.17	0	3430	105	8.5	502.0	22.0	1.60	0.04	0.020	0.015	0.020	48.20	9.69

Table 36: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sodium chloride—15 Charleville (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very shallow	20th	161	70	22	9	18	13	142	30	192	42	43	6	-	-	1031	130	7.4	153.5	-	0.20	0.00	-	-	-	5.95	0.42
	50th	362	75	28	11	32	14	403	43	313	46	59	10	-	-	1890	216	7.8	353.5	-	0.30	0.01	-	-	-	9.25	4.10
	80th	469	77	74	13	52	17	714	50	532	56	150	11	-	-	2886	409	8.5	605.0	-	0.47	3.15	-	-	-	11.50	5.69
Medium	20th	138	60	26	13	17	13	0	10	192	59	29	7	1.65	0	999	155	7.3	79.8	33.3	0.20	0.00	0.013	-	-	4.07	0.00
	50th	216	65	43	15	28	19	107	14	357	78	62	9	3.95	0	1450	227	7.7	107.0	60.0	0.28	0.00	0.020	-	-	6.45	0.00
	80th	314	72	72	21	39	22	152	26	613	82	104	12	7.30	1	2317	346	8.0	160.7	65.7	0.40	0.02	0.275	-	-	7.71	0.05
Deep	20th	149	63	22	12	18	16	53	5	251	68	27	6	1.71	0	991	127	7.2	78.9	60.0	0.16	0.00	0.004	-	-	5.08	0.00
	50th	357	70	55	13	47	17	123	8	656	80	91	10	4.30	0	2418	330	7.7	103.0	62.0	0.20	0.00	0.010	-	-	8.45	0.00
	80th	532	71	100	17	76	20	145	24	946	84	216	12	7.53	1	3538	564	8.2	122.3	68.0	0.29	0.02	0.020	-	-	11.00	0.00
Very deep	20th	123	62	26	11	23	15	85	3	223	68	38	9	4.91	0	914	162	7.1	69.4		0.14	0.00		-	-	4.19	
	50th	516	67	64	14	39	19	122	9	645	79	175	11	6.10	1	2961	368	7.7	100.0		0.25	0.01		-	-	9.60	
	80th	1247	74	205	16	155	22	160	23	2408	82	538	14	8.89	1	7965	1118	8.0	134.0		0.51	0.20		-	-	14.84	
Artesian	20th	139	97	2	1	0	0	196	46	85	33	19	5	0.00	0	669	6	7.9	175.2	17.0	0.20	0.00	0.003	-	-	17.75	2.44
	50th	190	98	3	1	0	0	303	51	105	38	26	8	0.50	0	910	8	8.7	251.0	22.0	0.30	0.01	0.010	-	-	27.40	5.32
	80th	356	99	3	3	1	1	455	61	217	44	76	10	6.25	1	1600	13	8.8	397.3	29.8	0.71	0.02	0.010	-	-	56.30	7.78

Table 37: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sodium chloride—16 Pingine (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very shallow	20th	494	69	21	5	2	1	53	0	626	67	100	6	2.43	0	2514	66	7.2	43.5	11.3	0.15	0.00	0.001	-	-	13.66	0.00
	50th	705	73	76	8	73	5	143	11	1122	78	146	11	7.80	0	4240	600	8.0	119.0	13.5	0.20	0.00	0.020	-	-	22.20	0.11
	80th	2881	93	824	22	137	19	705	23	5153	85	1217	15	17.68	0	16689	2363	8.2	598.0	34.3	0.45	0.00	0.124	-	-	28.98	2.94
Shallow	20th	692	70	56	4	92	10	95	0	919	64	-	-	-	-	3880	606	7.3	79.0	-	0.13	-	-	-	-	25.38	0.00
	50th	3100	72	338	11	296	12	195	2	5460	80	-	-	-	-	17150	2256	7.6	160.0	-	0.48	-	-	-	-	27.55	0.00
	80th	5443	84	1168	18	491	18	685	33	10308	86	-	-	-	-	32230	4948	7.9	561.8	-	0.93	-	-	-	-	33.88	4.96
Medium	20th	950	73	79	7	68	8	241	5	1565	72	37	1	-	-	5430	520	7.6	238.0	-	0.16	-	-	-	-	17.40	-
	50th	1453	79	126	9	70	12	299	9	2400	84	272	5	-	-	8252	700	7.8	365.0	-	0.22	-	-	-	-	18.50	-
	80th	1848	81	313	15	172	16	654	18	2723	88	958	13	-	-	9035	1180	8.1	574.6	-	0.42	-	-	-	-	28.09	-
Deep	20th	1443	77	80	5	59	5	13	1	2104	73	373	9	0.00	0	6963	446	7.3	96.1	22.0	0.09	-	-	-	-	24.54	-
	50th	1500	82	155	9	111	10	357	7	2300	80	505	13	0.35	0	7700	941	7.7	340.0	58.0	0.19	-	-	-	-	28.40	-
	80th	3670	88	670	14	136	13	750	14	6050	89	1488	14	1.50	0	15790	2209	7.9	601.0	69.5	0.70	-	-	-	-	34.30	-
Very deep	20th	931	74	29	4	17	3	74	2	1200	72	131	7	0.00	0	4680	208	7.3	124.1	14.1	0.10	0.00	0.001	-	-	19.80	0.00
	50th	1400	82	130	9	81	9	215	6	2264	80	410	12	0.50	0	7300	695	7.7	210.0	29.0	0.30	0.02	0.050	-	-	26.10	0.00
	80th	2422	90	322	13	143	12	404	15	3735	86	1047	19	5.00	0	11425	1606	8.1	377.3	54.8	0.66	0.11	0.198	-	-	33.62	4.85
Artesian	20th	261	91	3	1	0	0	148	8	65	16	0	0	0.00	0	1080	10	7.8	209.7	16.0	0.50	0.00	0.000	0.000	0.000	26.62	2.38
	50th	308	96	7	2	2	1	484	60	223	38	2	0	0.00	0	1331	29	8.3	427.5	22.0	0.60	0.02	0.010	0.010	0.010	33.20	8.50
	80th	982	98	57	6	14	3	601	84	1519	85	43	4	1.19	0	4965	216	8.6	517.0	24.0	0.90	0.09	0.050	0.010	0.015	38.09	9.99

Table 38: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sodium chloride—19 Winbin (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Medium	20th	1316	79	17	1	16	1	0	2	1827	83	17	0	-	-	6045	107		93.2	-	-	-	-	-	-	23.47	0.00
	50th	1768	93	110	3	39	5	21	3	3311	93	163	3	-	-	9515	717		184.0	-	-	-	-	-	-	65.80	0.00
	80th	4132	97	264	14	137	8	411	8	6970	97	307	9	-	-	20065	1133		407.5	-	-	-	-	-	-	74.58	4.60
Deep	20th	1038	85	14	2	13	1	0	3	1270	75	15	0	-	-	4750	88	7.5	110.0	-	0.31	-	-	-	-	28.80	0.00
	50th	1703	89	66	5	56	7	0	5	2827	83	180	6	-	-	9600	394	7.8	258.0	-	0.51	-	-	-	-	34.20	0.00
	80th	2381	95	203	8	129	8	501	22	3792	92	414	10	-	-	11563	993	8.0	465.5	-	1.29	-	-	-	-	45.55	6.63
Very deep	20th	634	83	7	1	2	0	0	2	583	59	2	0	0.00	0	2831	35	7.4	110.0	13.3	0.20	0.00	0.000	0.000	0.000	28.07	0.00
	50th	1321	92	67	5	17	2	73	7	1961	87	43	1	0.60	0	6200	271	8.0	210.0	15.0	0.41	0.01	0.010	0.005	0.010	39.05	1.26
	80th	2208	98	196	10	77	7	551	35	3654	95	284	10	5.52	0	10500	817	8.4	490.0	22.0	1.31	0.13	0.040	0.163	0.019	57.82	9.43
Artesian	20th	236	88	3	1	0	0	135	3	76	20	0	0	0.00	0	979	8	7.5	120.0	17.0	0.20	0.00	0.000	0.000	0.000	29.70	0.00
	50th	1148	94	51	4	11	2	267	7	1762	89	2	0	0.25	0	5495	171	8.1	275.0	20.0	0.50	0.01	0.013	0.010	0.010	35.20	7.12
	80th	1905	98	120	7	50	4	499	79	3198	97	20	1	3.00	0	9157	528	8.5	420.5	24.0	1.00	0.10	0.130	0.030	0.040	45.26	8.40

Table 39: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Relatively low sodium—20 Tinnenburra (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Shallow	20th	142	19	122	18	97	8	0	1	596	71	7	0	-	-	2190	914	-	173.5	-	-	-	-	-	-	2.02	-
	50th	1459	53	516	28	231	18	243	5	3124	88	428	6	-	-	9525	2125	-	229.0	-	-	-	-	-	-	15.60	-
	80th	2634	73	1526	31	388	53	394	28	6928	90	980	10	-	-	20153	5149	-	323.5	-	-	-	-	-	-	21.12	-
Very deep	20th	768	58	84	7	32	5	0	1	1494	80	51	1	0.36	0	4632	269	7.0	53.4	12.0	0.18	0.00	-	-	-	10.68	0.00
	50th	1843	69	400	16	249	13	49	3	4200	91	235	4	2.00	0	12250	2058	7.4	135.0	18.0	0.40	0.21	-	-	-	20.10	0.00
	80th	3571	86	1007	25	472	21	261	9	6772	98	588	12	3.00	0	20420	4453	7.7	319.9	29.5	0.72	4.62	-	-	-	27.70	0.00
Artesian	20th	267	85	3	1	0	0	0	2	61	15	0	0	0.00	0	1025	8	7.4	120.0	19.1	0.42	0.00	0.000	0.010	0.000	28.23	0.00
	50th	322	97	6	2	1	1	530	71	205	29	0	0	0.35	0	1370	22	8.0	465.0	22.0	0.80	0.00	0.003	0.010	0.010	35.50	8.98
	80th	2576	99	181	9	101	6	610	84	3863	89	250	2	2.60	0	11202	774	8.3	512.4	24.0	1.19	0.03	0.020	0.020	0.015	41.70	10.06

Table 40: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Relatively low sodium—23 Armadilla (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very deep	20th	150	32	199	38	38	13	0	7	372	48	322	31	-	-	2147	687	-	142.5	-	0.10	-	-	-	-	2.40	0.00
	50th	185	33	240	46	63	19	180	13	436	52	430	36	-	-	2400	803	-	170.0	-	0.39	-	-	-	-	2.80	0.00
	80th	332	44	277	50	76	22	207	17	695	57	590	44	-	-	3190	979	-	206.2	-	0.57	-	-	-	-	4.91	0.00

Table 41: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Relatively low sodium—25 Moorak (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very deep	20th	84	47	17	10	8	8	0	22	98	36	10	3	0.00	0	615	79	7.3	118.8	17.0	0.10	0.00	0.000	-	-	2.98	0.00
	50th	116	58	43	20	19	16	146	33	173	48	49	13	0.00	0	900	207	7.6	185.0	29.5	0.20	0.02	0.010	-	-	4.00	0.00
	80th	238	74	79	31	40	26	240	48	345	62	143	23	0.50	0	1706	407	8.2	235.3	34.0	0.40	0.03	0.034	-	-	9.60	1.05
Artesian	20th	189	72	3	2	0	0	344	52	64	19	0	0	0.00	0	830	8	8.2	331.8	19.1	0.49	0.01	0.000	-	-	12.25	4.11
	50th	212	98	5	2	0	0	415	78	74	21	2	0	0.00	0	894	13	8.4	369.0	29.5	0.80	0.02	0.010	-	-	28.10	6.82
	80th	291	98	30	10	36	12	464	80	162	39	74	9	1.18	0	1345	202	8.6	398.2	34.9	1.51	0.10	0.019	-	-	35.55	7.60

Table 42: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Relatively low sodium—26 Passchendale (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Shallow	20th	69	45	25	15	12	13	0	11	97	37	56	9	-	-	523	125	-	33.2	-	-	-	-	-	-	2.74	-
	50th	140	64	59	22	29	15	21	15	215	47	160	42	-	-	1168	302	-	152.5	-	-	-	-	-	-	4.30	-
	80th	383	74	105	29	46	25	225	22	329	64	544	48	-	-	2591	427	-	196.0	-	-	-	-	-	-	8.10	-
Very deep	20th	83	52	44	26	12	9	0	16	83	35	84	13	-	-	730	172	-	110.0	-	-	-	-	-	-	2.95	-
	50th	166	59	62	28	15	12	0	28	178	42	130	22	-	-	1187	213	-	176.0	-	-	-	-	-	-	4.30	-
	80th	299	65	106	34	28	15	210	38	503	60	213	29	-	-	2147	373	-	235.0	-	-	-	-	-	-	6.40	-

Table 43: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sulphate—31 Joe (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very deep	20th	166	36	69	9	30	12	72	5	248	40	320	28	0.12	0	1950	359	7.3	83.3	13.0	0.10	0.00	0.020	-	-	3.50	0.00
	50th	378	48	142	31	63	18	171	12	555	46	570	39	0.50	0	3090	702	7.8	181.5	15.5	0.29	0.02	0.030	-	-	5.25	0.00
	80th	747	70	254	40	217	29	333	22	1020	55	1268	50	2.70	0	5492	1148	8.1	276.0	27.2	0.63	0.10	0.488	-	-	11.65	0.00
Artesian	20th	11	40	6	14	2	1	14	19	13	23	28	13	0.00	0	145	31	6.2	12.9	-	0.00	0.00	-	-	-	0.70	0.00
	50th	20	45	7	26	4	29	19	24	16	27	32	47	0.00	0	211	34	7.0	43.0	-	0.08	0.05	-	-	-	0.90	0.00
	80th	233	64	57	34	18	30	281	63	157	30	165	53	0.93	0	1060	229	8.0	246.7	-	0.31	0.20	-	-	-	4.30	2.10

Table 44: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sulphate—33 Amby (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very shallow	20th	213	80	9	4	3	1	0	2	176	45	73	6	0.05	-	959	33	7.8	105.9	10.0	0.20	-	-	-	-	15.90	0.00
	50th	808	88	81	8	12	3	125	10	1005	55	483	24	0.50	-	4063	273	8.0	176.0	13.5	0.27	-	-	-	-	25.00	0.93
	80th	1811	93	273	15	83	8	367	38	2099	68	1611	36	2.23	-	9072	903	8.2	388.4	17.7	0.40	-	-	-	-	33.15	3.80
Shallow	20th	321	69	6	2	15	3	0	4	290	41	230	16	-	-	1689	15	7.0	188.4	-	0.21	-	-	-	-	11.69	0.00
	50th	823	76	152	14	53	10	249	16	904	58	941	32	-	-	4658	518	7.5	293.0	-	0.40	-	-	-	-	17.35	0.00
	80th	1300	98	342	22	197	19	410	43	1881	65	1474	41	-	-	8347	1491	8.4	362.9	-	0.94	-	-	-	-	38.02	7.00

Table 45: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Sulphate—34 Grenfield (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Very deep	20th	413	71	12	3	2	1	0	2	341	40	250	20	0.00	-	2133	47	7.0	97.7	9.9	0.20	0.00	0.010	-	-	14.89	0.00
	50th	1163	82	159	11	41	5	72	7	1182	51	1040	31	0.70	-	6522	615	7.7	193.0	14.5	0.50	0.01	0.020	-	-	20.70	0.00
	80th	1544	95	291	18	121	13	285	27	2080	67	1568	46	3.86	-	8888	1153	8.2	306.0	17.0	0.80	0.07	0.057	-	-	28.37	3.64

Table 46: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Similar to surface water—35 Yoothappinna (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Artesian	20th	17	29	14	24	8	20	100	42	18	16	5	4	0.00	0	254	75	7.2	82.0	11.0	0.10	0.00	0.009	0.000	0.000	0.70	0.00
	50th	26	35	26	35	12	27	141	67	30	25	11	7	0.00	0	345	113	7.7	125.0	12.0	0.10	0.01	0.040	0.000	0.010	1.10	0.09
	80th	48	49	40	42	19	34	210	79	58	43	43	14	0.50	0	472	174	8.2	185.0	14.0	0.13	0.02	0.070	0.025	0.018	1.85	0.88

Table 47: Water quality targets to protect aquatic ecosystem EVs for Groundwater Chemistry Group—Similar to surface water—36 Carnarvon (Refer to Figure 16)[1–5]

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC (µS/cm)	Hardness (mg/L)	pH	Alk (mg/L)	SiO_2 (mg/L)	F (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)	Cu (mg/L)	SAR	RAH (meq/L)
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%												
Medium	20th	26	25	25	26	14	19	0	59	15	9	0	0	-	-	334	134	6.6	159.0	-	0.17	-	-	-	-	0.85	0.50
	50th	38	35	32	32	18	31	243	84	25	12	8	3	-	-	532	158	7.9	204.0	-	0.20	-	-	-	-	1.35	0.98
	80th	100	48	69	37	39	43	279	87	79	37	34	8	-	-	880	299	8.1	259.5	-	0.40	-	-	-	-	2.80	1.34

Notes for Tables 31-47:

1. Refer to Figure 16 to locate relevant groundwater chemistry zones.
2. Within each chemistry zone, groundwater quality percentile values are provided in Tables 31-47 for different depths (Very shallow: <15 metres, Shallow: 15-30 metres, Medium: 30-45 metres, Deep: 45-60 metres, Very Deep: >60 metres, Artesian: All artesian (maximum >2000 metres)).
3. The management intent is to maintain 20th, 50th and 80th percentile values. Values are provided for each of these percentiles.
4. Tables 31-47 may be updated over time based on the availability of additional information.
5. Abbreviations: EC: Electrical conductivity, Ca: Calcium, Mg: Magnesium, Na: Sodium, Cl: Chloride, SO4: Sulphate, HCO3: Bicarbonate, NO3: Nitrate, Hardness as CaCO3: Calcium carbonate, Alk: Alkalinity, SiO2: Silica, F: Fluoride, Fe: Iron, Mn: Manganese, Zn: Zinc, Cu: Copper, SAR: Sodium adsorption ratio, RAH: Residual alkali hazard, '-': insufficient data to perform statistical summaries, or the parameter was not tested.

Source: Regional groundwater chemistry zones of the Queensland Murray-Darling Basin: Summary and results. Queensland Government (McNeil et al., 2015).

11.2.7 Target for wetland extent

As identified in Section 2.2 of this report, the extent and distribution of freshwater wetlands is the most important indicator of the state of wetland resources in Queensland, as any loss will mean that the services provided by that wetland will be diminished.

The target for the plan area is no reduction in the extent of natural wetlands (palustrine, lacustrine and riverine) from 2013 baseline levels.

The indicators are:

- Wetland area by system (2013): Whole of plan area
- Wetland area by system (2013): Water resource plan basins

Refer to Tables 2 and 3 of this report for a description of these indicators.

11.2.8 Riparian targets and catchment groundcover

11.2.8.1 Vegetation management

The clearing of native vegetation in Queensland is regulated by the *Vegetation Management Act 1999*, the *Sustainable Planning Act 2009* and associated policies and codes. This includes the regulation of clearing in water and drainage lines.

For vegetation management relating to waterways, reference should be made to:

- State Development Assessment Provisions (SDAP) Module 8: Native vegetation clearing. This module includes performance requirements relating to clearing of native vegetation and a table relating to watercourse buffer areas and stream order. To review the SDAP Modules, refer to the Department of Infrastructure, Local Government and Planning website.
- SDAP Module 11: Wetland protection area. This module ensures that development in wetland protection areas is planned, designed, constructed and operated to prevent the loss or degradation of wetland environmental values under the *Environmental Protection Regulation 2008*, or enhances the values of wetlands. The Environmental Protection Regulation section 81A defines environmental values for wetlands.
- relevant self-assessable vegetation clearing codes under the *Vegetation Management Act 1999*. These codes are activity based, some applying to different regions, and include performance requirements relating to watercourses and wetlands, aimed at maintaining water quality, bank stability, aquatic and terrestrial habitat. Codes include vegetation clearing controls that vary according to stream order. To review the latest applicable self-assessable codes (and other explanatory information) refer to the Queensland Government website.

To review the current vegetation management laws contact the Queensland Government website or Department of Natural Resources and Mines website.

To review the SDAP Modules, contact the Department of Department of Infrastructure, Local Government and Planning website. Local Government Planning schemes under the *Sustainable Planning Act 2009* may also specify riparian buffers (for example under catchment protection or waterway codes). Refer to the Department of Infrastructure, Local Government and Planning website and relevant local government websites for further information about planning schemes.

11.2.8.2 Riparian health

Riparian zones are recognised as an important component of riverine ecosystems. Healthy riparian zones contain varying proportions of both forest and groundcover vegetation. This vegetation helps to stabilize banks and reduce erosion, provides a filtering mechanism for catchment run-off, provides habitat for various aquatic related species and provides shading, which reduces temperature extremes in waterbodies. Maintaining healthy riparian zones is therefore important to overall ecosystem health and therefore riparian targets have been included in the HWMP for the Warrego, Paroo, Bulloo and Nebine basins.

For the purposes of this report, the riparian area is defined as the area within 100 metres either side of a (mapped) stream or riverine wetland. Mapping of riparian areas is done using satellite imagery with a pixel resolution of 30m. Details of mapping can be found in Clark et al. (2015). For the purposes of this document, two forms of riparian area are considered—forested and non-forested. These are defined as follows:

Forested: Areas where tree crown cover is >~20%

Non-forested: Areas where tree crown cover is <~20%

In wetter coastal areas, riparian areas would naturally be 100% forested. However, in the drier western catchments considered in this document, extensive reaches of the riparian zones may be naturally non-forested.

See Riparian Vegetation Levels in the Queensland Murray-Darling Basin and Bulloo Catchment for 2013 (Clark et al., 2015) for further information.

Indicators for forested riparian areas

Indicator 1—Total forested riparian area: This is the total forested riparian area measured in each catchment in 2013. The target is that there should be no further net loss of the existing (2013) forested area.

Indicator 2—Normalised Patch Density (NPD): Establishes the number of riparian forest patches per kilometre of stream network and provides a measure of the linear connectivity of riparian forest along the stream network. This measure is normalised to account for the different proportion of each catchment's riparian area that is forested. A low NPD score is assigned to catchments with a highly connected riparian forest. Conversely, a high NPD score indicates there is lower connectivity between riparian forest patches in a catchment. The target is to maintain existing (2013) NPD scores.

Indicator 3—Patch Size and Connectivity Index (PSCI): The PSCI analyses the size of riparian forest patches and the distance between them. As vegetation extent is increased, the PSCI value will also increase. This indicates that riparian forest patches have become larger and more connected at the landscape scale. Alternatively, as patches either become smaller or the distance between them increases, the PSCI value will decrease. This indicates a loss of connectivity at the landscape scale. A value of 100 indicates fully connected riparian forests while a value of 0 indicates no connectivity. The target is to maintain existing (2013) PSCI scores.

Indicators for non-forested riparian areas

In the non-forested areas, satellite imagery is able to assess the density of ground cover vegetation (grasses, small shrubs, general plant litter). The standardised method is to assess three categories of ground cover density:

- >70% ground cover
- 30 to 70% ground cover
- <30% ground cover

Non-forested riparian areas are classified in good condition if ground cover is >70%.

Indicator 4—Riparian area with ground cover >70%: This is the total non-forested riparian area with >70% cover as measured in each catchment in 2013. The objective is that there should be no further net loss of the existing area with >70% cover. It is recognised that riparian ground cover varies significantly with rainfall and so the objective will need to be assessed over a range of seasons.

Riparian targets

Due to the natural occurrence of non-forested riparian areas in these catchments, and also the variation in proportions of natural forested/non-forested riparian areas between catchments, the targets are tailored to each catchment. The overall aim is to maintain existing riparian quality as measured by the indicators described above.

Riparian targets, and corresponding indicators, are specified in Tables 48-50.

Table 48: Total forested riparian area target and supporting indicator

Target 1: No reduction in forested riparian areas from 2013 baseline levels.	
	Indicator 1—Total forested riparian area (ha) in 2013.
Bulloo	243,376
Paroo	184,173
Warrego	306,029
Nebine	81,982

Note: Targets are based on the Queensland drainage sub-basins layer on the SIR spatial database, which differs slightly to the water resource plan boundaries for the plan area.

Source: Riparian vegetation levels in the Queensland Murray-Darling Basin and Bulloo catchment for 2013 (Clark et al., 2015)

Table 49: Riparian connectivity target and supporting indicators

Target 2: No reduction in riparian forest connectivity from 2013 baseline levels.		
	Indicator 2—No increase in the Normalised Patch Density (NPD) value for each major catchment.	Indicator 3—No reduction in the Patch Size and Connectivity Index (PSCI) value for each major catchment.
Bulloo	42.8	53.4
Paroo	31.8	62.8
Warrego	18.3	67.1
Nebine	23.6	63.5

Note: Targets are based on the Queensland drainage sub-basins layer on the SIR spatial database, which differs slightly to the water resource plan boundaries for the plan area.

Source: Riparian vegetation levels in the Queensland Murray-Darling Basin and Bulloo catchment for 2013 (Clark et al., 2015)

Table 50: Riparian groundcover target and supporting indicator

Target 3: In non-forested areas, maintain riparian groundcover in each catchment at a level that minimises soil erosion by water.	
	Indicator 4—No reduction from 2013 baseline levels in the area of non-forested riparian groundcover that has more than 70% coverage (ha) in each major catchment.
Bulloo	20,625
Paroo	8117
Warrego	53,858
Nebine	10,765

Note: Targets are based on the Queensland drainage sub-basins layer on the SIR spatial database, which differs slightly to the water resource plan boundaries for the plan area.

Source: Riparian vegetation levels in the Queensland Murray-Darling Basin and Bulloo catchment for 2013 (Clark et al., 2015)

11.2.8.3 Groundcover in grazing lands

The Queensland Murray-Darling Basin Ground Cover Report—2015 (Van den berg, et al, 2015) established reporting regions in each Queensland Murray-Darling Basin drainage basin by identifying the grazing lands with less than 60% foliage projective cover. Within each reporting region, the mean (average) level of groundcover in each season was calculated for 2015, and compared to the corresponding 28-year mean. The report also calculated the area of the reporting region with less than 70% groundcover, as independent studies have indicated that a ground cover level of at least 70% is required to minimise erosion by water (Van den berg, et al., 2015).

Ground cover is defined as the vegetation (living and dead), biological crusts and stone that are in contact with the soil surface. Ground cover levels are the result of complex interactions between landscape function (soil type, topography and vegetation dynamics), climate and land management. Some areas maintain naturally higher levels of ground cover due to factors such as high soil fertility and consistently high annual rainfall. The impacts of grazing land management practices on ground cover levels in these areas may be minimal due to the resilience of the land to respond to pressures. In areas where rainfall is less reliable and soils are less fertile, ground cover levels can vary greatly and the influence of grazing land management practices on ground cover levels and the species composition of the ground cover can be more pronounced.

It is important to note that the influences of rainfall and grazing pressure can be particularly evident in Queensland Murray-Darling Basin (QMDB) catchments where a strong east to west rainfall gradient exists, the impacts of drought can be prolonged and rainfall can be highly variable in space and time. Some parts of the QMDB (e.g. Paroo and Bulloo catchments) also have soils of lower fertility and low mean annual rainfall. Ground levels in these areas are naturally lower than eastern QMDB catchments and will therefore rarely attain levels of ground cover above 70 per cent.

The Queensland Murray-Darling Basin Ground Cover Report—2015 (Van den berg, et al, 2015) set the groundcover results in the context of climatic conditions. Rainfall was below average in 2015 for all catchments within the QMDB, with large parts of western Queensland drought declared during mid-late 2013 and 2014. Generally drier conditions across the QMDB area led to reductions in mean ground cover levels. The effects of high rainfall in 2010 and 2011 were observed for all catchments, with significant increases in ground cover levels and subsequent reduction in the area with ground cover below 70 per cent.

Tables 51 to 54 characterise the level of groundcover in the grazing lands of each drainage basin in 2015. The values in each table can be used as a baseline to track increases or decreases in groundcover through time. Maintaining and/or improving groundcover levels in grazing lands from 2015, with consideration to soil type, topography, vegetation dynamics, climate and land management, would have multiple benefits to the Warrego, Paroo, Bulloo and Nebine drainage basins. Ground cover is a key component of many soil processes including infiltration, runoff and surface erosion. It is particularly important to try to maintain ground cover during dry periods or periods of unreliable rainfall to minimise loss of water, soil, and nutrients when rainfall eventually occurs. This will also maximise the pasture response to rainfall. Implementation of appropriate and sustainable land management practices, particularly careful management of grazing pressure, can help to maintain or improve ground cover and improve the stability and resilience of the grazing system.

See Queensland Murray-Darling Basin Ground Cover Report—2015 (Van den berg et al., 2015) for further information.

Nebine

Mean ground cover in the Nebine catchment was relatively low across all seasons in 2015, with the lowest recorded in spring, at 57 per cent, and the highest in winter, at 63 per cent. The mean ground cover for 2015 was noticeably lower than the 28 year means for all seasons. During spring the area of the catchment below 70% ground cover was 86 per cent.

Mean rainfall for 2015 in the Nebine catchment was 273 millimetres, 146 mm below the long term mean of 419 mm. The preceding year was also below the mean with 329 mm.

Table 51: A summary of groundcover in the Nebine drainage basin per season

	28-year mean ground cover (%)	2015 mean ground cover (%)	Area of reporting region with less than 70% ground cover averaged over past 28 years (%)	Area of reporting region with less than 70% ground cover in 2015 (%)
Summer	65	59	61	78
Autumn	70	61	44	69
Winter	73	63	36	65
Spring	63	57	65	86

Note: This assessment is based on the Queensland drainage sub-basins layer on the SIR spatial database, which differs slightly to the water resource plan boundaries for the plan area.

Source: Queensland Murray-Darling Basin Ground Cover Report—2015 (Van den berg et al., 2015)

Warrego

Relatively low mean ground cover was recorded for the Warrego catchment across all seasons in 2015. The lowest mean ground cover was in spring, at 66 per cent, and the highest was in autumn and winter, at 68 per cent. These results were very similar to the 28 year mean ground cover for summer and spring, but the autumn and winter results for 2015 were a little lower than the 28 year mean. The area below 70% ground cover was also the highest in spring, at 63 per cent.

Mean rainfall for 2015 in the Warrego catchment was 232 millimetres, 247 mm below the long term mean of 479 mm. The preceding year was just below the mean with 461 mm.

Table 52: A summary of groundcover in the Warrego drainage basin per season

	28-year mean ground cover (%)	2015 mean ground cover (%)	Area of reporting region with less than 70% ground cover averaged over past 28 years (%)	Area of reporting region with less than 70% ground cover in 2015 (%)
Summer	69	69	48	47
Autumn	74	68	34	49
Winter	74	68	31	50
Spring	66	64	55	63

Note: This assessment is based on the Queensland drainage sub-basins layer on the SIR spatial database, which differs slightly to the water resource plan boundaries for the plan area.

Source: Queensland Murray-Darling Basin Ground Cover Report—2015 (Van den berg et al., 2015)

Paroo

Mean ground cover in the Paroo catchment was relatively low and uniform across all seasons, with autumn and spring recording 57 per cent, and summer and winter, at 58% in 2015. These results were very similar to the 28 year mean ground cover for summer and spring, but the autumn and winter results for 2015 were a little lower than the 28 year mean. The area of the catchment below 70% cover was highest during spring, at 91%.

The Paroo catchment is the second driest in the QMDB. Mean rainfall for 2015 was 206 millimetres, 146 mm below the long term mean of 352 mm. The preceding year was also below the mean with 312 mm.

Table 53: A summary of groundcover in the Paroo drainage basin per season

	28-year mean ground cover (%)	2015 mean ground cover (%)	Area of reporting region with less than 70% ground cover averaged over past 28 years (%)	Area of reporting region with less than 70% ground cover in 2015 (%)
Summer	58	58	82	88
Autumn	62	57	68	85
Winter	65	58	61	84
Spring	57	57	83	91

Note: This assessment is based on the Queensland drainage sub-basins layer on the SIR spatial database, which differs slightly to the water resource plan boundaries for the plan area.

Source: Queensland Murray-Darling Basin Ground Cover Report—2015 (Van den berg et al., 2015)

Bulloo

Mean ground cover in the Bulloo catchment was relatively low and uniform across all seasons in 2015. These results were similar to the 28 year mean ground cover for summer and spring, but the autumn and winter results for 2015 were a little lower than the 28 year mean. The area of the catchment below 70% cover was highest during spring, at 90 per cent.

The Bulloo catchment is the driest in the QMDB. Mean rainfall for 2015 was 158 millimetres, 152 mm below the long term mean of 310 mm. The preceding year was also below the mean with 263 mm.

Table 54: A summary of groundcover in the Bulloo drainage basin per season

	28-year mean ground cover (%)	2015 mean ground cover (%)	Area of reporting region with less than 70% ground cover averaged over past 28 years (%)	Area of reporting region with less than 70% ground cover in 2015 (%)
Summer	51	54	83	85
Autumn	56	51	73	86
Winter	58	52	69	86
Spring	50	52	85	90

Note: This assessment is based on the Queensland drainage sub-basins layer on the SIR spatial database, which differs slightly to the water resource plan boundaries for the plan area.

Source: Queensland Murray-Darling Basin Ground Cover Report—2015 (Van den berg et al., 2015)

11.2.9 Targets for freshwater macroinvertebrates

Locally derived targets for freshwater macroinvertebrate indices, derived from Negus et al. (2013), are listed in Table 55. Freshwater macroinvertebrates are organisms without a backbone that are able to be seen with the naked eye and are found in freshwater environments. Freshwater macroinvertebrates are common and widespread throughout many aquatic ecosystems, are easily sampled and can provide an integrated measure of stream condition. Due to the standard methods and protocols used to study macroinvertebrates across Australia, and the training and accreditation requirements used for their application (refer to the AUSRIVAS website), data from a number of monitoring programs were combined to develop the locally derived freshwater macroinvertebrates targets.

In order to determine the macroinvertebrate targets, 10 metre sections of edge habitats were sampled in accordance with standard national protocols. Freshwater macroinvertebrate targets for Warrego, Paroo, Bulloo and Nebine drainage basins were developed for the following indices:

- Salinity index: The average of the salinity sensitivity grades assigned to macroinvertebrate taxa in a sample:
    - Grade 1—very tolerant to salinity (taxa have been recorded at a mean conductivity ≥ 350 µScm-1)
    - Grade 10—sensitive to salinity (taxa have been recorded at a mean conductivity < 300 µScm-1)
    - Grade 5—generally tolerant to salinity (Taxa neither very tolerant, nor sensitive) (Horrigan et al., 2005).
- Taxa richness: The number of different aquatic macroinvertebrate taxa collected in a sample.
- Average SIGNAL grade: The SIGNAL (Stream Invertebrate Grade Number—Average Level) index was developed for the bioassessment of water quality in rivers in Australia. A SIGNAL score is calculated by grading each detected macroinvertebrate family based upon its sensitivity to pollutants, ranging from 1 (tolerant) to 10 (sensitive). The target value is calculated by averaging the sensitivity grades of all the macroinvertebrate families collected. SIGNAL version 2.iv (Chessman, 2003) was used to develop the target values.
- % tolerant taxa: The proportion of taxa with 'tolerant' SIGNAL grades of 1–3, based on SIGNAL version 2.iv (Chessman, 2003).

Samples for the macroinvertebrate targets were identified in the laboratory to family level, except for Chironimidae (non-biting midges) that are identified to sub-family, and lower Phyla (Porifera, Nematoda, Nemertea, etc.), Oligochaeta (freshwater worms), Acarina (mites), and microcrustacea (Ostracoda, Copepoda, Cladocera) that are not identified further. The taxonomy used to calculate the target indices was based on SIGNAL version 2.iv taxa scores, with minor adjustments (Chessman, 2003; Negus et al., 2013). These taxonomic levels require consideration during the application of the freshwater macroinvertebrate targets specified in Table 55 to ensure numbers of taxa are comparable.

Table 55: Freshwater macroinvertebrate targets for slightly to moderately disturbed waters of the Warrego, Paroo, Bulloo and Nebine drainage basins (Negus et al., 2013)

Drainage basin	Index	Edge habitat [1]	
		20th percentile	80th percentile
Warrego	Salinity index	3.65	4.21
	Taxa richness	17	27
	Average SIGNAL grade	3.21	3.50
	% tolerant taxa	42.11	55.00
Paroo[2]	Salinity index	3.44	4.44
	Taxa richness	19	23
	Average SIGNAL grade	3.20	3.50
	% tolerant taxa	42.86	53.33
Bulloo	Salinity index	3.73	4.47
	Taxa richness	15.5	25
	Average SIGNAL grade	3.04	3.63
	% tolerant taxa	40.59	56.94
Nebine	Salinity index	3.86	4.31
	Taxa richness	15	27
	Average SIGNAL grade	3.14	3.38
	% tolerant taxa	42.86	60.00

Notes:

1. Edge habitat is located along the stream bank.

2. Indicates a limited number of samples were used to develop the target values and this should be considered an interim value until further data is available.

11.3 Water quality targets for the protection of Human Use Environmental Values

These water quality targets apply where the following Human Use Environmental Values have been identified in the SW region (Refer to section 5 of this report). Where more than one EV applies to a given water (for example aquatic ecosystem and recreational use), the adoption of the most stringent water quality target for each water quality indicator will then protect all identified EVs. The water quality targets in this section are, unless otherwise specified, based on national water quality guidelines, including ANZECC (2000), the National Health and Medical Research Council Guidelines for managing risks in recreational water, the Food Standards Australia New Zealand, and the Australian Drinking Water Guidelines. Where national guidelines are the source for the stated water quality targets, reference is necessary to obtain comprehensive listings of all indicators and up-to-date information.

11.3.1 Water quality targets for the protection of Primary Industry Environmental Values

Section 10.32 of the Basin Plan requires a WQM Plan to identify water quality targets for irrigation water.

The Healthy Waters Management Plan fulfils this requirement by specifying water quality target values to protect the 'Suitability for Irrigation' Environmental Value. The water quality target values for accreditation under section 10.32 of the Basin Plan are the water quality target values in Table 56, provisions (1) to (4) for the Cunnamulla Water Supply Scheme. While not accredited under the Basin Plan, Table 56 provision (5) for the Cunnamulla Water Supply Scheme and provision (1) for all other surface waters and groundwaters in the Warrego, Paroo, Bulloo and Nebine drainage basins are recognised to support the accredited water quality target values for irrigation water.

Note: The water quality target values for the Bulloo drainage basin are not accredited under the Basin Plan as the Bulloo drainage basin is a closed system that is not connected to the Murray-Darling Basin.

WATER QUALITY TARGET VALUES FOR PRIMARY INDUSTRY

Table 56: Suitability for irrigation

Environmental Value	Water type/area	Water quality targets to protect Environmental Value
Suitability for irrigation	Surface waters in the Cunnamulla Water Supply Scheme.	**For the Cunnamulla Water Supply Scheme[43]:** 1. The water quality targets for irrigation water are that the values for a water quality characteristic meet the target values set out below in (3) and (4) 95% of the time over each period of 10 years that ends at the end of a water accounting period. 2. The water quality targets referred to by provision (1) apply at sites in the Murray-Darling Basin where water is extracted by an irrigation infrastructure operator for the purpose of irrigation[44]. 3. The target value for electrical conductivity (EC) in the Warrego River is 838 µS/cm. Note: To convert EC to milligrams per litre (mg/L), the following approximate conversion factor can be used for the Warrego River: mg/L = EC multiplied by 0.8. 4. The target value for the sodium adsorption ratio of irrigation water is the value which, if exceeded, would cause soil degradation when that water is applied to land. This value will be dependent on local conditions and will need to be calculated in consideration of the specific soil condition where the water is to be applied. Note: Soil degradation means reduced permeability and soil structure breakdown caused by the level of sodium in the irrigation water, assessed using the sodium adsorption ratio. 5. Targets for all other parameters in the Cunnamulla Water Supply Scheme are as per

[43] Refer to Attachment 3 of the amended Warrego, Paroo, Bulloo and Nebine Resource Operations Plan 2016 for a map of the Cunnamulla Water Supply Scheme

[44] For the Cunnamulla Water Supply Scheme, the irrigation infrastructure operator, as defined under the *Water Act 2007* (Cth.), is SunWater.

		Table 56, provision 1 for all surface waters and groundwaters.
	All surface waters and groundwaters	**For the Warrego, Paroo, Bulloo and Nebine drainage basins:** 1. ANZECC (2000) targets for pathogens and metals are provided in tables 57 and 58. For all other indicators, such as salinity, sodicity and herbicides refer to the ANZECC Guidelines (2000).

Table 57: Irrigation EV - Water quality targets for thermotolerant (faecal) coliforms in irrigation waters used for food and non-food crops[1]

Intended use	Median values of thermotolerant coliforms (colony forming units–cfu) [2]
Raw human food crops in direct contact with irrigation water (e.g. via sprays, irrigation of salad vegetables)	<10 cfu/100mL
Raw human food crops not in direct contact with irrigation water (edible product separated from contact with water, e.g. by peel, use of trickle irrigation); or crops sold to consumers cooked or processed	<1000 cfu/100mL
Pasture and fodder for dairy animals (without withholding period)	<100 cfu/100mL
Pasture and fodder for dairy animals (with withholding period of five days)	<1000 cfu/100mL
Pasture and fodder (for grazing animals except pigs and dairy animals, i.e. cattle, sheep and goats)	<1000 cfu/100mL
Silviculture, turf, cotton, etc. (restricted public access)	<10 000 cfu/100mL

Notes:

1. Adapted from ARMCANZ, ANZECC and NHMRC (1999).

2. Refer to ANZECC (2000), Volume 1, Section 4.2.3.3 for advice on testing protocols.

Source: ANZECC (2000), Volume 1, Section 4.2.3.3 and Table 4.2.2.

Table 58: Irrigation EV—Water quality objectives for heavy metals and metalloids in agricultural irrigation water[1]—long-term trigger value (LTV), short-term trigger value (STV) and soil cumulative contamination loading limit (CCL)

Element	Soil cumulative contaminant loading limit (CCL) [2] (kg/ha)	Long-term trigger value (LTV) in irrigation water (up to 100 years) (mg/L)	Short-term trigger value (STV) in irrigation water (up to 20 years) (mg/L)
Aluminium	ND[2]	5	20
Arsenic	20	0.1	2.0
Beryllium	ND	0.1	0.5
Boron	ND	0.5	Refer to ANZECC (2000), Vol 3, Table 9.2.18
Cadmium	2	0.01	0.05
Chromium	ND	0.1	1
Cobalt	ND	0.05	0.1
Copper	140	0.2	5
Fluoride	ND	1	2
Iron	ND	0.2	10
Lead	260	2	5
Lithium	ND	2.5 (0.075 for citrus crops)	2.5 (0.075 for citrus crops)
Manganese	ND	0.2	10
Mercury	2	0.002	0.002
Molybdenum	ND	0.01	0.05
Nickel	85	0.2	2
Selenium	10	0.02	0.05
Uranium	ND	0.01	0.1
Vanadium	ND	0.1	0.5
Zinc	300	2	5

Notes:

1. Concentrations in irrigation water should be less than the trigger values. Trigger values should only be used in conjunction with information on each individual element and the potential for off-site transport of contaminants (refer ANZECC (2000), Volume 3, Section 9.2.5).

2. ND = Not determined; insufficient background data to calculate CCL.

Source: ANZECC (2000), Volume 1, Section 4.2.6 and Table 4.2.10.

WATER QUALITY TARGET VALUES FOR PRIMARY INDUSTRY **Table 59: Suitability for stock watering**		
Environmental Value	Water type/area	Water quality targets to protect Environmental Value
Suitability for stock watering	All surface waters and groundwaters	Water quality targets as per ANZECC (2000), including median faecal coliforms <100 organisms per 100 mL. Water quality targets for total dissolved solids and metals are provided in Tables 60 and 61, based on ANZECC (2000). For other water quality targets, such as cyanobacteria and pathogens, see ANZECC (2000).

Table 60: Stock watering EV: Water quality targets for tolerances of livestock to total dissolved solids (salinity) in drinking water[1]

Livestock	Total dissolved solids (TDS) (mg/L)		
	No adverse effects on animals expected.	Animals may have initial reluctance to drink or there may be some scouring, but stock should adapt without loss of production.	Loss of production and a decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually.
Beef cattle	0–4000	4000–5000	5000–10 000
Dairy cattle	0–2500	2500–4000	4000–7000
Sheep	0–5000	5000–10 000	10 000–13 000[2]
Horses	0–4000	4000–6000	6000–7000
Pigs	0–4000	4000–6000	6000–8000
Poultry	0–2000	2000–3000	3000–4000

Notes:

1. From ANZECC (1992), adapted to incorporate more recent information.

2. Sheep on lush green feed may tolerate up to 13 000 mg/L TDS without loss of condition or production.

Source: ANZECC (2000), Volume 1, Section 4.3.3.5 and Table 4.3.1.

Table 61: Stock watering EV: Water quality targets (low risk trigger values) for heavy metals and metalloids in livestock drinking water

Metal or metalloid	Trigger value (low risk)[1,2] (mg/L)
Aluminium	5
Arsenic	0.5 (up to 5[3])
Beryllium	ND
Boron	5
Cadmium	0.01
Chromium	1
Cobalt	1
Copper	0.4 (sheep), 1 (cattle), 5 (pigs), 5 (poultry)
Fluoride	2
Iron	Not sufficiently toxic
Lead	0.1
Manganese	Not sufficiently toxic
Mercury	0.002
Molybdenum	0.15
Nickel	1
Selenium	0.02
Uranium	0.2
Vanadium	ND
Zinc	20

Notes:

1. Higher concentrations may be tolerated in some situations (further details provided in ANZECC (2000), Volume 3, Section 9.3.5).

2. ND = not determined, insufficient background data to calculate.

3. May be tolerated if not provided as a food additive and natural levels in the diet are low.

Source: ANZECC (2000), Volume 1, Section 4.3.4 and Table 4.3.2.

WATER QUALITY TARGET VALUES FOR PRIMARY INDUSTRY

Table 62: Suitability for farm supply/use

Environmental Value	Water type/area	Water quality targets to protect Environmental Value
Suitability for farm supply/use	All surface waters and groundwaters	Targets as per ANZECC guidelines (2000).

WATER QUALITY TARGET VALUES FOR PRIMARY INDUSTRY

Table 63: Protection of the human consumer

Environmental Value	Water type/area	Water quality targets to protect Environmental Value
Protection of the human consumer	All surface waters and groundwaters	Targets as per ANZECC guidelines (2000) and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, 2007 and updates.

WATER QUALITY TARGET VALUES FOR PRIMARY INDUSTRY

Table 64: Suitability for aquaculture

Environmental Value	Water type/area	Water quality targets to protect Environmental Value
Suitability for aquaculture	All surface waters and groundwaters	Targets as per: • Table 65 of this report • ANZECC guidelines (2000) • Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, 2007 and updates.

WATER QUALITY TARGET VALUES FOR PRIMARY INDUSTRY

Table 65: Water quality targets for aquaculture (optimal growth of particular species in freshwater)

Water parameter	Barramundi	Eel	Silver perch	Jade perch	Sleepy cod	Redclaw
Dissolved oxygen	4–9mg/L	>3mg/L	>4mg/L	>3mg/L	>4.0mg/L	>4.0mg/L
Temperature ˚C	26–32	23–28	23–28	23–28	22–31	23–31
pH	7.5–8.5	7.0–8.5	6.5–9	6.5–9	7.0–8.5	7.0–8.5
Ammonia (TAN, Total ammonia-nitrogen)		<1.0mg/L			<1.0mg/L	<1.0mg/L
Ammonia (NH_3, un-ionised form)*pH dependent	<0.46mg/L	<0.1mg/L	<0.1mg/L	<0.1mg/L	<0.1mg/L	<0.1mg/L
Nitrate (NO_3)			<100mg/L			
Nitrite (NO_2)	<1.5mg/L	<1.0mg/L	<0.1mg/L		<1.0mg/L	<1.0mg/L
Salinity (extended periods)	0–35ppt		<5ppt	<5ppt		<4ppt
Salinity bath	0–35ppt		5–10ppt for 1 hour		max. 20ppt for 1 hour	
Hardness ($CaCO_3$)			>50 mg/L	>50 mg/L	>40mg/L	>40mg/L
Alkalinity	>20mg/L		100–400 ppm	100–400 ppm	>40mg/L	>40mg/L
Chlorine	<0.04mg/L				<0.04mg/L	
Hydrogen sulphide	0–0.3mg/L				0–0.3mg/L	
Iron	<0.1mg/L		<0.5mg/L	<0.5mg/L	<0.1mg/L	<0.1mg/L
Spawning temperature °C	Marine		23–28	23–28	>24 for more than 3 days	

Source: Department of Primary Industries and Fisheries: Water Quality in Aquaculture—DPI Notes April 2004.

11.3.2 Water quality targets for the protection of the Drinking Water Environmental Value

WATER QUALITY TARGET VALUES FOR DRINKING WATER

Table 66: Suitability for drinking water supply

Environmental Value	Water type/area	Water quality targets to protect Environmental Value
Suitability for drinking water supply	All surface waters and groundwaters	Local water quality targets for drinking water supply are provided in Table 67. The Australian Drinking Water Guidelines (2011 and updates) provides a framework for the quality of raw water for treatment for human consumption. For water quality after treatment or at point of use refer to legislation and guidelines, including: • Australian Drinking Water Guidelines (2011 and updates) • *Public Health Act 2005* and Regulation • *Water Fluoridation Act 2008* and Regulation • *Water Supply (Safety and Reliability) Act 2008*, including any approved drinking water management plan under the Act.

Table 67: Drinking Water EV—Water quality targets for drinking water supply in the vicinity of off-takes, including groundwater, before treatment

This table outlines the water quality targets for water **before treatment**, unless otherwise stated (e.g. ADWG). For water quality after treatment or at the point of use, refer to relevant legislation and guidelines, including *Public Health Act 2005* and Regulation, *Water Supply (Safety and Reliability) Act 2008* and Regulation, including any approved drinking water management plan under the Act, *Water Fluoridation Act 2008* and Regulation, and the Australian Drinking Water Guidelines (ADWG, 2011 and updates).

Indicator	Water quality target
Giardia	0 cysts (Queensland Water Supply Regulator) If *Giardia* is detected in drinking water then the health authorities should be notified immediately and an investigation of the likely source of contamination undertaken (ADWG).
Cryptosporidium	0 cysts (Queensland Water Supply Regulator) If *Cryptosporidium* is detected in drinking water then the health authorities should be notified immediately and an investigation of the likely source of contamination undertaken (ADWG).
E. coli	<100 cfu/100mL Treatment plants with effective barriers and disinfection are designed to address faecal contamination. *E. coli* or thermotolerant coliforms should not be present in any 100 mL sample of (treated) drinking water (ADWG).
Blue-green algae (cyanobacteria)	<2000 cells/mL
Algal toxin	ADWG (2011 and updates) health guideline: <1.3 µg/L Microcystin
pH	6.5-8.0
Sulphate	ADWG (2011 and updates) health guideline: <500 mg/L
Dissolved oxygen	60-110 % saturation
Pesticides	Raw supplies: Below detectable limits. Treated drinking water: Refer to ADWG.
Other indicators (including physico-chemical indicators)	Refer to ADWG.

11.3.3 Water quality targets for the protection of the Cultural, Spiritual and Ceremonial Environmental Value

These water quality targets apply where the Cultural, Spiritual and Ceremonial Environmental Value has been identified in the South West region (Refer to section 5 of this report).

WATER QUALITY TARGET VALUES FOR CULTURAL, SPIRITUAL AND CEREMONIAL VALUES

Table 68: Protection of cultural, spiritual and ceremonial values

Environmental Value	Water type/area	Water quality targets to protect Environmental Value
Protection of cultural, spiritual and ceremonial values	All surface waters and groundwaters	Protect or restore cultural, spiritual and ceremonial heritage consistent with key policies and plans. The following documents may provide information in support of the cultural, spiritual and ceremonial value: • Caring for Water on Country in South West Queensland (South West NRM Ltd, 2012b) • Planning for climate variability in south west Queensland: Yarning with Traditional Owners in south west Queensland (South West NRM Ltd, 2014b).

11.3.4 Water quality targets for the protection of the Industry Environmental Value

These water quality targets apply where the Industry Environmental Value has been identified in the SW region (Refer to section 5 of this report).

WATER QUALITY TARGET VALUES FOR INDUSTRY

Table 69: Suitability for industrial use

Environmental Value	Water type/area	Water quality targets to protect Environmental Value
Suitability for industrial use 	All surface waters and groundwaters	Water quality requirements for industry vary within and between industries. The ANZECC guidelines (2000) do not provide targets to protect industries, and indicate that industrial water quality requirements need to be considered on a case-by-case basis. This environmental value is usually protected by other values, such as the aquatic ecosystem environmental value.

11.3.5 Water quality targets for the protection of the Primary, Secondary and Visual Recreation Environmental Values

The following water quality targets apply where the following recreational Environmental Values have been identified in the SW region (Refer to section 5 of this report).

Section 10.32 of the Basin Plan requires a WQM Plan to identify water quality targets for recreational purposes.

The Healthy Waters Management Plan fulfils this requirement by specifying that the water quality targets for water used for recreational purposes includes the values for cyanobacteria cell counts or biovolume as set out in Chapter 6 of the Guidelines for Managing Risks in Recreational Water. The water quality target values for accreditation under section 10.32 of the Basin Plan are the water quality target values in Table 70, provision (1) for primary, secondary and visual recreation. The accredited water quality target values apply in the Warrego, Paroo and Nebine drainage basins. While not accredited under the Basin Plan, Table 70 provision (2) for primary, secondary and visual recreation is recognised to support the accredited water quality target values for recreational purposes.

Note: The water quality target values for the Bulloo drainage basin are not accredited under the Basin Plan as the Bulloo drainage basin is a closed system that is not connected to the Murray-Darling Basin.

WATER QUALITY TARGET VALUES FOR RECREATION

Table 70: Suitability for primary, secondary and visual recreation

Environmental Value	Water type/area	Water quality targets to protect Environmental Value
Suitability for primary contact recreation 	All surface waters and groundwaters	1. Cyanobacteria and algae targets as per Chapter 6 of the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008), including: • Recreational water bodies should not contain: o Level 1[1]: ≥ 10 µg/L total microcystins; or ≥ 50 000 cells/mL toxic *Microcystis aeruginosa*; or biovolume equivalent of ≥ 4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume; or o Level 2[1]: ≥ 10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present; or o cyanobacterial scums consistently present. Further details are contained in (NHMRC, 2008) and Table 71. 2. All other targets for fresh waters as per the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008), including: • water free of physical (floating and submerged) hazards[45] • temperature range: 16–34°C • pH range: 6.5–8.5 • DO: >80% • faecal contamination: designated recreational waters are protected against direct contamination with fresh faecal material, particularly of human or domesticated animal origin. Two principal components are required for assessing faecal contamination: o assessment of evidence for the likely influence of faecal material o counts of suitable faecal indicator bacteria (usually *enterococci*) These two components are combined to produce an overall microbial classification of the recreational water body. • intestinal *enterococci*: 95th percentile ≤ 40 organisms per 100mL (for healthy adults) (NHMRC, 2008; Table 5.7) • avoiding exposure to freshwater free-living microorganisms (e.g. the protozoan

[45] Where permanent hazards exist appropriate warning signs should be clearly displayed.

		Naegleria fowleri in warm fresh waters) • waters contaminated with chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreational purposes.
Suitability for secondary contact recreation 	All surface waters and groundwaters	1. Cyanobacteria and algae targets as per Chapter 6 of the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008). Refer to the cyanobacteria and algae targets for primary recreation, NHMRC (2008) and Table 71 for further detail. 2. All other targets for fresh waters as per the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008), including: • intestinal *enterococci*: 95th percentile ≤ 40 organisms per 100mL (for healthy adults) (NHMRC, 2008; Table 5.7).
Suitability for visual recreation 	All surface waters and groundwaters	1. Cyanobacteria and algae targets as per Chapter 6 of the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008). Refer to the cyanobacteria and algae targets for primary recreation, NHMRC (2008) and Table 71 for further detail. 2. All other targets for fresh waters as per the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008), including: • recreational water bodies should be aesthetically acceptable to recreational users. The water should be free from visible materials that may settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity; and substances and conditions that produce undesirable aquatic life.

Notes:

1. Level 1 recognises the probability of adverse health effects from ingestion of known toxins, in this case based on the toxicity of microcystins. Level 2 covers circumstances in which there are very high cell densities of cyanobacterial material, irrespective of the presence of toxicity or known toxins. Increased cyanobacterial densities increase the likelihood of non-specific adverse health outcomes, principally respiratory, irritation and allergy symptoms (NHMRC, 2008; 8)

Table 71 Recreational waters: Alert levels and corresponding actions for management of cyanobacteria

When cyanobacteria are present in large numbers they can present a significant hazard, particularly to primary contact users of waters. Monitoring/action requirements relative to cyanobacteria 'alert' levels are summarised below, and are explained more fully in the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008). Further details on the process to determine suitability of waters for recreation, relative to historical cyanobacterial levels and susceptibility to cyanobacterial contamination, are contained in Section 6 of the NHMRC guidelines (2008).

Green level surveillance mode[1]	Amber level alert mode[1]	Red level action mode[1]
Fresh waters		
≥ 500 to <5000 cells/mL *M. aeruginosa* or biovolume equivalent of >0.04 to <0.4 mm^3/L for the combined total of all cyanobacteria.	≥ 5000 to <50 000 cells/mL *M. aeruginosa* or biovolume equivalent of ≥0.4 to <4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume[2]. or[3] ≥0.4 to <10 mm^3/L for the combined total of all cyanobacteria where known toxin producers are not present.	Level 1 guideline[4]: ≥ 10 µg/L total microcystins. or ≥ 50 000 cells/mL toxic *M. aeruginosa* or biovolume equivalent of ≥ 4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume. or[3] Level 2 guideline[4]: ≥ 10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present. or cyanobacterial scums are consistently present[5].

Notes:

1. Recommended actions at different alert levels are outlined below (based on NHMRC, 2008, Table 6.6—Fresh waters).
    a. **Green:** Regular monitoring. Weekly sampling and cell counts at representative locations in the water body where known toxigenic species are present (i.e. *Microcystis aeruginosa*, *Anabaena circinalis*, *Cylindrospermopsis raciborskii*, *Aphanizomenon ovalisporum*, *Nodularia spumigena*); or fortnightly for other types including regular visual inspection of water surface for scums.
    b. **Amber:** Notify agencies as appropriate. Increase sampling frequency to twice weekly at representative locations in the water body where toxigenic species (above) are dominant within the alert level definition (i.e. total biovolume) to establish population growth and spatial variability in the water body. Monitor weekly or fortnightly where other types are dominant. Make regular visual inspections of water surface for scums. Decide on requirement for toxicity assessment or toxin monitoring.
    c. **Red:** Continue monitoring as for (amber) alert mode. Immediately notify health authorities for advice on health risk. ('In action mode the local authority and health authorities warn the public of the existence of potential health risks; for example, through the media and the erection of signs by the local authority.' NHMRC, 2008; 114). Make toxicity assessment or toxin measurement of water if this has not already been done. Health authorities warn of risk to public health (i.e. the authorities make a health risk assessment considering toxin monitoring data, sample type and variability).
2. The definition of 'dominant' is where the known toxin producer comprises 75% or more of the total biovolume of cyanobacteria in a representative sample.
3. This applies where high cell densities or scums of 'non-toxic' cyanobacteria are present i.e. where the cyanobacterial population has been tested and shown not to contain known toxins (microcystin, nodularian, cylindrospermopsin or saxitoxins).
4. Health risks and levels: Level 1 is developed to protect against short-term health effects of exposure to cyanobacterial toxins ingested during recreational activity, whereas the Level 2 applies to the circumstance where there is a probability of increased likelihood of non-specific adverse health outcomes, principally respiratory, irritation and allergy symptoms, from exposure to very high cell densities of cyanobacterial material irrespective of the presence of toxicity or known toxins (NHMRC, 2008; 114).
5. This refers to the situation where scums occur at the recreation site each day when conditions are calm, particularly in the morning. Note that it is not likely that scums are always present and visible when there is a high population as the cells may mix down with wind and turbulence and then reform later when conditions become stable.

Source: Summarised from NHMRC (2008) Guideline for Managing Risks in Recreational Water (Tables 6.2 and 6.6).

11.4 Salinity targets for the purposes of long-term salinity planning and management

WATER QUALITY TARGET VALUES FOR LONG-TERM SALINITY PLANNING AND MANAGEMENT

Table 72: Queensland Basin Salinity Management Strategy End-of-Valley Salinity Targets

Valley	Baseline as at 1 Jan 2000			End-of-Valley targets (as absolute value)			Valley reporting site	AWRC Site Number	Map EoV Site ID
	Salinity (EC µS/cm)		Salt Load (t/yr)	Salinity (EC µS/cm)		Salt Load (t/yr)			
	Median (50%ile)	Peak (80%ile)	Mean	Median (50%ile)	Peak (80%ile)	Mean			
Queensland									
Paroo	90	100	24,000	90	100	24,000	Paroo R @ Caiwarro	424201A	88
Warrego	101	110	4,800	101	110	4,800	Warrego R @Barringun No.2	423004[1]	86
	100	130	5,500	100	130	5,500	Cuttaburra Ck @Turra	423005[1]	87

Notes:

1. These sites are operated by NSW on behalf of Queensland.

Source: Appendix 1 of Schedule B to the Murray-Darling Basin Agreement (Schedule 1 of the Water Act 2007). Version 15 June 2010, and as amended.

SECTION 12: MONITORING, EVALUATION AND REPORTING

12 Monitoring, data management, reporting and governance

12.1 Monitoring

Monitoring should be designed in accordance with the EPP Water Monitoring and Sampling Manual 2009. The principles in section 13.04 of the Basin Plan (listed below in Table 73) should also be implemented when conducting monitoring and evaluation in the plan area. These principles apply to all South West drainage basins, including the Bulloo drainage basin. This ensures consistency in monitoring practices across the South West region, as well as the Murray-Darling Basin.

Table 73: Principles to be applied in monitoring and evaluating the effectiveness of the Basin Plan (section 13.04 Basin Plan)

Principle	Description
Principles 1-2	Not applicable to the Queensland Government or other state agencies.
Principle 3	Commonwealth agencies and Basin States should report against matters in a manner which reflects the degree to which they are responsible for those matters.
Principle 4	Monitoring and evaluation should be undertaken within the conceptual framework of program logic. Note: Program logic is a mechanism that helps to determine when and what to evaluate so that resources can be used effectively and efficiently: see the Australian Government's NRM MERI Framework.
Principle 5	Monitoring and evaluation findings, including in respect of progress towards meeting targets and trends in the condition and availability of the Basin water resources, should enable decision-makers to use adaptive management.
Principle 6	Monitoring and evaluation should harness the monitoring capabilities of existing Basin State and Commonwealth programs (including jointly funded programs), provided that the programs are consistent with the principles in this Part, with a view to aligning and improving these programs over time. Note: For example, water information provided by Basin States to the Bureau of Meteorology under Part 7 of the Water Act 2007 may be used, where possible, for monitoring and evaluation to avoid duplication in the sourcing of that information.
Principle 7	The best available knowledge (including scientific, local and cultural knowledge), evidence and analysis should be used where practicable to ensure credibility, transparency and usefulness of monitoring and evaluation findings.
Principle 8	Basin States and the Commonwealth should collaborate on the technical and operational elements of monitoring and evaluation in order to build engagement and ownership.
Principle 9	A risk-based approach should be used for investment in monitoring and evaluation.
Principle 10	Monitoring and reporting should be timely, efficient, cost-effective and consistent, and should supply the information needed for evaluation.
Principle 11	To the extent possible, there should be open access to information collected or used in, or generated by, monitoring and evaluation.

12.2 Data management and reporting

Data management and reporting should be consistent with the following:

1. Data should be stored with sufficient identifiers and metadata associated with the data to ensure its integrity.
2. A common, secure and accessible platform for archiving (storing and retrieval) and displaying water quality information is required.
3. Reporting should be specifically linked to management responses and outcomes.
4. Integration of reporting and linking to related reports should be considered, where possible.
5. Reporting should address progress against actions, performance indicators and timelines. Reporting should also address the outcomes of any review processes undertaken and any updates or improvements made to the plan.
6. Reporting should be web based, where possible.
7. Decision support models should be utilised, if available, to assist with the evaluation of progress and possible management intervention scenarios.

12.3 Governance

A collaborative partnership between the Queensland Government and South West NRM Ltd is the recommended approach for the delivery of the HWMP for the Warrego, Paroo, Bulloo and Nebine drainage basins. Resources and implementation of the various management responses to address risks and contribute to the achievement of objectives for water resources will involve Commonwealth and State governments, key stakeholders (including industry, commerce, landholders, science providers, environment groups and Traditional Owner groups) and the broader community.

12.3.1 South West NRM Limited

South West NRM Ltd is a community-based organisation and the designated regional body for natural resource management in Warrego, Paroo, Bulloo and Nebine drainage basins. It is one of fifty-seven regional bodies throughout Australia and one of fourteen in Queensland.

South West NRM Ltd works with the community, Landcare groups, Traditional Owners, local government and industry groups to achieve sustainable natural resource management, and fosters landcare and catchment management ethics.

As a community-based company, South West NRM Ltd’s vision is reflective of the community’s values and priorities for natural resource management in the region:

“The community working together to build a healthy, sustainable, attractive, and profitable South West Queensland, through the effective management of our natural resources.”

The roles of the company are to:

- Develop, coordinate and facilitate implementation of the Regional Natural Resource Management Plan;
- Provide support to natural resource management groups within the South West NRM Ltd region;
- Have input into policy development at a local, regional and state level; and
- Foster landcare and catchment management ethics.

The company is responsible for the regional delivery of federal and state NRM investment program funds in the Bulloo, Nebine-Mungallala-Wallam, Paroo and Warrego drainage basins.

The main office of South West NRM Ltd is located in Charleville. For more information, refer to the South West NRM Ltd website.

SECTION 13: IMPACT ON NEW SOUTH WALES WATER RESOURCES

13 Impact on New South Wales water resources

Consultation with the New South Wales Government on the Warrego-Paroo-Nebine Water Quality Management Plan (WQM Plan), encompassing the HWMP for Warrego, Paroo, Bulloo and Nebine basins, was undertaken in accordance with section 10.05, 10.32 and 10.35 of the Basin Plan. This consultation is described in Section 4.7 of this report.

The final draft HWMP and WQM Plan was provided to water quality representatives from the New South Wales Department of Primary Industries for comment on the:

- water quality target values refined through local data
- impact of Queensland measures on the ability of New South Wales to meet water quality targets
- any adverse impacts measures may have on New South Wales water resources.

The Department of Environment and Heritage Protection received a response from the Department of Primary Industries on the final draft WQM Plan on 21 January 2016. The New South Wales Department of Primary Industries was supportive of Queensland's WQM Plan for the Warrego-Paroo-Nebine plan area, including the impact of targets and measures on New South Wales drainage basins. Specific comments were as follows:

Proposed alternative water quality target values based on local data analysis

Queensland's water quality targets are appropriate. Where the targets differ from the Basin Plan, the Queensland Government has followed the ANZECC procedure for setting local water quality targets. The majority of these changes result in stronger targets.

The impact of Queensland measures on the ability of New South Wales to meet water quality targets; any adverse impacts measures may have on New South Wales water resources

The Queensland Government has nominated one accredited measure under the Basin Plan—limiting groundwater take to minimise risk from salinity. This measure is appropriate to mitigate this risk. Other risks from increased levels of turbidity/sediments and decreased levels of dissolved oxygen have been identified, however as these are primarily driven by pressures related to land-use management they are considered outside the scope of flow-related measures under the WQM Plan.

The implementation of the WQM Plan, incorporating the HWMP for Warrego, Paroo, Bulloo and Nebine basins, is considered appropriate to address the risks in the plan area and minimise cross-border impacts between Queensland and New South Wales.

SECTION 14: DICTIONARY

14 Dictionary

ADWG means the Australian Drinking Water Guidelines (2011 and as updated), prepared by the National Health and Medical Research Council (NHMRC) in collaboration with the Natural Resource Management Ministerial Council (NRMMC).

ANZECC means the Australian and New Zealand Environment and Conservation Council.

ANZECC Guidelines mean the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (October 2000), prepared by the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

Aquatic ecosystems (defined in the AWQG) comprise the animals, plants and micro-organisms that live in water, and the physical and chemical environment and climatic regime in which they interact. It is predominantly the physical components (e.g. light, temperature, mixing, flow, habitat) and chemical components (e.g. organic and inorganic carbon, oxygen, nutrients) of an ecosystem that determine what lives and breeds in it, and therefore the structure of the food web. Biological interactions (e.g. grazing and predation) can also play a part in structuring many aquatic ecosystems.

ARMCANZ means the Agriculture and Resource Management Council of Australia and New Zealand.

AWQG means the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (October 2000), prepared by the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

Basin Plan means the *Basin Plan 2012*, prepared under the Commonwealth *Water Act 2007*.

Ecological health (defined in the AWQG) means the 'health' or 'condition' of an ecosystem. It is the ability of an ecosystem to support and maintain key ecological processes and organisms so that their species compositions, diversity and functional organisations are as comparable as possible to those occurring in natural habitats within a region (also termed ecological integrity).

Environmental values (EVs) for water are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These EVs need to be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. Particular waters may have different EVs. EVs for a specified region are listed in schedule 1 of the EPP Water.

EPP Water is the Environmental Protection (Water) Policy 2009.

Level of protection for a water (aquatic ecosystem EV) means the level of aquatic ecosystem condition specified in Table 2 of this document that the corresponding WQOs for that water are intended to achieve (refer to management intent definition below for further information).

Management intent (aquatic ecosystem EV) is defined in s. 14 of the EPP (Water). It is the management intent for the waters that the decision to release waste water or contaminant to the waters must ensure the following:

- for high ecological value (HEV) waters—the measures for the indicators are maintained
- for slightly disturbed (SD) waters—the measures for the slightly modified physical or chemical indicators are progressively improved to achieve the water quality objectives for high ecological value water
- for moderately disturbed (MD) waters:
    - if the measures for indicators of the EVs achieve the water quality objectives for the water—the measures for the indicators are maintained at levels that achieve the water quality objectives for the water, or
    - if the measures for indicators of the EVs do not achieve the water quality objectives for the water—the measures for indicators of the EVs are improved to achieve the water quality objectives for the water
- for highly disturbed (HD) waters—the measures for the indicators of all environmental values are progressively improved to achieve the water quality objectives for the water.

QWQG means the Queensland Water Quality Guidelines.

Queensland waters (as defined in *Acts Interpretation Act 1954*): means all waters that are a) within the limits of the state; or b) coastal waters of the state.

Toxicant (defined in the AWQG) means a chemical capable of producing an adverse response (effect) in a biological system at concentrations that might be encountered in the environment, seriously injuring structure or function or producing death. Examples include pesticides, heavy metals and biotoxins.

Water quality guidelines (defined in the EPP (Water)) are numerical concentration levels or statements for indicators that protect a stated environmental value. Under the EVs setting process contained in the EPP (Water), water quality guidelines are used as an input to the development of WQOs.

Water quality indicator (for an EV) means a property that is able to be measured or decided in a quantitative way. Examples of water quality indicators include physical indicators (e.g. temperature), chemical indicators (e.g. nitrogen, phosphorus, metals), and biological indicators (e.g. macroinvertebrates, seagrass, fish).

Water quality objectives (WQOs) are long-term goals for water quality management. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. Water quality objectives are not individual point source emission objectives, but the receiving water quality objectives. They are based on scientific criteria or water quality guidelines but may be modified by other inputs (e.g. social, cultural, economic). Examples of WQOs include:

- total phosphorus concentration less than 20 micrograms per litre (µg/L)
- chlorophyll a concentration less than 1 µg/L
- dissolved oxygen between 95% and 105% saturation
- family richness of macroinvertebrates greater than 12 families
- exotic individuals of fish less than five per cent.

Water type means groupings of waters with similar characteristics. Water types can include fresh waters (lowland, upland, lakes/reservoirs), wetlands and groundwaters.

SECTION 15: REFERENCED SOURCES

15 Referenced sources

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SECTION 16: APPENDICES

16 Appendices

Appendix 1—South West NRM Ltd Projects

The following South West NRM Ltd projects are representative of the management responses to address risks and contribute to the achievement of objectives for water resources.

SWNRM project—Enhancing Primary Production through Control of Total Grazing Pressure (TGP) and improved land management (70% Sustainable Ag., 30% Weeds and Pests)

This project was approved by the Queensland Regional NRM Programs for the period 2013/14—2015/16.

Project Description

Uncontrolled grazing pressure through overstocking and concentration of stock in riparian areas and waterways is causing land condition erosion, sedimentation of rivers, pollution of water resources and degradation of environmental assets. Prevention of feral species incursion, such as wild dogs, that are mitigated through total exclusion fencing on a landscape scale.

The project will:

- Control total grazing pressure across large areas of agricultural land to assist in the ability to conduct rotational grazing and paddock spelling.
- Demonstrate a substantial increase in ground cover condition, perennial grass species, soil stability, and moisture penetration, allowing for improved livestock health through increased pasture availability.
- Reduce predation of livestock to allow graziers to return to sheep grazing if desired.
- Reduce invasive weeds (Parkinsonia, Hudson Pear, Parthenium), which are prevalent in the SW region.
- Develop a holistic approach to environmental conservation and protection, implementing collaborative pest and weed management at a magnitude that reflects significant economies of scale.

Approach

- Engage with land users to establish collaborative area management clusters.
- Construct total grazing pressure control methods using high integrity fencing, water point control and other technology for control of landscape across 2,000,000 hectares of grazing lands.
- Conduct strategic and collaborative feral pest planning and control (trapping, baiting) for eradication of pests across 2,000,000 hectares.
- Conduct strategic and collaborative weed planning and control for eradication of weeds across 2,500,000 hectares.

Caring for our Country—Sustainable Environment: Maintenance of ecosystem services

This sub-project is funded by the Commonwealth government for five years, commencing in July 2013 and finishing in June 2018. Caring for our Country is evolving into the National Landcare Program for 2015 to 2018. The maintenance of ecosystem services and Aboriginal engagement sub-programs under the Sustainable Environment stream will be combined into one sub-program under the National Landcare Program.

Project Description

The sub-project acts to develop, educate and implement cost-effective, strategic actions to conserve and protect the species and ecosystems within the areas of national, state and regional environmental significance in the SW Region. Through engagement with rural landholders, Traditional Owners, industry and government, the project will demonstrate and promote methods for enhancing the condition and resilience of critical drought refugia, threatened ecological communities, and other vulnerable ecosystems within the region's highly variable climate.

The project will:

- Reduce turbidity and silt deposition in critical drought refugia throughout the Warrego, Bulloo and Nebine catchments (The Paroo catchment is managed through the sub-project below) to improve the health and conservation of fauna dependent on water, such as the Murray Cod, Yakka Skink, Koala, and other threatened fauna.
- Manage predation of endangered and threatened ground dwelling and migratory species including the Grey Grasswren (Bulloo catchment), Australian Painted Snipe (Bulloo, Warrego and Nebine catchments), and Yakka Skink (Warrego and Nebine catchments) from feral pests such as pigs, wild dogs, cats, foxes.
- Reduce core infestations of Weeds of National Significance.
- Address feral pest incursions with baiting and trapping regimes on a landscape scale.

Approach

- Demonstration sites/trials
- Collaborative planning
- On-ground activities
- Workshops and field days.

Caring for our Country—Sustainable Environment: Protecting Ramsar site and values

This sub-project is funded by the Commonwealth government for five years, commencing in July 2013 and finishing in June 2018.

Project Description

The sub-project acts to develop, educate and implement cost-effective, strategic actions to protect the Currawinya Lakes Ramsar site (traditionally owned by the Budjiti community) and its matters of national environmental significance. The project strategically targets the Paroo catchment (High Ecological Value Aquatic Ecosystem - HEVAE) as the primary tributary to the iconic Currawinya wetlands.

The project will:

- Reduce turbidity and silt deposition in critical drought and wildlife refugia throughout the Currawinya Lakes Ramsar and the Paroo River (HEVAE) to improve the health and conservation of threatened fauna such as the Painted Snipe, Grey Snake and Freckled Duck, and other threatened fauna.
- Prevent the spread of invasive weeds identified upstream of the Ramsar site such as Parthenium, Parkinsonia, and Rubbervine from encroaching on the native ecological communities within the Currawinya Lakes.
- Prevent degradation of the Ramsar's five freshwater lakes, two saltwater lakes and many temporary small claypan lakes and swamps, as well as riparian areas along the Paroo River from feral pigs.

Approach

- Demonstration sites/trials
- Workshops and field days
- Collaborative planning
- On-ground activities.

Caring for our Country—Sustainable Agriculture: Mulga Graze

This sub-project is funded by the Commonwealth government for five years, commencing in July 2013 and finishing in June 2018.

Project Description

The sub-project 'MULGA graze' is an investment program to facilitate the desired outcomes 2013-2018 for the Caring for our Country - Sustainable Agriculture stream that focuses on the "sustainable production of food" through the investigation of alternative grazing systems to ensure protection and enhancement of perennial native pasture species.

The project will:

- Improve the sustainability and productivity of grazing enterprises from perennial pasture utilisation.
- Improve the ecological services of native perennial pastures endemic to the grazing trial system localities.
- Enhance the native perennial pasture resilience to climate change in an area that experiences wide seasonal fluctuations in environmental conditions.
- Increase the number of farming entities that are adopting sustainable land use practices.
- Increase the community awareness and understanding of Australia's natural resources.

Approach

- On property participatory learning sites established each year.
- Workshops/field days hosted each year to promote best practice sustainable agriculture outcomes.

Caring for our Country—Sustainable Agriculture: Landcare in the Mulga Lands

This sub-project is funded by the Commonwealth government for five years, commencing in July 2013 and finishing in June 2018.

Project Description

The sub-project 'Landcare in the Mulga lands' is an investment program to facilitate the desired outcomes 2013-2018 for the Caring for our Country - Sustainable Agriculture stream that has the primary focus on "A Skilled and capable Land care community" through the investment of NRM services that encompass community skill, knowledge and capacity development for regional land managers and associated NRM partners. The 'Eco schools' program is a component of this sub-project.

Approach

Students will be empowered to be the change a sustainable world needs by engaging them in fun, action-orientated learning. Landcare activities will be undertaken by schools in the South West region to improve biodiversity, reduce waste and create water wise and resilient school grounds in a changing climate. South West NRM Ltd will work with schools to design projects that align with these themes that facilitate the national environmental significance values of South West Queensland.

Caring for our Country—Enhancing capacity of Indigenous communities to conserve and protect natural resources

This sub-project is funded by the Commonwealth government for five years, commencing in July 2013 and finishing in June 2018.

Project Description

The project acts to enhance the capacity of the Indigenous communities of south west Queensland, to conserve and protect natural resources, in particular those species and ecosystems within SWNRM's areas of national, state and regional environmental significance. Through engagement with Traditional Owners, the project will demonstrate and promote methods for enhancing the condition and resilience of critical drought refugia, threatened ecological communities, and other vulnerable ecosystems within the region's highly variable climate, to allow for a return to a traditional landscape.

Approach

The project will identify and promote traditional culture and values that underpin biodiversity conservation, heritage conservation and the sustainable use of natural resources. The project encompasses the Indigenous communities of the Kooma (Guwamu), Bidjara, Kunja, Mardigan, Budjiti, and Kullilli people within the Warrego, Paroo, Bulloo and Nebine catchments. The project specifically focuses on the implementation of aspirational NRM change on the Indigenous Protected Areas and Nature Refuges of Murra Murra and Bendee Downs (49,974 hectares; Kooma (Guwamu) people) and Mount Tabor (70,574 hectares; Bidjara people). Additionally, the project works with other Indigenous communities to strategize and implement opportunities for enhancing culture and opportunity. The project will leverage off and value-add to the experience and success of previous cooperative Indigenous projects; further enhancing the strategic relationships of the organisation with respect to the education and adoption of natural resource management strategies within Indigenous communities.

Appendix 2—Refining water quality targets for fresh water-dependent ecosystems to reflect local conditions

The need to refine water quality targets to reflect local conditions

Under s9.16 and Schedule 11 of the Basin Plan, the water quality target values for fresh water-dependent ecosystems are inappropriate and the target application zones are not relevant to developing local measures (on-ground actions) that address the causes of water quality degradation. The target application zones are not relevant at a spatial scale that recognises the different Queensland Murray-Darling Basin water types, mapped at sub-catchment level (Refer to Figure 15).

The adoption of the same water quality target values for key indicators across 60% of the Queensland Murray-Darling Basin in Schedule 11 of the Basin Plan is inappropriate for the respective water resource plan areas. Most of the water quality target values in Schedule 11 are less stringent than local water quality target values and for key water–dependent ecosystem indicators, such as suspended solids, the water quality target values are unrealistically low. Consequently, the Schedule 11 water quality target values are neither environmentally nor economically appropriate.

For example, the water quality target values for suspended solids are unlikely to have been achievable pre-1770, and are inappropriate targets for the development of measures that address the key causes of degradation for high risk threats. They are inconsistent with s5.02 (1) (d) of the Basin Plan—by failing to optimise social, economic or environmental outcomes in the national (or local community or state) interest.

Under the water quality framework of the ANZECC guidelines and the EPP Water, local water quality targets hold higher precedence over regional, state or national targets. Local water quality targets for fresh water-dependent ecosystems are critical for appropriate economic and environmental management, as the direct application of default regional, state or national water quality targets often do not reflect local water types or water quality characteristics. This results in water quality targets, particularly for physico-chemical indicators, that potentially offer insufficient protection for the local aquatic ecosystem or impose excessive constraints on stakeholders to manage water quality to an inappropriate standard for the local area.

The ANZECC guidelines emphasise the need to tailor water quality targets to local conditions:

“It is not possible to develop a universal set of specific guidelines that apply equally to the very wide range of ecosystem types or production systems, in varying degrees of health, in Australia and New Zealand. Environmental factors can reduce or increase the effects of physical and chemical parameters at a site and these factors can vary considerably across the two countries. A framework is provided that allows the user to move beyond single-number, necessarily conservative values, to guidelines that can be refined according to local environmental conditions — that is, to developing site-specific guidelines. This is a key message of the Water Quality Guidelines….”

“This can produce values more appropriate to a particular water resource. Although tailoring guidelines to local conditions requires more work in some cases, it results in much more realistic management goals. It therefore has the potential to reduce costs for industry.” (ANZECC, 2000; Introduction to the guidelines, 8 - 9)

The ANZECC guidelines refer to four large regions of Australia (Figure A), and derive ‘default’ water quality guidelines for water types in each region. The split between the ‘Tropical’ region and the southern regions is the Tropic of Capricorn.

The Queensland Murray-Darling Basin drainage basins (416-Border Rivers, 417-Moonie, 422 Balonne-Condamine, 423-Warrego and 424-Paroo) and the Bulloo (011) fall within the ANZECC ‘South-east Australia’ region, which includes waters in New South Wales, Victoria and Tasmania.

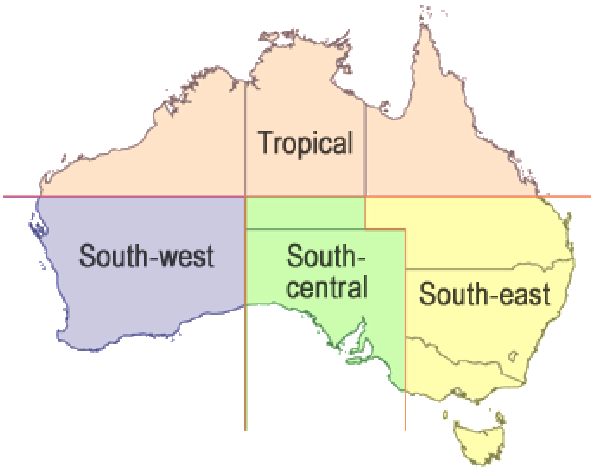


Figure A: ANZECC water type regions

The ANZECC guidelines state:

"The default trigger values in the present guidelines were derived from ecosystem data for unmodified or slightly-modified ecosystems supplied by state agencies. However, the choice of these reference systems was not based on any objective biological criteria. This lack of specificity may have resulted in inclusion of reference systems of varying quality, and further emphasises that the default trigger values should only be used until site- or ecosystem-specific values can be generated."

The water quality targets for fresh-water dependent ecosystems stated in Schedule 11 of the Basin Plan can be considered as 'default' regional trigger values, in the absence of local water quality targets. Refining the regional water quality targets for fresh-water dependent ecosystems stated in Schedule 11 of the Basin Plan based on local water quality data provides the best opportunity to achieve objectives and outcomes for water quality in the SW region. Thus, where the water quality targets for fresh water-dependent ecosystems differ from those specified in the Basin Plan, they will be as effective in achieving consistency with the objectives described in the table below.

Table A: Justification for why alternative water quality targets for freshwater dependent ecosystems are consistent with water quality objectives

Objective	Objective description	Justification for alternative water quality targets
The objective and outcome in relation to water quality and salinity	The objective in relation to water quality and salinity is to maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the SW region.	Local water quality targets for fresh water-dependent ecosystems provide the best opportunity to maintain appropriate water quality for the SW region. Local data reflects current water quality at reference sites across the SW region.
	The outcome in relation to water quality and salinity is that SW region water resources remain fit for purpose.	Tailoring guidelines to local conditions results in much more realistic management goals (ANZECC, 2000; Introduction to the guidelines, 8—9).
The objective for water-dependent ecosystems that are Declared Ramsar wetlands.	The water quality objective for declared Ramsar wetlands is that the quality of water is sufficient to maintain the ecological character of those wetlands.	The Ecological Character Description for Currawinya Lakes Ramsar site is under development by the Queensland Government. In order to prevent water quality degradation at the Currawinya Lakes Ramsar site, alternative water quality target values were developed based on local data that reflects the diverse range of aquatic environments within the site. This includes alternative water quality targets for both

		saline and fresh water lakes, based on best available data. The accreditation of the water quality range determined through local data analysis (20th, 50th and 80th percentiles) seeks to ensure no deterioration of existing water quality to protect the Currawinya Lakes Ramsar site.
The objective for water-dependent ecosystems other than declared Ramsar wetlands.	The water quality objective is that the quality of water is sufficient: • to protect and restore the ecosystems, and • to protect and restore the ecosystem functions of the ecosystems, and • to ensure that the ecosystems are resilient to climate change and other risks and threats	Refining water quality targets for fresh water-dependent ecosystems by incorporating local data provides the best opportunity to protect and restore ecosystems in the SW region and ensure they are resilient to the risks identified in the risk assessment (Refer to Section 8). Under the ANZECC guidelines and the EPP Water, local water quality targets hold higher precedence over regional, state or national targets.

Procedure

Local water quality targets for fresh water-dependent ecosystems (surface water) were derived based on the procedure outlined for 'Physical and chemical stressors' in section 3.3 of the ANZECC guidelines. The purpose of establishing local water quality targets from this section of the ANZECC guidelines is to ensure that the slightly to moderately disturbed ecosystems of the SW region are adequately protected (Refer to Section 6).

The procedure for determining groundwater quality target values is described in McNeil et al. (2015).

Data sources

Best available data was sourced from a variety of databases for the development of water quality target values, as described below.

Surface water

Section 3.3 of the ANZECC Guidelines describes the sources of information for use when deriving water quality targets for physical and chemical stressors:

1. Biological and ecological effects data
2. Reference system data
3. Predictive modelling
4. Professional judgement.

The following local data and information sources were used to refine the water quality targets for fresh water-dependent ecosystems stated in Schedule 11 of the Basin Plan:

- Department of Natural Resources and Mines water quality and quantity monitoring data (Hydstra project database)
- Surat and Galilee Basin Baseline Monitoring—December 2012-June 2013
- South West NRM monitoring (trailer) data
- Border Rivers Commission Intersecting Streams data
- Bureau of Rural Science monitoring data for the SW region
- Sustainable Rivers Audit monitoring data from the Murray-Darling Basin Authority
- Published journal articles and data.

The refined water quality targets were prepared in conjunction with professional advice from the Water Quality Technical Panel. Data from approximately 850 water quality sampling occasions, conducted in the plan area between 1964 and 2014, was used in the analysis.

In the absence of local data for indicators, the regional targets specified in Schedule 11 of the Basin Plan apply.

Groundwater

Data was sourced from the Groundwater Database managed by the Queensland Department of Natural Resources and Mines. In the Queensland Murray-Darling Basin, there are more than 7,700 sub-artesian and 4,200 artesian water quality samples, supplemented by over 2,500 groundwater level measurements from around 6600 bores, mostly since the mid-1960s. The numbers of bores with water quality samples that were analysed to derive the groundwater quality targets for the plan area were as follows: Warrego 602 (240 artesian); Paroo 298 (245 artesian); Bulloo 239 (55 artesian); Nebine 202 (171 artesian) (McNeil et al., 2015).

Site selection

Refer to Figure B for the surface water sites with available data that was analysed to derive alternative water quality targets for fresh water-dependent ecosystems in the Warrego, Paroo, Bulloo and Nebine plan area.

Refer to Figure C for the groundwater bores with available chemistry data that was analysed to develop groundwater quality targets for the Warrego, Paroo, Bulloo and Nebine plan area.

Data quality

Nutrient samples taken before 1995 were excluded from analyses due to inconsistencies with current sampling and laboratory procedures. Extreme or questionable data was inspected in finer detail, e.g. comparing the sampling dates with meteorological data, comparison with other variables, potential typographical errors, data reported in different units. Obvious errors were excluded, unless the data could be rationalized (e.g. EC recorded in mS/cm instead of μS/cm).

Consultation

Draft water quality target values were developed in consultation with the local government, natural resource management groups, industry groups, the Northern Basin Aboriginal Nations, the New South Wales Government and the community, based on participation at meetings held between 2011 and 2015.

Further information

The EHP fact sheet that outlines the framework for the derivation of local water quality guidelines under the EPP Water is published at <www.ehp.qld.gov.au>.

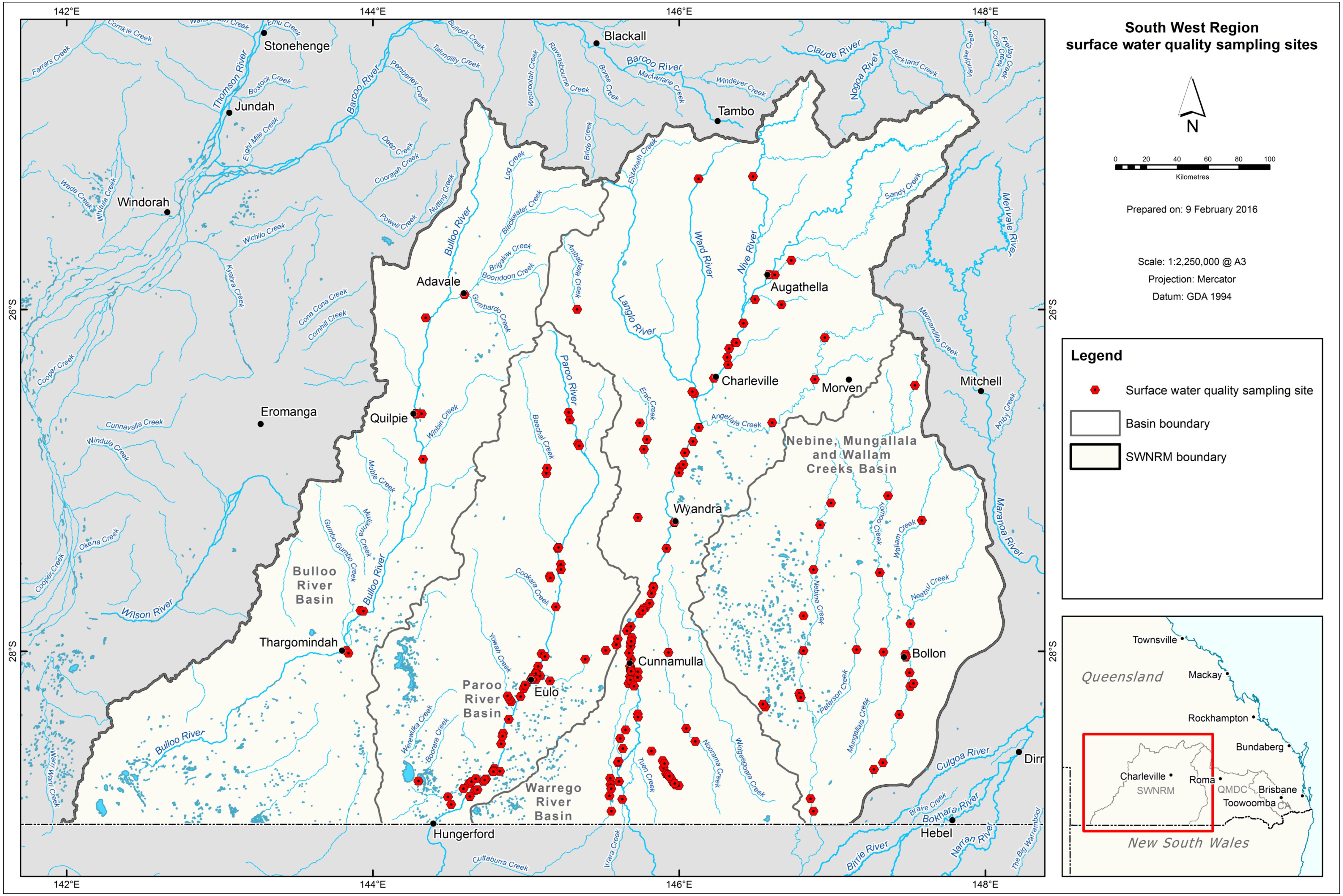


Figure B: Surface water sample sites in the Warrego, Paroo, Bulloo and Nebine plan area.

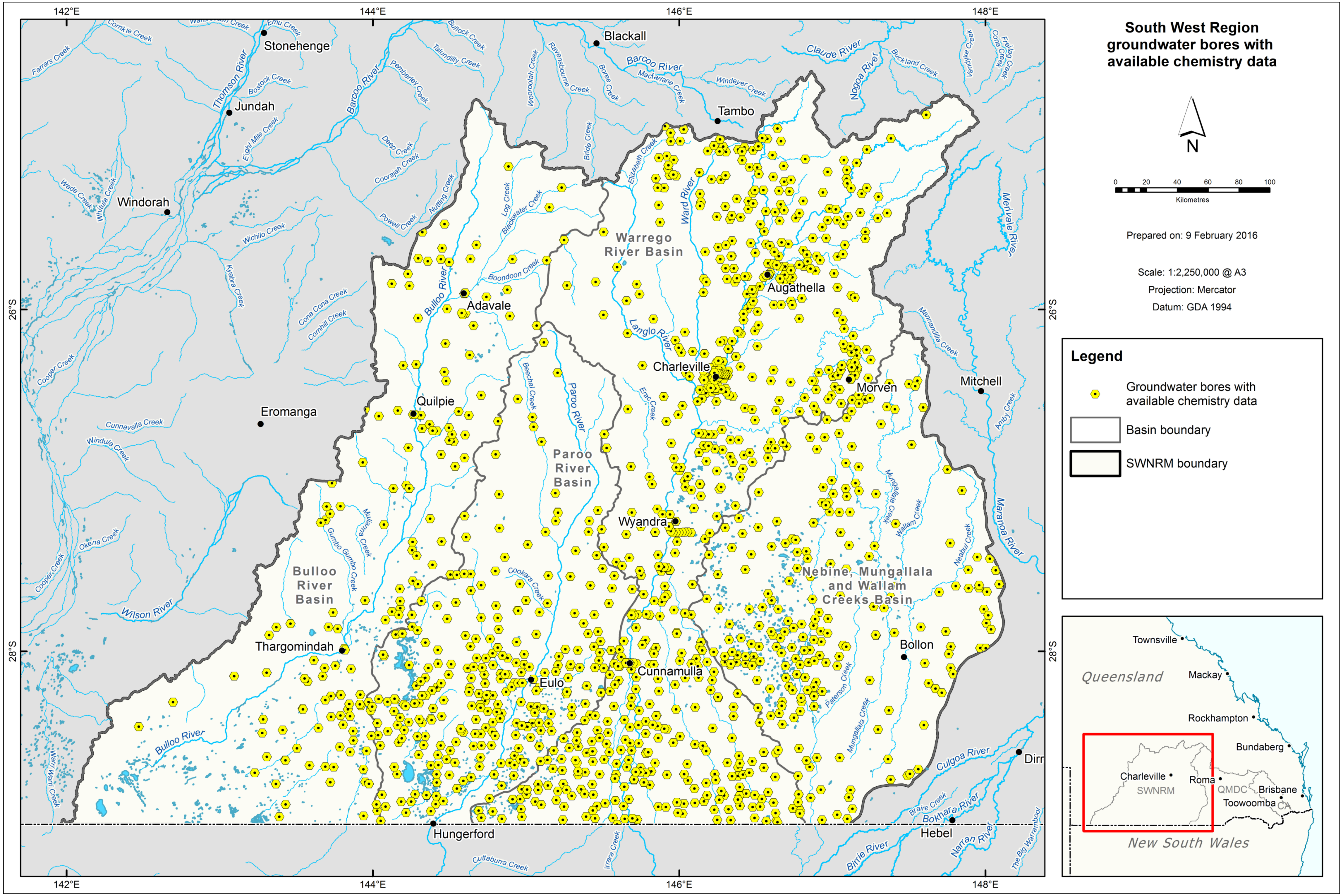


Figure C: Groundwater bores with available chemistry data in the Warrego, Paroo, Bulloo and Nebine plan area.

Appendix 3—Description of water types in the Warrego, Paroo, Bulloo and Nebine basins

The Queensland Water Quality Guidelines 2009 states that the aim of defining water types is to create groupings within which water quality (or biological condition) is sufficiently consistent that a single guideline value can be applied to all waters within each group or water type. Water types are developed through expert opinion of soil type, geology, topography and rainfall. The water types were considered to best represent ecologically relevant spatial areas for key water quality parameters.

The common soil types in the Warrego, Paroo, Bulloo and Nebine basins are as follows (Queensland Government, 2013):

1. Dermosol: Red, brown, yellow, grey or black soils which have loam to clay textures. The potential for erosion is dependent upon the level of slope and groundcover.
2. Vertosol: Brown, grey or black soils which crack open when dry. This soil type has very high fertility and a large water-holding capacity, although is prone to sheet erosion if groundcover is not maintained.
3. Kandosol: Red, yellow and grey soils which have low fertility and poor water-holding capacity. Kandosols are the most common soil type across the Warrego, Paroo, Bulloo and Nebine basins. This soil type produces significant runoff under low vegetation cover and is highly erodible. Red Kandosols are dominant throughout the region and are associated with extensive areas of hard (stony) and soft (sandy/loamy) Mulga lands.
4. Sodosol: Texture-contrast soils which are low in nutrients and very vulnerable to erosion (gully and tunnel) and dryland salinity when vegetation is removed.
5. Kurosol: Texture-contrast soils which are strongly acidic and prone to erosion if vegetation is removed.
6. Tenosols and Rudosols: Poorly developed, shallow, stony soils which generally have low fertility and low water-holding capacity (highly erodible).

The following descriptions of water types in the Warrego, Paroo, Bulloo and Nebine basins were informed by Waters (2008) and expert opinion from the Water Quality Technical Panel.

Water Type	Landscape Description
Ambathala Creek	The Ambathala Creek water type was established as it is a closed drainage system which terminates at Lake Dartmouth. This water type is comprised of hard and soft Mulga lands, dissected residuals[46] and desert Eucalypt woodlands. The dominant soil types are texture-contrast soils (Sodosols) and loamy soils (Kandosols), with some clay soils (Vertosols) present. The topography of this water type is similar to the Ward and Langlo Rivers water type.
Carnarvon Sandstones	This water type is dominated by quartzose sandstone. Some finegrain sandstone and basalt plains are also present. The Carnarvon Sandstones water type is comprised of sandy, stony soils (Tenosols and Rudosols), as well as texture-contrast soils (Sodosols). This water type is located in the highest rainfall zone across the Warrego, Paroo, Bulloo and Nebine basins, receiving over 600 mm per year average annual rainfall. The terrain is relatively steep in comparison to other regions of the Warrego, Paroo, Bulloo and Nebine basins.
Lower Bulloo River	The Lower Bulloo River water type consists of the alluvial floodplain featuring closed depressions and claypans. The landscape is predominately comprised of clay soil (Vertosols) and sandy, stony soil (Tenosols and Rudosols). This water type has the driest conditions, receiving an average annual rainfall less than 300mm per year.

[46] Rocky outcrops produced through erosion and weathering.

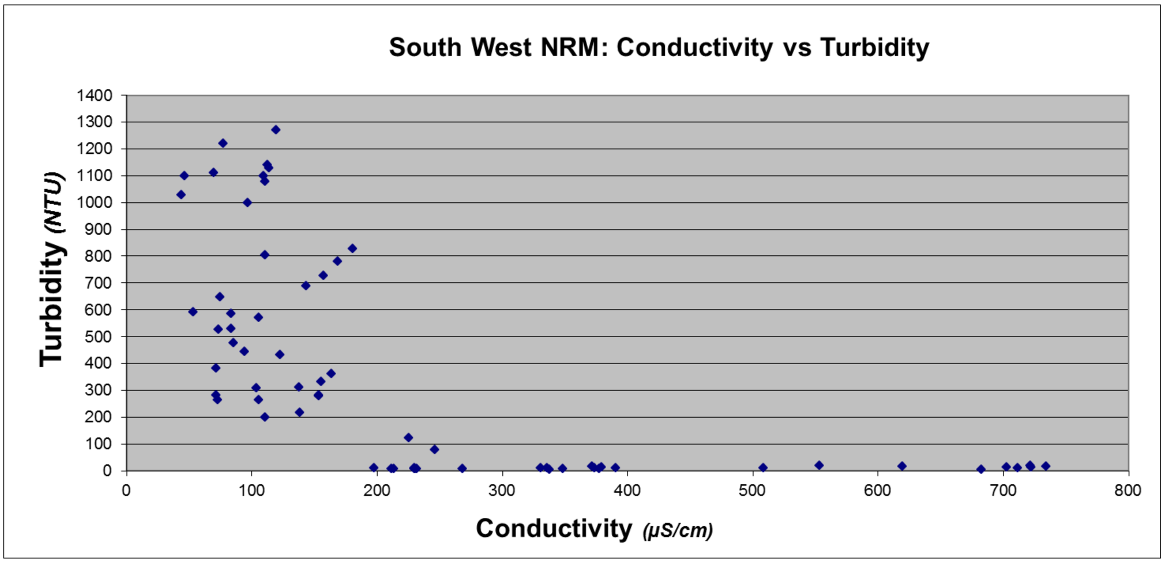
Lower Mungallala/Wallam Creeks	This water type reflects the lowland zone of the Mungallala/Wallam Creeks catchments. The water type is predominately an alluvial, flat landscape, containing natural sinks. As such, clay soils (Vertosols) are the dominant soil type, with pockets of sandy, stony soil (Tenosols), texture-contrast soils (Sodosols) and loamy soils (Kandosols) also present. Average annual rainfall is between 400-500 mm per year.
Lower Nebine Creek	This water type reflects the lowland zone of the Nebine Creek catchment. The water type is predominately an alluvial, flat landscape, containing natural sinks and claypans. As such, clay soils (Vertosols) are the dominant soil type, with pockets of sandy, stony soil (Tenosols), texture-contrast soils (Sodosols) and loamy soils (Kandosols) also present. Average annual rainfall is predominately between 400-500 mm per year.
Lower Paroo River	This water type reflects the Paroo River basin alluvial floodplain. Average annual rainfall in this water type is 300-400 mm per year. In large flood events, the Warrego River can flow into this water type via a breakout north of Cunnamulla. The landscape of this water type is comprised of alluvial woodlands, channel country, mulga and spinifex sandplains.
Lower Warrego River	This water type reflects the Warrego River basin alluvial floodplain. Average annual rainfall in this water type is 300-400 mm/year. Clay soils (Vertosols) and sandy, stony soils (Tenosol) are the dominant soil types. The landscape of this water type is comprised of alluvial woodlands, channel country, mulga and spinifex sandplains. This water type includes the Warrego River Distributary System, which fans out north and south of Cunnamulla.
Middle Warrego River	This water type was generated to separate the upland zone from the Lower Warrego River alluvial floodplain. The landscape is a mix of weathered sediments and alluvia. The dominant soils types within this water type are clay soils (Vertosols), sandy, stony soils (Tenosols) and loamy soils (Kandosols). Texture-contrast soils (Sodosols) on fine grain sandstone are also present in the area surrounding Morven.
Paroo Salt Lakes	This water type represents the saline lakes and claypans located in the Lower Paroo alluvial floodplain, including Lake Wyara, Lake Wombah and Lake Thorlindah.
Upper Bulloo River	This water type reflects the upland zone of the Bulloo River basin and the extent of the hard and soft mulga, dissected residuals and desert eucalypt woodlands across the landscape. Within the water type, average annual rainfall ranges from 200-500 mm/year, with the heavier rainfall located north of Adavale. Despite receiving less rainfall than the Warrego River basin, the Bulloo River basin has a higher average annual runoff. This is due to comparatively low levels of groundcover and shallower, less permeable soils.
Upper Mungallala/Wallam Creeks	This water type reflects the upland zone of the Mungallala/Wallam Creeks catchments. The water type is predominately comprised of weathered sediments, containing hard and soft Mulga, dissected residuals and desert eucalypt woodlands. Kandosols are the dominant soil type. Natural sinks are present in the landscape, but are more prevalent in the Lower Mungallala/Wallam Creeks water type.
Upper Nebine Creek	This water type reflects the upland zone of the Nebine Creek catchment. The water type is predominately comprised of weathered sediments, containing hard and soft Mulga, dissected residuals and desert eucalypt woodlands. Kandosols are the dominant soil type. Claypans are present in the landscape, as well as rocky hillslopes in the far north of this water type.

Upper Paroo River	This water type reflects the upland zone of the Paroo River basin and the extent of the hard and soft mulga, dissected residuals and desert eucalypt woodlands across the landscape. Average annual rainfall is predominately 300-400 mm per year. Despite receiving less rainfall than the Warrego River basin, the Paroo River basin has a higher average annual runoff. This is due to comparatively lower levels of groundcover and shallower, less permeable soils. The southern extent of this water type contains a ridge of mulga lands that, under baseflow conditions, separates the Paroo River floodplain from the Warrego River floodplain.
Upper Warrego River	This water type reflects the dominant soil types of the landscape—clay soils (Vertosols) and texture-contrast soils (Sodosols). This water type has the second highest average annual rainfall in the Warrego, Paroo, Bulloo and Nebine basins (generally 500-600mm per year). Despite receiving higher rainfall than the Paroo and Bulloo River basins, average annual runoff is much lower. This is due to the permeable sandstone areas above Augathella generating little runoff. The Upper Warrego water type has a varied mix of landscapes. Undulating downs, gidgee downs and wooded downs are present in the area surrounding Augathella. Brigalow uplands occur towards the border of the Carnavon Sandstones water type. The remaining landscape consists of basalts, hard and soft Mulga, dissected residuals and desert eucalypt woodlands.
Ward and Langlo Rivers	The Ward and Langlo Rivers water type reflects a higher presence of Kandosols in comparison to the neighbouring Upper Warrego River water type. As a result, the Ward and Langlo Rivers water type is likely to have increased potential for runoff and erosion in comparison to the north eastern upland zones of the Warrego River basin. This water type contains the largest area of undulating downs, gidgee downs and wooded downs in the Warrego, Paroo, Bulloo and Nebine basins. The eastern side of the water type consists of a sandplain dominated by mulga vegetation.

Appendix 4—Electrical conductivity and turbidity relationship in the Warrego, Paroo, Bulloo and Nebine basins

During the first six months of 2013, water quality was monitored by South West NRM Ltd at 9 sites in the Warrego, Bulloo, Paroo and Nebine river systems. Each site was sampled 8 times. The conductivity and turbidity data from this program showed a very clear relationship. This is illustrated in the graph below.

Essentially, the graph shows that at conductivity levels below 200µS/cm, turbidity levels are variable but always high; ranging from 200 to 1300NTU. At conductivities above 200µS/cm, there is an abrupt change, with turbidity levels nearly always well below 50NTU and usually <30NTU. It is surmised that the abrupt decrease in turbidity above 200µS/cm is related to the flocculation effect that the increased concentrations of charged ions have on the fine particulates that are the main cause of turbidity. The precise mechanism is not known at this stage but the relationship is strong enough to justify its application in defining turbidity guideline values. It is worth noting that an almost identical relationship was found in data from streams in the Galilee Basin area.



Appendix 5—Warrego, Paroo, Bulloo and Nebine Water Quality Risk Assessment Methodology

Aim

This document aims to ensure that the risk assessment undertaken for the Healthy Waters Management Plans (HWMPs) for the Queensland Murray-Darling Basin Water Resource Plan (WRP) areas meets the requirements of the Murray-Darling Basin Plan (Basin Plan). The Healthy Waters Management Plans intend to fulfil the requirement for a Water Quality Management Plan (WQM Plan) under section 10.29 of the Basin Plan.

This document outlines the methodology to identify, evaluate and treat water quality risks to the current and future condition and continued availability of the water resources of Queensland Murray-Darling Basin WRP areas.

Background

Water quality for Queensland waters is managed under the Environmental Protection Act 1994 and the Environmental Protection (Water) Policy 2009. This legislation provides the framework for establishing Environmental Values, Water Quality Objectives and HWMPs for Queensland waters. This process is currently being undertaken across the Queensland Murray-Darling Basin WRP areas. It is being conducted by the Department of Environment and Heritage Protection (EHP), in partnership with the three Natural Resource Management groups of this region—Condamine Alliance, Queensland Murray-Darling Committee and South West NRM Ltd.

Under section 10.29 of the Basin Plan, a water resource plan is to include a Water Quality Management Plan. The Queensland Government established that the HWMPs developed under the Environmental Protection (Water) Policy 2009 will be aligned with the requirements of the Basin Plan to create a single process.

Chapter 10, Part 9 of the Basin Plan describes the approaches to addressing risks to water resources to be included in a water resource plan. In accordance with section 10.41(7) of the Basin Plan, the water resource plan must describe the data and methods used to identify and assess risks.

Chapter 4 of the Basin Plan identifies high level risks to the condition, or continued availability, of Basin water resources and strategies to manage, or address, those risks. Section 4.02 of the Basin Plan identifies the following three risks to the condition, or continued availability, of Basin water resources—

- insufficient water available for the environment;
- water being of a quality unsuitable for use; and
- poor health of water-dependent ecosystems.

Three separate risk assessments will be completed to address these risks. The focus of the risk assessment for HWMPs will be on risks to the condition, or continued availability, of Basin water resources arising from water being of a quality unsuitable for use. For the purpose of the risk assessment for HWMPs, 'use' is taken to mean all the Environmental Values applicable in the area. Thus, the risk assessment will assess the risks to the condition, or continued availability, of Basin water resources arising from water being of a quality unsuitable to protect the identified Environmental Values in the plan area. Environmental Values represent economic, social, cultural and environmental interests.

The remaining two risk assessments have been completed by the Department of Natural Resources and Mines (DNRM), and the Department of Science, Information Technology, Innovation and the Arts (DSITIA). All three risk assessments will use a similar approach and align with the requirements of the Basin Plan.

While Chapter 4 of the Basin Plan identifies key risks and strategies to address these risks, Chapter 10, Part 9 of the Basin Plan is where the 'rubber hits the road' for the states. It details the requirements for addressing risks that Basin States must follow when preparing water resource plans.

Key requirements and considerations under Chapter 10, Part 9 are—

1. A water resource plan must be prepared having regard to current and future risks to the condition and continued availability of the water resources of the water resource plan area (Section 10.41(1)).
2. Section 10.41(2) explains that the risks are to include (where applicable):
   a. risks to the capacity to meet environmental watering requirements (Risk assessment conducted by DNRM)
   b. risks arising from the matters referred to in subsection 10.20(1), that is, a water resource plan must be prepared having regard to whether it is necessary for it to include rules which ensure that:
      i. there is no structural damage to an aquifer (whether within or outside the water resource plan area) arising from take within the long-term annual diversion limit for a Sustainable Diversion Limit (SDL)

resource unit, and
   ii. hydraulic relationships and properties between groundwater and surface water systems, between groundwater systems, and within groundwater systems are maintained (Risk assessment conducted by DNRM).
   c. risks arising from potential interception activities (Risk assessment conducted by DNRM)
   d. risks arising from elevated levels of salinity or other types of water quality degradation (Risk assessment conducted by EHP).
3. The water resource plan must list and assess each identified risk (Sections 10.41(4) and (5)).
4. Risks must be identified at least as low, medium or high (Section 10.41(6)).
5. The water resource plan must describe any quantified uncertainties in the level of risk attributed to each risk (Section 10.41(8)).
6. In accordance with Sections 10.42 and 10.43 of the Basin Plan, if a water resource plan defines a risk as having a medium or higher level of risk, it must describe the risk (including associated risk factors) and either the management strategy that will address the risk or explain why the risk cannot be addressed by the water resource plan. If the water resource plan identifies a risk which relates to a matter dealt with by a requirement in another Part of Chapter 10, the strategy must take account of that requirement. The strategies should be prepared having regard to subsection 4.03 (3) and any guidelines published by the Authority in accordance with section 4.04.

This risk assessment will form a component of the accreditation packages for Queensland Murray-Darling Basin WRP areas.

Approach

The risk assessment for water quality will be conducted in line with the approach used by the Department of Natural Resources and Mines (DNRM) to conduct the risk assessment for water quantity. The approach is based on the DNRM policy titled 'DERM Risk Management Policy and Procedure Review: June 2012 Version: 2.0' (DNRM risk management policy). This policy is consistent with the AS/NZS ISO 31000:2009 Risk Management—Principles and Guidelines. It is also consistent with the National Water Initiative Policy Guidelines for Water Planning and Management—Risk Assessment Module developed by the Department of Sustainability, Environment, Water, Population and Communities.

The risk management process follows 6 steps in a cycle—

1. Communicate and consult (i.e. Internal and external stakeholder perspectives are considered at each stage to obtain or provide relevant risk information)
2. Establish the context (the environment and its boundaries that should be applied when considering risks)
3. Identify risks (describing risks in terms of what can happen and the impact that can result)
4. Analyse risks (rate each risk in terms of consequences and likelihood to establish the level of risk, taking into account existing processes to control risks)
5. Evaluate and treat risks (determine which risks require treatment or whether the risk can be tolerated without treatment, then identify the options to treat intolerable risks and implement the most appropriate treatment/s that can be undertaken to reduce the risk level)
6. Monitor and review (periodic reporting and review of risks, their level and progress on treatments).

Step 1: Communicate and consult

The following process was designed to ensure appropriate communication and consultation with internal and external stakeholders—

- Preliminary desktop assessment of known risks.
- Develop risk assessment methodology to meet the requirements of the Basin Plan.
- Conduct a workshop to further identify and analyse risks featuring a panel of experts (internal and external) with knowledge of the local area.
- Present outcomes of risk assessment process to workshop participants for feedback.
- Obtain external feedback on the risk assessment through the formal consultation process for the HWMP.

Step 2: Establish the context

For each Queensland Murray-Darling Basin WRP area, the assessment of surface water quality risks will be based on the water types developed through the development of local water quality targets. The Queensland Water Quality Guidelines 2009 states that the aim of defining water types is to create groupings within which water quality (or biological condition) is sufficiently consistent that a single guideline value can be applied to all waters within each group or water type. Water types are developed through expert opinion of geology and supported by water quality data. The assessment of groundwater quality risks will be based on the Groundwater and Deep Groundwater SDL resource units published by the Murray-Darling Basin Authority.

Step 3: Identify risks

This step describes risks in terms of what can happen and the impact that can result.

Risks are to be identified based on the 10-year life span of a water resource plan as defined by the Water Act 2000 and the Basin Plan.

Section 10.41(3) of the Basin Plan states that when identifying risks, regard must be given to the risks identified in section 4.02, that is—

- insufficient water available for the environment;
- water being of a quality unsuitable for use; and
- poor health of water-dependent ecosystems.

As previously stated, the risk assessment for the HWMPs will focus on the second dot-point only—water being of a quality unsuitable for use. For the purpose of the HWMP risk assessment, 'use' is taken to mean all the Environmental Values applicable in the area. Thus, the risk assessment will assess the risks to the condition, or continued availability, of Basin water resources arising from water being of a quality unsuitable to protect the identified Environmental Values in the plan area.

Under section 10.41(2), the risks are to include (where applicable) risks arising from elevated levels of salinity or other types of water quality degradation.

Step 4: Analyse risks

Each risk must be must be rated in terms of consequences and likelihood to establish the risk level (AS/NZS ISO 31000:2009 Risk Management - Principles and Guidelines).

The Basin Plan does not specify detailed requirements for the risk assessment, such as a preferred risk analysis matrix. However, section 10.41(6) states that the level of risk, must be defined using the following categories—

- low
- medium
- high
- if it is considered appropriate, any additional category.

Section 10.42 of the Basin Plan specifies that a water resource plan must describe each risk identified as having a medium or higher risk and the factors that contribute to the risk.

Section 4.04 of the Basin Plan states that the Authority may publish guidelines setting out specific actions that may be taken in relation to the implementation of the strategies listed in subsection 4.03(3) to deal with the risks identified in section 4.02. These guidelines may include a specific risk assessment tool such as a risk analysis matrix; however, no such guidelines are currently available from the Authority. In the absence of specified guidelines, the existing risk analysis tools implemented through DNRM policy for water and aquatic ecosystems were utilised. This ensures consistency between the risk assessment approaches undertaken by both DNRM and EHP for the purpose of the Basin Plan accreditation package.

Defining consequence

The method for defining consequences of a risk is to adopt an approach similar to that used in the risk assessments conducted by DNRM. Each consequence is categorised into ecological, economic and social/cultural impacts. Environmental Values were grouped under each of these headings, as shown below:

Ecological:	Aquatic ecosystems
Economic:	Irrigation, stock watering, aquaculture, farm use/supply, industry, human consumption and drinking water
Social/cultural:	Cultural, ceremonial and spiritual values, primary recreation, secondary recreation and visual amenity.

Important: For a risk to be assigned a given consequence it should reflect the situations described for each of the respective categories. However, as per step 4.2 of the DNRM risk management policy, where more than one impact category is relevant, select the one with the highest consequences to arrive at one

consequence level for the particular risk.

Refer to Table 1 for a description of each consequence and its associated impacts.

TABLE 1: DEFINING CONSEQUENCES

Consequence	Ecological Impacts	Economic Impacts	Social and Cultural Impacts	Score
Insignificant	No impact to aquatic ecosystem Environmental Value. Undetectable change from current water quality.	No financial losses to economic Environmental Values.	No impact on cultural, ceremonial and spiritual values, recreational values and/or visual amenity.	1
Minor	Minimal impact to the aquatic ecosystem Environmental Value. Deterioration of current water quality is detectable, albeit minimal, and may result in non-compliance with aquatic ecosystem local water quality targets	Financial loss may occur for at least one economic Environmental Value and require reprioritisation and/or restructuring of business.	Minor impact on cultural, ceremonial and spiritual values, recreational values and/or visual amenity. Impacts are noticeable; however site access or use is not unduly affected.	2
Moderate	Some impact to the aquatic ecosystem Environmental Value. Deterioration of current water quality results in non-compliance with some aquatic ecosystem local water quality targets. The aquatic ecosystem is able to recover in the short-term.	Financial loss to the individual for an economic Environmental Value, resulting in minimal community level impact.	Some impacts to cultural, ceremonial and spiritual values, recreational values and/or visual amenity. Vital community resources are affected in the short-term.	3
Major	Major impact to the aquatic ecosystem Environmental Value. Deterioration of current water quality results in significant non-compliance with aquatic ecosystem local water quality targets. The aquatic ecosystem is able to recover in the medium-term.	Major financial loss for at least one economic Environmental Value, resulting in severe individual and some community level impact.	Major disturbances to cultural, ceremonial and spiritual values, recreational values and/or visual amenity. Access to resource denied, or vital community resource unavailable, in the medium to long-term.	4
Catastrophic	Disastrous impact to the aquatic ecosystem Environmental Value. Deterioration of current water quality results in no ability to maintain aquatic ecosystem local water quality targets. The aquatic ecosystem may recover in the long term or impacts may be permanent.	Disastrous long-term financial loss for at least one economic Environmental Value, resulting in severe individual and community level impact.	Disastrous impacts to cultural, ceremonial and spiritual values, recreational values and/or visual amenity. Site access or vital community resource permanently removed.	5

Defining likelihood

The likelihood (chance of something happening) table is based on DNRM policy and is consistent with risk assessments conducted by both DNRM and the Queensland Stream and Estuary Assessment Program. Table 2 identifies the likelihood categories and their definitions.

TABLE 2: LIKELIHOOD TABLE

Likelihood categories	Definition	Score
Rare	Impact may occur only in exceptional circumstances	1
Unlikely	Impact could occur at some time but it is improbable	2
Possible	Identified factors indicate the impact might occur at some time	3
Likely	Impact will probably occur in many circumstances	4
Almost certain	Impact is expected to occur in most circumstances	5

Level of risk

The level of risk is determined using the definitions identified in the consequence and likelihood tables and the matrix shown in Table 3. The AS/NZS ISO 31000:2009 Risk Management - Principles and Guidelines states the following:

- consequences may be expressed qualitatively or quantitatively,
- the risk can escalate though knock-on effects
- likelihood can be defined, measured or determined objectively or subjectively, qualitatively or quantitatively and described using general terms or mathematically.

TABLE 3: CONSEQUENCE AND LIKELIHOOD SCORING

	Consequence				
Likelihood	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Almost certain (5)	Low (5)	Medium (10)	High (15)	Very high (20)	Very high (25)
Likely (4)	Low (4)	Medium (8)	High (12)	High (16)	Very high (20)
Possible (3)	Low (3)	Low (6)	Medium (9)	High (12)	High (15)
Unlikely (2)	Low (2)	Low (4)	Low (6)	Medium (8)	Medium (10)
Rare (1)	Low (1)	Low (2)	Low (3)	Low (4)	Low (5)

Based on table 3, the level of risk is categorised into low, medium, high or very high as per the scoring in table 4.

TABLE 4: LEVEL OF RISK

Level of risk	Criteria
Low	Score of 1 to 6
Medium	Score of 8 to 10
High	Score of 12 to 16
Very high	Score of 20 to 25

As per section 10.43 of the Basin Plan, any risk identified as medium or above must be addressed by management strategies within a water resource plan. The exception to this is if it can be explained why the risk cannot be addressed by the water resource plan in a manner commensurate with the level of risk. It is important therefore to clearly explain why a risk would be considered low and therefore tolerable without need for mitigation measures. The following is an explanation of the reasoning behind the 'low' level of risk identified in Table 4.

- Any risk that has a consequence of insignificant is considered a low risk because the consequences of the event occurring, irrespective of the likelihood of occurrence, would have undetectable impacts (refer to Table 1).
- A risk that has a consequence of minor and a likelihood of possible or less is considered a low risk because even if the event were to occur the consequences of the event are minimal and are recoverable in the short-term. This reasoning also applies to a risk that has a consequence of moderate but a likelihood of unlikely.
- A risk that has a likelihood of rare is ranked as low because it is only likely to occur in exceptional circumstances. The water resource plan will include measures to manage extreme events, as required under section 10.51 of the Basin Plan.

Confidence rating for level of risk

In accordance with section 10.41(8) of the Basin Plan, the risk assessment must describe any quantified uncertainty in the level of risk attributed to each risk. To do so, a confidence score for each risk was implemented as per the following tables (Based on the approach used by the Queensland Department of Science, Information Technology and Innovation for the Q-Catchments program).

Confidence scoring will be applied to both the likelihood and consequence ranking.

TABLE 5: CONFIDENCE SCORES

Confidence	Score
High	3
Medium	2
Low	1

TABLE 6: DEFINITION OF CONFIDENCE SCORES

Confidence categories	Definition
High	Strong confidence in the score—able to substantiate with documented and anecdotal evidence to support the scores applicability across the reporting area.
Medium	Reasonable confidence in the score—knowledge may not cover the entire reporting area. The information and other evidence to support this may be incomplete in part.
Low	Little confidence in the score—a lack of scientific information and other evidence and/or little expertise on the area of concern.

Step 5: Evaluate and treat risks

This step determines which risks require treatment or whether the risk can be tolerated without treatment. Options are identified to treat intolerable risks and ensure the most appropriate treatment/s for reducing the level of risk is implemented.

Section 10.43 of the Basin Plan states that if the level of risk is medium or higher, the water resource plan must either—

- describe a strategy for the management of the water resources of the water resource plan area that will address the risk, in a manner commensurate with the level of risk; or
- explain why the risk cannot be addressed by the water resource plan in a manner commensurate with the level of risk.

For the purposes of the accreditation package, the index will direct the reader to the various instruments that make up the water resource plan as defined under section 10.04 of the Basin Plan. The instruments will include measures to address risks.

Step 6: Monitor and review

Section 10.46 of the Basin Plan states that a water resource plan must specify the monitoring of the water resources of the water resource plan area that will be done to enable the Basin State to fulfil its reporting obligations under section 13.14. There will also be the opportunity for a formal review of water resource plans, including the Water Quality Management Plans, at five (5) and 10 year intervals under the Basin Plan.

Appendix 5, Attachment 1 — Water Quality Risk Assessment Workshop Comments and Analysis

Nebine drainage basin surface water risk register						
Risk factor/source	Risk analysis			Confidence score		
	L	C	Level of Risk	L	C	Justification
Elevated levels of salinity	1	4	4	3	2	**Likelihood** The expert panel indicated that ambient saline groundwater and surface water discharges into surface water systems would not present a water quality degradation issue over the next ten years. Biggs et al., 2010 contains a map of closed depressions and flow constrictions in the Nebine/Mungallala/Wallam region, which are a major contributing factor in the development of primary salinity and can be further exacerbated by poor land management. However, the expert panel indicated that existing land uses are not expected to change dramatically in the life of the plan and produce salinity impacts. This region has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth of water use in this region. In terms of increased deep drainage below irrigated agricultural land displacing saline groundwater to surface water systems—livestock grazing is the dominant land use in the Nebine/Mungallala/Wallam region (approximately 97% of land area). There are negligible levels of cropping or other practices that would cause elevated salinity in this catchment (DSITIA, 2012). Land management practices involving the replacement of deep-rooted vegetation with shallow-rooted crops and pastures, resulting in increased rainfall recharge displacing saline groundwater to surface water systems –Biggs et al., 2010 stated that due to clearing in the Nebine-Mungallala in the last decade, it will be many decades before any secondary salinity expression is visible in these areas. The Water Quality Technical Panel indicated application of high risk water is occurring between St George and Bollon. However, the extent of the land where the high risk water is being applied is very limited in comparison to the size of the catchment and was therefore considered a low risk to the degradation of water resources in the drainage basin. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to

						prevent salinity impacts. Climate change presents the risk of causing an increase in bare ground due to extreme events. This in turn can lead to elevated levels of salinity. However, the expert panel indicated that the likelihood of an extreme event producing the extent of bare ground required to produce a consequence was very rare. Under the best estimate (median) 2030 climate scenario for the Condamine-Balonne (incorporating Nebine/Mungallala/Wallam), there is predicted to be a 9% reduction in mean annual runoff (CSIRO, 2008). It is assumed this would not be of an extreme to produce excessive bare ground. Note: If the water allocation and planning policy were to change in this region it would affect the likelihood score. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of salinity. However, specific knowledge of the South West environment in terms of its response to elevated levels of salinity could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999). Additional confidence in the consequence score of the impact of salinity in the Nebine/Mungallala/ Wallam landscape is derived from Biggs et al. 2010.
Elevated levels of suspended matter—Including deposited sediment	3	4	12	2	2	**Likelihood** As livestock grazing represents approximately 97% of the Nebine/Mungallala/Wallam region, overgrazing of catchments and grazing of riverbanks and floodplains are possible. The expert panel indicated grazing management (e.g. goats, kangaroos and cattle) is required to prevent overgrazing from occurring—particularly in the dry season. A low percentage of ground cover at the end of the winter dry season can leave soils exposed to erosion from wind and rain from summer storms, resulting in sediment being deposited in waterways, increasing turbidity, and carrying nutrients. Grazing and other anthropogenic factors that currently contribute to elevated levels of suspended matter are not expected to increase in area in the next ten years due to low population growth rate prediction (OESR, 2011). The expert panel assumed hillslope and gully erosion would be low due to the soils and terrain in the catchment. Riparian forest clearing contributes to the likelihood of elevated levels of suspended matter in the Nebine/Mungallala/Wallam region. Of the 34.4% of riparian forest cleared since pre-European settlement in the Nebine/Mungallala/Wallam region, a total of 14.7% riparian forest loss was recorded between 1988 and 2013. This was the highest clearing percentage for QMDB catchments for this period (Clark et al., 2015). In contrast, no more than 2% of riparian forest was cleared in the Bulloo and Paroo drainage basins between 1988 and 2013. The DNRM water quality dataset for monitoring sites within Nebine/Mungallala/Wallam indicates turbidity in this catchment is highly variable. The expert panel stated that due to the relatively flat landscape, natural sinks and low flows in the Nebine/Mungallala/Wallam, sediment is not readily

						flushed from the basin. Additional knowledge is required to support the likelihood of deposited sediment in the Nebine/Mungallala/Wallam—however anecdotal community information has indicated siltation of waterholes is occurring. The expert panel indicated that the existing stressors (overgrazing, clearing of riparian zones and reduced groundcover) that contribute to elevated levels of suspended matter, including deposited sediment, will need to be managed over the next ten years to ensure current sediment levels are maintained and/or improved. Note: Elevated levels of suspended matter, including deposited sediment, will be exacerbated in exceptional circumstances, such as an extreme prolonged drought event. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of suspended matter, including deposited sediment. However, specific knowledge of the South West environment in terms of its response to elevated levels of suspended matter, particularly deposited sediment, needs to be improved. The expert panel indicated that the South West ecosystem has evolved under conditions of elevated suspended matter, likely resulting in less consequence to the area from this risk. However, elevated levels of deposited sediment are predicted to be having a greater impact on the system, presumably through the siltation of refugial waterholes. This is supported by higher consequence scores for deposited sediment than suspended sediment in Negus et al, 2012. Further research into the impact of deposited sediment will be conducted (Negus et al, 2012)
Elevated levels of nutrients, including phosphorus and nitrogen	1	4	4	3	2	**Likelihood** The percentage land use of aquaculture, cropping, manufacturing and industrial, production forestry, and waste treatment and disposal in the Nebine/Mungallala/Wallam basin is negligible (DSITIA, 2012). As a result, the expert panel indicated that the likelihood of the following factors causing water quality degradation as a result of these land uses in the Nebine/Mungallala/Wallam catchments would be rare: • soil and organic matter; • animal waste; • fertilisers; • sewage and industrial discharges; • nutrients from water storages released as a result of storage management practices. The expert panel indicated that these land uses that contribute to elevated nutrients in streams are not expected to change dramatically in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat

						basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent nutrient impacts. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of nutrients. However, specific knowledge of the South West environment in terms of its response to elevated levels of nutrients could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated cyanobacteria cell counts or biovolume, toxins and odour compounds	1	4	4	3	2	**Likelihood** The expert panel indicated that elevated cyanobacterial outbreaks in the Nebine/Mungallala/Wallam were rare, as the factors that cause an event are unlikely to combine unless in extreme circumstances. This is based on local knowledge of outbreaks in the region. There is also a lack of land uses that input excessive quantities of phosphorus and nitrogen into the water in this region (DSITIA, 2012). The expert panel also indicated that the watercourses are too turbid, which would limit potential outbreaks as it restricts the amount of light available to the cyanobacteria to photosynthesise. Potentially toxic cyanobacteria are often a concern in regulated water systems, however 87% of predevelopment flows in the Nebine/Mungallala/Wallam basin reach the Queensland/New South Wales border (Cottingham, 1999). Cyanobacteria in South West catchments is expected to be similar to those recorded in Cooper Creek, which are mostly nontoxic species that represent an important part of the foodweb (Cottingham, 1999). **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated cyanobacteria. However, specific knowledge of the South West environment in terms of its response to elevated cyanobacteria could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Dissolved oxygen outside natural ranges	1	4	4	3	2	**Likelihood** There is a rare likelihood of dissolved oxygen outside natural ranges as a result of micro-organisms consuming organic matter released from sewage treatment plants. The percentage of waste treatment and disposal in the Nebine/Mungallala/Wallam basin is negligible in terms of land use (DSITIA, 2012). The low population growth, predicted to occur in the region, is likely to mitigate any potential occurrence of this water quality issue into the future. The population of the South West region was approximately 10 720 people in 2011 (ABS census). Forecast population growth is the lowest rate in the QMDB at

						approximately 0.35% p.a. until 2031 (OESR, 2011). The expert panel indicated that due to the low population and the limited likelihood of land use change and industry expansion, the occurrence of dissolved oxygen outside natural ranges is not expected to increase in the life of the plan. Due to the low risk of 'Elevated levels of nutrients, including phosphorus and nitrogen'—Eutrophication is not anticipated to occur and cause dissolved oxygen outside natural ranges. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent dissolved oxygen impacts. **Consequence** There is some confidence in the score due to general knowledge about the impacts of dissolved oxygen outside natural ranges. However, specific knowledge of the South West environment in terms of its response to dissolved oxygen outside natural ranges could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated levels of pesticides, heavy metals and other toxic contaminants	1	4	4	3	2	**Likelihood** In the Nebine/Mungallala/Wallam, land uses that produce elevated levels of pesticides and other contaminants (such as aquaculture, cropping, manufacturing and industrial, production forestry, and waste treatment and disposal) are negligible (DSITIA, 2012). The expert panel indicated that the current land uses that contribute to elevated levels of pesticides and other contaminants are not expected to increase in the South West region over the life of the plan due to the low population growth rate prediction (OESR, 2011). The likelihood of the following causes of elevated levels of pesticides, heavy metals and other toxic contaminates is assessed below: • pesticide spray drift—The Water Quality Technical Panel indicated there is a rare likelihood of this cause of water quality degradation occurring as land uses that implement pesticide sprays are negligible in the catchment. • allowing pesticides or other contaminants into surface water runoff—South West NRM Ltd. indicated that the majority of pesticides are used for cattle and sheep and these are no longer applied as dips, but rather as direct application (minimising runoff). • allowing pesticides or other contaminants to leach into groundwater—South West NRM Ltd. indicated most sheep dips have been non-commissioned and they are generally found in heavy clays where there is good containment of leachates. • allowing erosion of contaminated soil—The Water Quality Technical Panel indicated that this would be rare due to the negligible occurrence of contaminated soil in the catchment. • inappropriate disposal of pesticides—No evidence was presented to suggest inappropriate disposal

	1	4		3	2	of pesticides is occurring in the South West region. However, community consultation at Mungallala in 2011 noted that the community would benefit if additional opportunities for the responsible disposal of chemicals were provided. • inappropriate disposal and management of industrial and other waste (including from mining and coal-seam gas extraction)—No evidence was presented to suggest inappropriate disposal and management of industrial and other waste is occurring in the South West region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from elevated levels of heavy metals and other toxic contaminants. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of pesticides and other contaminants. However, specific knowledge of the South West environment in terms of its response to elevated levels of contaminants could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated pathogen counts	1	4	4	3	2	**Likelihood** The population of the South West region was approximately 10 720 people in 2011 (ABS census). Forecast population growth is the lowest rate in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). Due to the low population growth, increased sewage discharges from urban areas are not expected in the life of the plan. Intensive animal production and other point source discharge industries in the region are negligible (DSITIA, 2012). The expert panel indicated that due to the large land area, diffuse pathogen inputs from grazing lands are of low risk. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated pathogen counts. However, specific knowledge of the South West environment in terms of its response to elevated pathogen counts could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
pH outside natural ranges	1	4	4	3	2	**Likelihood** The expert panel indicated that oxidation of iron sulphide in the soil is of low risk in the Nebine/Mungallala/Wallam due to alkaline soils. Existing cropping and production forestry in the area is negligible and agricultural practices that lead to the acidification of soils are not expected to increase in

						the life of the plan (DSITIA, 2012). High diurnal variation in pH as an indirect result of eutrophication is also of low risk due to the absence of land uses that input excessive nutrients into streams (DSITIA, 2012). Note: Monosulfides naturally occur in the saline lakes present in the Murray-Darling Basin (MDBA, 2011). However, the expert panel indicated that the chance of development increasing in the Nebine/Mungallala/Wallam to disturb the soils of the saline lakes was deemed a low risk. **Consequence** There is some confidence in the score due to general knowledge about the impacts of pH outside natural ranges. However, specific knowledge of the South West environment in terms of its response to pH outside natural ranges could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Water temperature outside natural ranges	1	4	4	3	2	**Likelihood** There are no water storages in the Nebine/Mungallala/Wallam basin that would generate a significant risk of altered water temperatures. The removal of shading riparian vegetation to the extent it would produce altered water temperatures was deemed a low risk by the expert panel. In the Nebine/Mungallala/Wallam basin, 34.4% of riparian forest has been cleared since pre-European settlement (Clark et al., 2015). Removal of riparian vegetation is not consistent with natural resource management in the region. In 2010/11, 51% of agricultural businesses in the South West with creeks and rivers undertook activities to protect them (DSITIA, 2012b). The most popular protection activities were associated with protecting the riparian zone, including controlling livestock access, managing weeds and retaining native vegetation (DSITIA, 2012b). Riparian and wetland vegetation is also retained for its economic value as well as its biodiversity value. The local pastoral industry makes use of riparian and wetland vegetation such as water couch, channel millet (Echinochloa turnerana - is not widespread in the region—only found at Lake Dartmouth in the SWNRM region) following floods (Cottingham, 1999). **Consequence** The consequence of water temperature outside natural ranges in the Nebine/Mungallala/Wallam basin specifically is unknown. However, there is knowledge of the ecological consequences of vegetation removal and dam releases in other Australian river systems (For example, Rutherford et al, 2004 and EPA Victoria, 2004).
Pest fauna - land	4	3	12	3	3	**Likelihood** The expert panel indicated that due to the behaviour of feral pigs and other pest species, controlling land-based pest fauna will be an ongoing concern into the future. Of the land-based pest fauna, feral

						pigs represent the greatest risk to water quality. Feral pigs are present in at least 25-50% of the Nebine/Mungallala/Wallam basin (DEEDI, 2007). Feral pigs are prolific breeders, with the population able to increase five-fold in 12 months (Kirby, 2007a). As a result, feral pig control is a difficult and ongoing process. **Consequence** The impact of the aquatic impacts of feral pigs and other pest fauna in the South West region is well documented, not only in literature but also anecdotally from land managers (http://www.southwestnrm.org.au/ihub/nrm-topics/pigs). Feral pigs stay near water to drink and wallow, leading to fouling of water bodies, vegetation removal and erosion (Kirby, 2007a). The resulting damage to the aquatic ecosystem has economic, environmental and social implications. Rabbits and feral goats contribute to soil erosion and the subsequent siltation of aquatic ecosystems (Negus et al., 2012).
Pest fauna - aquatic	3	4	12	3	3	**Likelihood** Gambusia, carp and goldfish are present in the Nebine/Mungallala/Wallam basin (Negus et al, 2012). Redclaw crayfish are not currently present and were not identified as a high potential to enter the basin (Negus et al, 2012). The expert panel indicated that natural resource management actions are being applied to try and control the further spread of the pest aquatic fauna in the Nebine/Mungallala/Wallam basin. **Consequence** Carp are known to lead to direct water quality deterioration through increases to suspended sediment and nutrients (Invasive Animals CRC 2012; DAFF 2012). Gambusia dominates instream habitats and reduces numbers of native fish (DAFF 2012). The expert panel has field knowledge of infestations of pest aquatic fauna across South West.
Pest flora - land	4	2	8	3	3	**Likelihood** Based on expert knowledge of the Nebine/Mungallala/Wallam basin from land managers and the awareness of property infestations, the risk of terrestrial pest flora in the riparian zone is likely to occur into the future. The exotic weeds of concern in the Nebine/Mungallala/Wallam basin are the Bathurst Burr, Harrisia Cactus, Mimosa Bush, Mother of Millions, Parkinsonia, Parthenium, Prickly Pear (South West NRM, 2012). **Consequence** The expert panel established that the consequence of land-based pest flora specifically for water quality

						is minor. Although land-based pest flora are damaging to the ecosystem, they can produce benefits to water quality by providing bank stabilisation and shade to the main channel (Ede & Hunt, 2008). There may be a risk of herbicide entering the channel if used in incorrect quantities to control pest flora. However, it is recommended that the use of herbicides near waterways is minimised and alternative techniques are adopted instead (Ainsworth & Bowcher, 2005).
Pest flora - aquatic	4	4	16	3	3	**Likelihood** Based on knowledge of the Nebine/Mungallala/Wallam basin from land managers and research into pest flora species, outbreaks of aquatic pest flora species are possible. Water lettuce is already established in the Nebine/Mungallala/Wallam due to favourable conditions (water lettuce prefers stationary or slow-moving streams) (DEEDI, 2012). The Nebine/Mungallala/Wallam basin is at high risk of Hymenachne becoming established (DEEDI, 2011). **Consequence** Outbreaks of water lettuce have many implications for the aquatic ecosystem including water loss through excessive transpiration, increased debris, sunlight inhibition and oxygen exchange prevention (Kirby, 2007b; DEEDI, 2012). This can lead to social, economic and environmental consequences such as preventing access to recreational areas, inhibiting stock watering and impeding native plant growth, respectively (DEEDI, 2012). Hymenachne degrades aquatic ecosystems, causing adverse impacts to recreation, irrigation, infrastructure and the natural environment (DAFF 2013).
Climate change	1	3	3	2	2	**Likelihood** In the 10 year life of the plan, the risk that water quality impacts from climate change would occur is assumed to be rare. Based on CSIRO (2008), the 'best estimate 2030 climate scenario' for the Condamine-Balonne (incorporating Nebine/Mungallala/Wallam) identifies a 9% reduction in mean annual runoff. There is some uncertainty in the climate change predictions, meaning mean annual runoff could range from a 20% reduction to a 26% increase (CSIRO, 2008). **Consequence** The expert panel indicated that the South West landscape has evolved under an extreme climate, therefore a 9% reduction in mean annual runoff for the Condamine-Balonne (incorporating Nebine/Mungallala/Wallam) region under an applied ‘best estimate 2030 climate scenario’ is not expected to have major consequences for water quality. CSIRO (2008) states that uncertainty arises in the global warming projections and the global climate modelling of local rainfall response to the global warming. If climate change does increase the frequency and duration of extreme events, it is predicted that communities in South West Queensland may be better able to adapt to these conditions compared to communities that currently do not experience climate extremes on a regular basis (Queensland Government, 2009).

Warrego drainage basin surface water risk register						
Risk factor/source	Risk analysis			Confidence score		
	L	C	Level of Risk	L	C	Justification
Elevated levels of salinity	1	4	4	2	3	**Likelihood** The expert panel indicated that in some areas of the Warrego the salt stores in the landscape are high and there is high evaporative demand. Irrigation close to major watercourses increases the likelihood of salt entering the stream. There is a high salt store (shallow, saline watertable) in the lower Warrego (near Cunnamulla) that could produce salinity consequences if irrigation is not conducted appropriately. As long as irrigators (currently around Cunnamulla) continue to implement water use efficient practices (e.g. trickle irrigation, lateral moves and pivot irrigation), the risk of elevated levels of salinity occurring in this area will be rare. In addition, due to the low population growth rate expected in the next ten years, an expansion of irrigation is not expected (OESR, 2011). There is lesser risk of elevated levels of salinity from irrigation around Charleville as a lower salt store occurs here. Although potential for inland acid sulphate soils (monosulfides) are found naturally and in conjunction with irrigation development in the Warrego basin, the expert panel indicated that the likelihood of development increasing in the Warrego to disturb these soils was rare (MDBA, 2011). The salinity audit for the Warrego and Paroo Rivers in 2007 indicated that secondary salinity from rising groundwater and in runoff was not posing a significant threat to water quality in either of these systems (Power et al., 2007). In terms of increased deep drainage below irrigated agricultural land displacing saline groundwater to surface water systems—livestock grazing is the dominant land use in the Warrego region (approximately 97% of land area) (DSITIA, 2012). There is more development in the Warrego in comparison to the other South West basins; however in the context of the size of the basin the development is minimal and is not expected to produce salinity impacts if appropriate irrigation management continues. Land management practices involving the replacement of deep-rooted vegetation with shallow-rooted crops and pastures, resulting in increased rainfall recharge displacing saline groundwater to surface water systems—The expert panel, including staff responsible for the implementation of the Basin Salinity Management Strategy in Queensland, assessed the likelihood as rare due to minimal cropping development in the region. The expert panel indicated that existing land uses are not expected to change dramatically in the life of the plan. This region has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth of water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in

						the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent salinity impacts. Note: If the water allocation and planning policy were to change in this region it would affect the likelihood score. Climate change presents the risk of causing an increase in bare ground due to extreme events. This in turn can lead to elevated levels of salinity. However, the expert panel indicated that the likelihood of an extreme event producing the extent of bare ground required to produce a consequence was very rare. Under the best estimate (median) 2030 climate scenario for the Warrego there would only be a 6% reduction in mean annual runoff across the entire region (CSIRO, 2007). It is assumed this would not be of an extreme to produce excessive bare ground. **Consequence** If irrigation is not conducted appropriately and the shallow, saline water tables in the lower Warrego alluvia discharge to land/stream, there is potential to cause major financial loss to irrigators. Other Environmental Values would also be adversely affected, but could recover in the medium term. The confidence in the consequence score of the impact of salinity in the Warrego landscape is largely derived from the salinity audit for this region (Power et al., 2007).
Elevated levels of suspended matter—Including deposited sediment	4	4	16	2	2	**Likelihood** As livestock grazing represents approximately 97% of the land area in the Warrego catchment, overgrazing of catchments and grazing of riverbanks and floodplains is likely (DSITIA, 2012). The expert panel indicated grazing management (e.g. goats, kangaroos and cattle) is required to prevent overgrazing from occurring—particularly in the dry season. A low percentage of ground cover at the end of the winter dry season can leave soils exposed to erosion from wind and rain from summer storms, resulting in sediment being deposited in waterways, increasing turbidity, and carrying nutrients. Grazing and other anthropogenic factors that currently contribute to elevated levels of suspended matter are not expected to increase in area in the next ten years due to low population growth rate prediction (OESR, 2011). The DNRM water quality datasets for Warrego River at Cunnamulla, Augathella and Wyandra indicate levels of turbidity in this catchment are highly variable. The expert panel indicated that the terrain of the Warrego is not as steep in comparison to Paroo and Bulloo. The Warrego basin is also characterised by soft mulga lands (Power et al., 2007). There is higher rainfall in the majority of the Warrego in comparison to the Bulloo and Paroo, resulting in typically more catchment groundcover (Van den berg et al., 2015). The expert panel also indicated that the alluvial soils in the bottom reaches of the Warrego also contribute to higher levels of groundcover (Power et al., 2007). They also advised that the types of irrigation management currently implemented also lowers the likelihood of sediment runoff. For these reasons, the likelihood of elevated levels of suspended matter, including deposited sediment, was

						classified as “likely” rather than “almost certain” in the Warrego basin. SunWater, as the scheme operator for Cunnamulla Water Supply Scheme, manages Allan Tannock Weir through the operating rules specified in the Resource Operations Plan for the plan area. SunWater is required to notify the Department of Natural Resources and Mines of any incidents of bank slumping that occur in the Cunnamulla Water Supply Scheme. The Minister’s Reports for Water Resource Plans indicate that there have been no reportable incidents of bank slumping in the Cunnamulla Water Supply Scheme over the past 10-years. This is not considered to be a cause of water quality degradation in the Warrego catchment and is a rare likelihood of occurring. South West NRM Ltd. indicated that wave wash in Allan Tannock Weir and the Ward River Recreational Area is occurring—however additional knowledge is required to characterise the risk. Additional knowledge is required to support the likelihood of deposited sediment in the Warrego catchment—however anecdotal community information has indicated siltation of waterholes is occurring. In addition, the Sustainable Rivers Audit 2[47] noted some evidence of channel contraction in the Warrego Valley due to channel narrowing and bed aggradation. The expert panel indicated that the existing stressors (overgrazing, clearing of riparian zones and reduced groundcover) that contribute to elevated levels of suspended matter, including deposited sediment, will need to be managed over the next ten years to ensure current sediment levels are maintained and/or improved. Note: Elevated levels of suspended matter, including deposited sediment, will be exacerbated in exceptional circumstances, such as an extreme prolonged drought event. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of suspended matter, including deposited sediment. However, specific knowledge of the South West environment in terms of its response to elevated levels of suspended matter, particularly deposited sediment, needs to be improved. The expert panel indicated that the South West ecosystem has evolved under conditions of elevated suspended matter, likely resulting in less consequence to the area from this risk. However, elevated levels of deposited sediment are predicted to be having a greater impact on the system, presumably through the siltation of refugial waterholes. This is supported by higher consequence scores for deposited sediment than suspended sediment in Negus et al, 2012. Further research into the impact of deposited sediment will be conducted (Negus et al, 2012).

47 http://www.mdba.gov.au/sites/default/files/SRA2-SUMMARY-FINAL.pdf

Elevated levels of nutrients, including phosphorus and nitrogen	1	4	4	3	2	**Likelihood** The percentage land use of cropping, effluent ponds, intensive animal production, irrigated agriculture, landfill, manufacturing and industrial, production forestry, residential, rural residential, and waste treatment and disposal in the Warrego basin is minimal (Approximately 1.2% of the landscape) (DSITIA, 2012). As a result, the expert panel indicated that the likelihood of the following factors causing water quality degradation as a result of these land uses in the Warrego catchment would be rare: • soil and organic matter; • animal waste; • fertilisers; • sewage and industrial discharges; • nutrients from water storages released as a result of storage management practices. The expert panel indicated that these land uses that contribute to elevated nutrients in streams are not expected to change dramatically in the life of the plan. The expert panel also added that the types of irrigation management currently implemented also lowers the likelihood of elevated levels of nutrients. South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent nutrient impacts. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of nutrients. However, specific knowledge of the South West environment in terms of its response to elevated levels of nutrients could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated cyanobacteria cell counts or biovolume, toxins and odour compounds	1	4	4	3	2	**Likelihood** The expert panel indicated that cyanobacterial outbreaks in the Allan Tannock Weir have occurred due to slightly higher nutrient runoff and siltation. Allan Tannock Weir provides town water to Cunnamulla and irrigation water to landholders. The Cunnamulla Water Supply Scheme is managed by SunWater. The recreation facilities are managed by the Paroo Shire Council. The expert panel advised that the

						frequency of cyanobacterial outbreaks at Allan Tannock Weir is not expected to increase in future and that there are processes in place to manage events. In other areas of the Warrego, elevated cyanobacterial outbreaks over the next ten years were deemed to be rare, as the factors that cause an event are unlikely to combine unless in extreme circumstances. This is based on local knowledge of outbreaks in the region. The land uses that input excessive quantities of phosphorus and nitrogen into the water in this region are not expected to increase due to low population growth predictions (OESR, 2011). The expert panel also indicated that the watercourses are too turbid, which would limit potential outbreaks as it restricts the amount of light available to the cyanobacteria to photosynthesise. Potentially toxic cyanobacteria are often a concern in regulated water systems, however the Warrego has an end-of-system flow for the catchment of 89% of pre-development flows (Cottingham, 1999). Cyanobacteria in South West catchments is expected to be similar to those recorded in Cooper Creek, which are mostly nontoxic species that represent an important part of the foodweb (Cottingham, 1999). **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated cyanobacteria. However, specific knowledge of the South West environment in terms of its response to elevated cyanobacteria could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Dissolved oxygen outside natural ranges	1	4	4	3	2	**Likelihood** There is a rare likelihood of dissolved oxygen outside natural ranges as a result of micro-organisms consuming organic matter released from sewage treatment plants. The percentage of waste treatment and disposal in the Warrego basin is minimal in terms of land use (DSITIA, 2012). The low population growth, predicted to occur in the region, is likely to mitigate any potential occurrence of this water quality issue into the future. The population of the South West region was approximately 10 720 people in 2011 (ABS census). Forecast population growth is the lowest rate in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). The expert panel indicated that due to the low population and the limited likelihood of land use change and industry expansion, the occurrence of dissolved oxygen outside natural ranges is not expected to increase in the life of the plan. Flushing of natural organic material from the floodplain during heavy rainfall contributes to the natural range of dissolved oxygen in South West catchments. Natural flushing is not exacerbated by the regulation of flows through Allan Tannock Weir. The stock and domestic releases from the weir (a maximum of 300 ML per day) would be confined to in-channel flow. Due to the low risk of ‘Elevated levels of nutrients, including phosphorus and nitrogen’—Eutrophication is not anticipated to occur and cause dissolved oxygen outside natural ranges. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat

						basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent dissolved oxygen impacts. **Consequence** There is some confidence in the score due to general knowledge about the impacts of dissolved oxygen outside natural ranges. However, specific knowledge of the South West environment in terms of its response to dissolved oxygen outside natural ranges could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated levels of pesticides, heavy metals and other toxic contaminants	1	4	4	3	2	**Likelihood** In the Warrego catchment, land uses that produce elevated levels of pesticides and other contaminants (such as cropping, effluent ponds, intensive animal production, irrigated agriculture, landfill, manufacturing and industrial, production forestry, residential, rural residential, and waste treatment and disposal) are minimal (Approximately 1.2% of the landscape) (DSITIA, 2012). The expert panel indicated that the current land uses that contribute to elevated levels of pesticides are not expected to increase in the South West region over the life of the plan due to the low population growth prediction (OESR, 2011). The expert panel noted that there has been a shift from organic to conventional farming, however due to the size of the basin the impact has been negligible. The likelihood of the following causes of elevated levels of pesticides, heavy metals and other toxic contaminates is assessed below: • pesticide spray drift—The Water Quality Technical Panel indicated there is a rare likelihood of this cause of water quality degradation occurring as land uses that implement pesticide sprays are negligible in the catchment. • allowing pesticides or other contaminants into surface water runoff—South West NRM Ltd. indicated that the majority of pesticides are used for cattle and sheep and these are no longer applied as dips, but rather as direct application (minimising runoff). • allowing pesticides or other contaminants to leach into groundwater—South West NRM Ltd. indicated most sheep dips have been non-commissioned and they are generally found in heavy clays where there is good containment of leachates. • allowing erosion of contaminated soil—The Water Quality Technical Panel indicated that this would be rare due to the negligible occurrence of contaminated soil in the catchment. • inappropriate disposal of pesticides—No evidence was presented to suggest inappropriate disposal of pesticides is occurring in the South West region. • inappropriate disposal and management of industrial and other waste (including from mining and coal-seam gas extraction)—No evidence was presented to suggest inappropriate disposal and management of industrial and other waste is occurring in the South West region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note

						that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from elevated levels of heavy metals and other toxic contaminants. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of pesticides and other contaminants. However, specific knowledge of the South West environment in terms of its response to elevated levels of contaminants could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated pathogen counts	1	4	4	3	2	**Likelihood** The population of the South West region was approximately 10 720 people in 2011 (ABS census). Forecast population growth is the lowest rate in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). Due to the low population growth, increased sewage discharges from urban areas are not expected in the life of the plan. Intensive animal production and other point source discharge industries in the region are minimal (DSITIA, 2012). The expert panel indicated that due to the large land area, diffuse pathogen inputs from grazing lands are of low risk. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated pathogen counts. However, specific knowledge of the South West environment in terms of its response to elevated pathogen counts could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
pH outside natural ranges	1	4	4	3	2	**Likelihood** The expert panel indicated that oxidation of iron sulphide in the soil is of low risk in the Warrego due to alkaline soils. Existing irrigated cropping and production forestry in the area is minimal and agricultural practices that lead to the acidification of soils are not expected to increase in the life of the plan (DSITIA, 2012). High diurnal variation in pH as an indirect result of eutrophication is also of low risk due to the absence of land uses that input excessive nutrients into streams (DSITIA, 2012). Note: Monosulfides naturally occur in the saline lakes present in the Murray-Darling Basin (MDBA, 2011). However, the expert panel indicated that the chance of development increasing in the Warrego to disturb the soils of the saline lakes was deemed a low risk. **Consequence** There is some confidence in the score due to general knowledge about the impacts of pH outside

						natural ranges. However, specific knowledge of the South West environment in terms of its response to pH outside natural ranges could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Water temperature outside natural ranges	1	4	4	3	2	**Likelihood** The Allan Tannock Weir at Cunnamulla has an operating rule which requires the first 300 ML/day of inflow to be passed (or stored for later release) (Warrego, Paroo, Bulloo and Nebine Resource Operations Plan). The likelihood that cold water releases would occur is limited by the fact that the maximum embankment height is 4.5 metres. The removal of shading riparian vegetation to the extent it would produce altered water temperatures was deemed a low risk by the expert panel. In the Warrego catchment, 23% of riparian forest has been cleared since European settlement (Clark et al., 2015). Removal of riparian vegetation is not concurrent with natural resource management in the region. In 2010/11, 51% of agricultural businesses in the South West with creeks and rivers undertook activities to protect them (DSITIA, 2012b). The most popular protection activities were associated with protecting the riparian zone, including controlling livestock access, managing weeds and retaining native vegetation (DSITIA, 2012b). Riparian and wetland vegetation is also retained for its economic value as well as its biodiversity value. The local pastoral industry makes use of riparian and wetland vegetation such as water couch, channel miller and neverfail following floods (Cottingham, 1999). **Consequence** The consequence of water temperature outside natural ranges in the Warrego system specifically is unknown. However, there is knowledge of the ecological consequences of vegetation removal and dam releases in other Australian river systems (For example, Rutherford et al, 2004 and EPA Victoria, 2004).
Pest fauna - land	4	3	12	3	3	**Likelihood** The expert panel indicated that due to the behaviour of feral pigs and other pest species, controlling land-based pest fauna will be an ongoing concern into the future. Of the land-based pest fauna, feral pigs represent the greatest risk to water quality. Feral pigs are present in at least 25-50% of the Warrego basin (DEEDI, 2007). Feral pigs are prolific breeders, with the population able to increase five fold in 12 months (Kirby, 2007a). As a result, feral pig control is a difficult and ongoing process. **Consequence** The impact of the aquatic impacts of feral pigs and other pest fauna in the South West region is well documented, not only in literature but also anecdotally from land managers (http://www.southwestnrm.org.au/ihub/nrm-topics/pigs). Feral pigs stay near water to drink and wallow, leading to fouling of water bodies, vegetation removal and erosion (Kirby, 2007a). The resulting

						damage to the aquatic ecosystem has economic, environmental and social implications. Rabbits and feral goats contribute to soil erosion and the subsequent siltation of aquatic ecosystems (Negus et al., 2012).
Pest fauna - aquatic	3	4	12	3	3	**Likelihood** Gambusia, carp and goldfish are present in the Warrego basin (Negus et al, 2012). Redclaw crayfish are not currently present and were not identified as a high potential to enter the basin (Negus et al, 2012). The expert panel indicated that natural resource management actions are being applied to try and control the further spread of the pest aquatic fauna in the Warrego basin. **Consequence** Carp are known to lead to direct water quality deterioration through increases to suspended sediment and nutrients (Invasive Animals CRC, 2012; DAFF, 2012). Gambusia dominates instream habitats and reduces numbers of native fish (DAFF, 2012). The expert panel has field knowledge of infestations of pest aquatic fauna across South West.
Pest flora - land	4	2	8	3	3	**Likelihood** Based on expert knowledge of the Warrego system from land managers and the awareness of property infestations, the risk of terrestrial pest flora in the riparian zone is likely to occur into the future. The exotic weeds of concern in the Warrego are African Boxthorn, Mesquite (Prosopis pallida), Mimosa Bush, Mother of Millions, Noogoora Burr, Parkinsonia, Parthenium, Prickly Pear and Coral Cactus (South West NRM, 2012 and 2014). **Consequence** The expert panel established that the consequence of land-based pest flora specifically for water quality is minor. Although land-based pest flora are damaging to the ecosystem, they can produce benefits to water quality by providing bank stabilisation and shade to the main channel (Ede & Hunt, 2008). There may be a risk of herbicide entering the channel if used in incorrect quantities to control pest flora. However, it is recommended that the use of herbicides near waterways is minimised and alternative techniques are adopted instead (Ainsworth & Bowcher, 2005).
Pest flora - aquatic	3	4	12	3	3	**Likelihood** Based on knowledge of the Warrego system from land managers and research into pest flora species, outbreaks of aquatic pest flora species are possible. Water lettuce is already established in the Warrego due to favourable conditions (water lettuce prefers stationary or slow-moving streams) (DEEDI, 2012). The Warrego basin is at high risk of Hymenachne becoming established (DEEDI, 2011).

						Consequence Outbreaks of water lettuce have many implications for the aquatic ecosystem including water loss through excessive transpiration, increased debris, sunlight inhibition and oxygen exchange prevention (Kirby, 2007b; DEEDI, 2012). This can lead to social, economic and environmental consequences such as preventing access to recreational areas, inhibiting stock watering and impeding native plant growth, respectively (DEEDI, 2012). Hymenachne degrades aquatic ecosystems, causing adverse impacts to recreation, irrigation, infrastructure and the natural environment (DAFF, 2013).
Climate change	1	3	3	2	2	**Likelihood** The expert panel indicated that the risk that water quality impacts from climate change would occur in the life of the water resource plan is assumed to be rare. Based on CSIRO (2007), the 'best estimate 2030 climate scenario' for the Warrego identifies a 6% reduction in mean annual runoff. There is some uncertainty in the climate change predictions, meaning mean annual runoff could range from a 25% reduction to a 46% increase (CSIRO, 2007). **Consequence** The expert panel indicated that the South West landscape has evolved under an extreme climate, therefore a 6% reduction in average water availability for the Warrego region under an applied ‘best estimate 2030 climate scenario’ is not expected to have major consequences for water quality. As indicated by CSIRO (2007), there is still uncertainty as to extent of climate change impacts. If climate change does increase the frequency and duration of extreme events, it is predicted that communities in South West Queensland may be better able to adapt to these conditions compared to communities that currently do not experience climate extremes on a regular basis (Queensland Government, 2009).

Paroo drainage basin surface water risk register						
Risk factor/source	Risk analysis			Confidence score		
	L	C	Level of Risk	L	C	Justification
Elevated levels of salinity	1	4	4	3	2	**Likelihood** The expert panel indicated that ambient saline groundwater and surface water discharges into surface water systems would not present a water quality degradation issue over the next ten years. The salinity audit for the Warrego and Paroo Rivers in 2007 indicated that secondary salinity from rising groundwater and in runoff was not posing a significant threat to water quality in either of these systems (Power et al., 2007). In terms of increased deep drainage below irrigated land displacing saline groundwater to surface water systems—livestock grazing is the dominant land use in the Paroo region (approximately 95% of land area). There is minimal irrigation or other practices that cause elevated levels of salinity (DSITIA, 2012). Land management practices involving the replacement of deep-rooted vegetation with shallow-rooted crops and pastures, resulting in increased rainfall recharge displacing saline groundwater to surface water systems—The expert panel, including staff responsible for the implementation of the Basin Salinity Management Strategy in Queensland, assessed the likelihood as rare due to minimal cropping development in the region. The expert panel indicated that existing land uses are not expected to change dramatically in the life of the plan. This region has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth of water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent salinity impacts. Note: If the water allocation and planning policy were to change in this region it would affect the likelihood score. Climate change presents the risk of causing an increase in bare ground due to extreme events. This in turn can lead to elevated levels of salinity. However, the expert panel indicated that the likelihood of an extreme event producing the extent of bare ground required to produce a consequence was very rare. Under the best estimate (median) 2030 climate scenario for the Paroo there would only be a 2% reduction in mean annual runoff across the entire region (CSIRO, 2007). It is assumed this would not

						be of an extreme to produce excessive bare ground. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of salinity. However, specific knowledge of the South West environment in terms of its response to elevated levels of salinity could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999). Additional confidence in the consequence score of the impact of salinity in the Paroo landscape is derived from the salinity audit for this region (Power et al., 2007).
Elevated levels of suspended matter—Including deposited sediment	5	4	20	2	2	**Likelihood** As livestock grazing represents approximately 95% of the land area in the Paroo catchment, overgrazing of catchments and grazing of riverbanks and floodplains is likely (DSITIA, 2012). The expert panel indicated grazing management (e.g. goats, kangaroos and cattle) is required to prevent overgrazing from occurring—particularly in the dry season. A low percentage of ground cover at the end of the winter dry season can leave soils exposed to erosion from wind and rain from summer storms, resulting in sediment being deposited in waterways, increasing turbidity, and carrying nutrients. A discernible and widespread impact in the Bulloo region, which contributes to elevated levels of suspended matter, is riparian and bank damage by stock access (Choy et al, 2002). Due to similar characteristics between the two basins, it is assumed this would be having a similar impact in the Paroo. Grazing and other anthropogenic factors that currently contribute to elevated levels of suspended matter are not expected to increase in area in the next ten years due to low population growth rate prediction (OESR, 2011). The DNRM water quality dataset for Paroo River at Caiwarro indicates levels of turbidity in this catchment are highly variable. The expert panel indicated that the landscape of the Paroo is comprised of hard mulga and rocky residuals, resulting in low permeability and high runoff. The expert panel also indicated that hillslope erosion is an issue in this catchment. Due to the soils and slope of the catchment, elevated suspended matter is almost certain. Additional knowledge is required to support the likelihood of deposited sediment in the Paroo catchment—however anecdotal community information has indicated siltation of waterholes is occurring. The expert panel indicated that the existing stressors (overgrazing, clearing of riparian zones and reduced groundcover) that contribute to elevated levels of suspended matter, including deposited sediment, will need to be managed over the next ten years to ensure current sediment levels are maintained and/or improved. Note: Elevated levels of suspended matter, including deposited sediment, will be exacerbated in exceptional circumstances, such as an extreme prolonged drought event.

						Consequence There is some confidence in the score due to general knowledge about the impacts of elevated levels of suspended matter, including deposited sediment. However, specific knowledge of the South West environment in terms of its response to elevated levels of suspended matter, particularly deposited sediment, needs to be improved. The expert panel indicated that the South West ecosystem has evolved under conditions of elevated suspended matter, likely resulting in less consequence to the area from this risk. However, elevated levels of deposited sediment are predicted to be having a greater impact on the system, presumably through the siltation of refugial waterholes. This is supported by higher consequence scores for deposited sediment than suspended sediment in Negus et al, 2012. Further research into the impact of deposited sediment will be conducted (Negus et al, 2012).
Elevated levels of nutrients, including phosphorus and nitrogen	1	4	4	3	2	**Likelihood** The percentage land use of intensive animal production, manufacturing and industrial, perennial horticulture, and waste treatment and disposal in the Paroo basin is negligible (DSITIA, 2012). As a result, the expert panel indicated that the likelihood of the following factors causing water quality degradation as a result of these land uses in the Paroo catchment would be rare: • soil and organic matter; • animal waste; • fertilisers; • sewage and industrial discharges; • nutrients from water storages released as a result of storage management practices. The expert panel indicated that existing land uses that contribute to elevated nutrients in streams are not expected to change dramatically in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent nutrient impacts. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of nutrients. However, specific knowledge of the South West environment in terms of its response to elevated levels of nutrients could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994;

						Cottingham, 1999).
Elevated cyanobacteria cell counts or biovolume, toxins and odour compounds	1	4	4	3	2	**Likelihood** The expert panel advised that outbreaks of cyanobacteria are limited by high turbidity, which restricts the amount of light available to cyanobacteria to photosynthesis. There is also a lack of land uses that input excessive quantities of phosphorus and nitrogen into the water in this region (DSITIA, 2012). Cyanobacterial growth is inhibited if nutrient inputs are limited. Potentially toxic cyanobacteria are often a concern in regulated water systems, however the Paroo has an end-of-system flow for the catchment of 99% of pre-development flows (Cottingham, 1999). Cyanobacteria in South West catchments is expected to be similar to those recorded in Cooper Creek, which are mostly nontoxic species that represent an important part of the foodweb (Cottingham, 1999). **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated cyanobacteria. However, specific knowledge of the South West environment in terms of its response to elevated cyanobacteria could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Dissolved oxygen outside natural ranges	2	4	8	3	2	**Likelihood** Blackwater events in the Paroo drainage basin were assessed by the expert panel as isolated events that are typically localised to a section of river or waterhole. They are unlikely to occur unless the factors that cause an event combine in extreme circumstances. Advice from South West NRM Ltd. (C. Alison pers. comm.) indicates that a blackwater event occurs in the Paroo drainage basin approximately once a year. Blackwater events have primarily been recorded by South West NRM Ltd. following a significant rainfall event, where organic material (predominately Eucalypt leaves) is carried from the riparian zone into the watercourse. If the vegetation matter enters a low and shallow stream or waterhole that contains optimal temperature conditions, a blackwater event can result. Blackwater events are a natural part of the ecology of lowland river systems, particularly during high flows. As the Paroo drainage basin has an end-of-system flow of 99% of pre-development flows, the frequency of blackwater events is unlikely to increase as a result of water resource management. There is a rare likelihood of dissolved oxygen outside natural ranges as a result of micro-organisms consuming organic matter released from sewage treatment plants. The percentage of waste treatment and disposal in the Paroo catchment is negligible in terms of land use (DSITIA, 2012). The low population growth, predicted to occur in the region, is likely to mitigate any potential occurrence of this water quality issue into the future. The population of the South West region was approximately 10 720 people in 2011 (ABS census). Forecast population growth is the lowest rate in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). The expert panel indicated that due to the low

						population and the limited likelihood of land use change and industry expansion, the occurrence of dissolved oxygen outside natural ranges is not expected to increase in the life of the plan. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent dissolved oxygen impacts. **Consequence** Advice from South West NRM Ltd. (C. Alison pers. comm.) indicates that blackwater events impact the local community through fish kills. Local fishers are particularly impacted by fish kills of yellow-belly (Macquaria ambigua). Specific knowledge of the South West environment in terms of its response to dissolved oxygen outside natural ranges could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated levels of pesticides, heavy metals and other toxic contaminants	1	4	4	3	2	**Likelihood** In the Paroo catchment, land uses that produce elevated levels of pesticides and other contaminates (such as intensive animal production, manufacturing and industrial, perennial horticulture, and waste treatment and disposal) are negligible. The expert panel indicated that the current land uses that contribute to elevated levels of pesticides and other contaminates are not expected to increase in the South West region over the life of the plan due to the low population growth rate prediction (OESR, 2011). The likelihood of the following causes of elevated levels of pesticides, heavy metals and other toxic contaminates is assessed below: • pesticide spray drift—The Water Quality Technical Panel indicated there is a rare likelihood of this cause of water quality degradation occurring as land uses that implement pesticide sprays are negligible in the catchment. • allowing pesticides or other contaminants into surface water runoff—South West NRM Ltd. indicated that the majority of pesticides are used for cattle and sheep and these are no longer applied as dips, but rather as direct application (minimising runoff). • allowing pesticides or other contaminants to leach into groundwater—South West NRM Ltd. indicated most sheep dips have been non-commissioned and they are generally found in heavy clays where there is good containment of leachates. • allowing erosion of contaminated soil—The Water Quality Technical Panel indicated that this would be rare due to the negligible occurrence of contaminated soil in the catchment. • inappropriate disposal of pesticides—No evidence was presented to suggest inappropriate disposal of pesticides is occurring in the South West region. • inappropriate disposal and management of industrial and other waste (including from mining and

						coal-seam gas extraction)—No evidence was presented to suggest inappropriate disposal and management of industrial and other waste is occurring in the South West region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from heavy metals and other toxic contaminants. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of pesticides and other contaminants. However, specific knowledge of the South West environment in terms of its response to elevated levels of contaminants could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated pathogen counts	1	4	4	3	2	**Likelihood** The population of the South West region was approximately 10 720 people in 2011 (ABS census). Forecast population growth is the lowest rate in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). Due to the low population growth, increased sewage discharges from urban areas are not expected in the life of the plan. Intensive animal production and other point source discharge industries in the region are negligible (DSITIA, 2012). The expert panel indicated that due to the large land area, diffuse pathogen inputs from grazing lands are of low risk. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated pathogen counts. However, specific knowledge of the South West environment in terms of its response to elevated pathogen counts could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
pH outside natural ranges	1	4	4	3	2	**Likelihood** The expert panel indicated that oxidation of iron sulphide in the soil is of low risk in the Paroo due to alkaline soils. Existing perennial horticulture in the area is negligible and agricultural practices that lead to the acidification of soils are not expected to increase in the life of the plan (DSITIA, 2012). High diurnal variation in pH as an indirect result of eutrophication is also of low risk due to the absence of land uses that input excessive nutrients into streams (DSITIA, 2012). Note: Monosulfides naturally occur in the saline lakes present in the Murray-Darling Basin (MDBA, 2011). However, the expert panel indicated that the chance of development increasing in the Paroo to

						disturb the soils of the saline lakes was deemed a low risk. **Consequence** There is some confidence in the score due to general knowledge about the impacts of pH outside natural ranges. However, specific knowledge of the South West environment in terms of its response to pH outside natural ranges could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Water temperature outside natural ranges	1	4	4	3	2	**Likelihood** There are no water storages in the Paroo basin that would generate a significant risk of altered water temperatures. The removal of shading riparian vegetation to the extent it would produce altered water temperatures was deemed a low risk by the expert panel. In the Paroo catchment, approximately 15% of riparian forest has been cleared since European settlement (Clark et al., 2015). Removal of riparian vegetation is not concurrent with natural resource management in the region. In 2010/11, 51% of agricultural businesses in the South West with creeks and rivers undertook activities to protect them (DSITIA, 2012b). The most popular protection activities were associated with protecting the riparian zone, including controlling livestock access, managing weeds and retaining native vegetation (DSITIA, 2012b). Riparian and wetland vegetation is also retained for its economic value as well as its biodiversity value. The local pastoral industry makes use of riparian and wetland vegetation such as water couch, channel miller and neverfail following floods (Cottingham, 1999). **Consequence** The consequence of water temperature outside natural ranges in the Paroo system specifically is unknown, due to the lack of barriers to flow and the naturally low levels of vegetation in this semi-arid system (Clark et al., 2015; Van den berg, et al., 2015). However, there is knowledge of the ecological consequences of vegetation removal and dam releases in other Australian river systems (For example, Rutherford et al, 2004 and EPA Victoria, 2004).
Pest fauna - land	4	3	12	3	3	**Likelihood** The expert panel indicated that due to the behaviour of feral pigs and other pest species, controlling land-based pest fauna will be an ongoing concern into the future. Of the land-based pest fauna, feral pigs represent the greatest risk to water quality. Feral pigs are present in at least 25-50% of the Paroo catchment (DEEDI, 2007). Feral pigs are prolific breeders, with the population able to increase five fold in 12 months (Kirby, 2007a). As a result, feral pig control is a difficult and ongoing process. **Consequence** The impact of the aquatic impacts of feral pigs and other pest fauna in the South West region is well

						documented, not only in literature but also anecdotally from land managers (http://www.southwestnrm.org.au/ihub/nrm-topics/pigs). Feral pigs stay near water to drink and wallow, leading to fouling of water bodies, vegetation removal and erosion (Kirby, 2007a). The resulting damage to the aquatic ecosystem has economic, environmental and social implications. Rabbits and feral goats contribute to soil erosion and the subsequent siltation of aquatic ecosystems (Negus et al., 2012).
Pest fauna - aquatic	3	4	12	3	3	**Likelihood** Gambusia, carp and goldfish are present in the Paroo basin (Negus et al, 2012). Redclaw crayfish are not currently present and were not identified as a high potential to enter the basin (Negus et al, 2012). The expert panel indicated that natural resource management actions are being applied to try and control the further spread of the pest aquatic fauna in the Paroo basin. **Consequence** Carp are known to lead to direct water quality deterioration through increases to suspended sediment and nutrients (Invasive Animals CRC, 2012; DAFF, 2012). Gambusia dominates instream habitats and reduces numbers of native fish (DAFF, 2012). The expert panel has field knowledge of infestations of pest aquatic fauna across South West.
Pest flora - land	4	2	8	3	3	**Likelihood** Based on expert knowledge of the Paroo system from land managers and the awareness of property infestations, the risk of terrestrial pest flora in the riparian zone is likely to occur into the future. The exotic weeds of concern in the Paroo are Parkinsonia (Parkinsonia aculeata), Noogoora Burr and Bathurst Burr (South West NRM, 2012). The native woody weeds of concern are Ellangowan, Grey Turkey Bush, Green Turkey Bush, Buddha, Hopbush, Needle Brush and Mulga (South West NRM, 2012). **Consequence** The expert panel established that the consequence of land-based pest flora specifically for water quality is minor. Although land-based pest flora are damaging to the ecosystem, they can produce benefits to water quality by providing bank stabilisation and shade to the main channel (Ede & Hunt, 2008). There may be a risk of herbicide entering the channel if used in incorrect quantities to control pest flora. However, it is recommended that the use of herbicides near waterways is minimised and alternative techniques are adopted instead (Ainsworth & Bowcher, 2005).
Pest flora - aquatic	4	4	16	3	3	**Likelihood** Based on knowledge of the Paroo system from land managers and research into pest flora species, outbreaks of water lettuce and other aquatic pest flora species is possible. Predictive weed maps by the

						Department of Agriculture, Fisheries and Forestry indicate that the climate suitability for water lettuce growth in the Bulloo is marginal, compared to the tropical conditions of the east coast (DAFF, 2011). However, as water lettuce prefers stationary or slow-moving streams, it has the potential to become established in most of Queensland (DEEDI, 2012). The expert panel indicated that the likelihood of water lettuce entering the Paroo is increased as the Paroo and Warrego are interconnected and water lettuce is already established in the Warrego. **Consequence** Outbreaks of water lettuce have many implications for the aquatic ecosystem including water loss through excessive transpiration, increased debris, sunlight inhibition and oxygen exchange prevention (Kirby, 2007b; DEEDI, 2012). This can lead to social, economic and environmental consequences such as preventing access to recreational areas, inhibiting stock watering and impeding native plant growth, respectively (DEEDI, 2012).
Climate change	1	3	3	2	2	**Likelihood** In the 10 year life of the plan, the expert panel indicated that the risk that water quality impacts from climate change would occur is assumed to be rare. Based on CSIRO (2007), the 'best estimate 2030 climate scenario' for the Paroo identifies a 2% reduction in mean annual runoff for the region. However, the report states that there is considerable uncertainty in the climate predictions for 2030 (different climate models and different global warming scenarios), meaning mean annual runoff could range from a 16% reduction to a 40% increase (CSIRO, 2007). **Consequence** The expert panel indicated that the South West landscape has evolved under an extreme climate, therefore a 2% reduction in mean annual runoff for the Paroo region under an applied ‘best estimate 2030 climate scenario’ is not expected to have major consequences for water quality. As indicated by CSIRO (2007), there is still uncertainty as to extent of climate change impacts. If climate change does increase the frequency and duration of extreme events, it is predicted that communities in South West Queensland may be better able to adapt to these conditions compared to communities that currently do not experience climate extremes on a regular basis (Queensland Government, 2009).

Bulloo drainage basin surface water risk register						
Risk factor/source	Risk analysis			Confidence score		
	L	C	Level of Risk	L	C	Justification
Elevated levels of salinity	1	4	4	3	2	**Likelihood** The expert panel indicated that ambient saline groundwater and surface water discharges into surface water systems would not present a water quality degradation issue over the next ten years. In terms of increased deep drainage below irrigated land displacing saline groundwater to surface water systems—livestock grazing is the dominant land use in the Bulloo region (approximately 95% of land area). There is minimal irrigation or other practices that cause elevated levels of salinity (DSITIA, 2012). Land management practices involving the replacement of deep-rooted vegetation with shallow-rooted crops and pastures, resulting in increased rainfall recharge displacing saline groundwater to surface water systems—The expert panel, including staff responsible for the implementation of the Basin Salinity Management Strategy in Queensland, assessed the likelihood as rare due to minimal cropping development in the region. The expert panel indicated that existing land uses are not expected to change dramatically in the life of the plan. This region has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth of water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent salinity impacts. Note: If the water allocation and planning policy were to change in this region it would affect the likelihood score. Climate change presents the risk of causing an increase in bare ground due to extreme events. This in turn can lead to elevated levels of salinity. However, the expert panel indicated that the likelihood of an extreme event producing the extent of bare ground required to produce a consequence was very rare. No climate change modelling has been undertaken for the Bulloo catchment. However given the proximity to and the similarities it shares with the Paroo catchment, it is likely to be affected in a similar way to Paroo catchment. Under the best estimate (median) 2030 climate scenario for the Paroo there would only be a 2% reduction in mean annual runoff across the entire region (CSIRO, 2007). It is assumed this would not be of an extreme to produce excessive bare ground.

						Consequence There is some confidence in the score due to general knowledge about the impacts of elevated levels of salinity. However, specific knowledge of the South West environment in terms of its response to elevated levels of salinity could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated levels of suspended matter—Including deposited sediment	5	4	20	2	2	**Likelihood** As livestock grazing represents approximately 95% of the land area in the Bulloo catchment, overgrazing of catchments and grazing of riverbanks and floodplains is likely (DSITIA, 2012). The expert panel indicated grazing management (e.g. goats, kangaroos and cattle) is required to prevent overgrazing from occurring—particularly in the dry season. A low percentage of ground cover at the end of the winter dry season can leave soils exposed to erosion from wind and rain from summer storms, resulting in sediment being deposited in waterways, increasing turbidity, and carrying nutrients. A discernible and widespread impact in the Bulloo region, which contributes to elevated levels of suspended matter, is riparian and bank damage by stock access (Choy et al, 2002). Grazing and other anthropogenic factors that currently contribute to elevated levels of suspended matter are not expected to increase in area in the next ten years due to low population growth rate prediction (OESR, 2011). The expert panel indicated that the landscape of the Bulloo is comprised of hard mulga and rocky residuals, resulting in low permeability and high runoff. The expert panel also indicated that hillslope erosion is an issue in this catchment. Due to the soils and slope of the catchment, elevated suspended matter is almost certain. Additional knowledge is required to support the likelihood of deposited sediment in the Bulloo catchment—however anecdotal community information has indicated siltation of waterholes is occurring. The expert panel indicated that the existing stressors (overgrazing, clearing of riparian zones and reduced groundcover) that contribute to elevated levels of suspended matter, including deposited sediment, will need to be managed over the next ten years to ensure current sediment levels are maintained and/or improved. South West NRM Ltd. indicated that wave wash in Lake Houdraman is occurring—however additional knowledge is required to characterise the risk. Note: Elevated levels of suspended matter, including deposited sediment, will be exacerbated in exceptional circumstances, such as an extreme prolonged drought event. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels

						of suspended matter, including deposited sediment. However, specific knowledge of the South West environment in terms of its response to elevated levels of suspended matter, particularly deposited sediment, needs to be improved. The expert panel indicated that the South West ecosystem has evolved under conditions of elevated suspended matter, likely resulting in less consequence to the area from this risk. However, elevated levels of deposited sediment are predicted to be having a greater impact on the system, presumably through the siltation of refugial waterholes. This is supported by higher consequence scores for deposited sediment than suspended sediment in Negus et al, 2012. Further research into the impact of deposited sediment will be conducted (Negus et al, 2012).
Elevated levels of nutrients, including phosphorus and nitrogen	1	4	4	3	2	**Likelihood** The percentage land use of intensive animal production, manufacturing and industrial, perennial horticulture, and waste treatment and disposal in the Bulloo basin is negligible (DSITIA, 2012). As a result, the expert panel indicated that the likelihood of the following factors causing water quality degradation as a result of these land uses in the Bulloo catchment would be rare: • soil and organic matter; • animal waste; • fertilisers; • sewage and industrial discharges; • nutrients from water storages released as a result of storage management practices. The expert panel indicated that these land uses that contribute to elevated nutrients in streams are not expected to change dramatically in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent nutrient impacts. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of nutrients. However, specific knowledge of the South West environment in terms of its response to elevated levels of nutrients could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).

Elevated cyanobacteria cell counts or biovolume, toxins and odour compounds	1	4	4	3	2	**Likelihood** The expert panel advised that outbreaks of cyanobacteria are limited by high turbidity, which restricts the amount of light available to cyanobacteria to photosynthesis. There is also a lack of land uses that input excessive quantities of phosphorus and nitrogen into the water in this region (DSITIA, 2012). Cyanobacterial growth is inhibited if nutrient inputs are limited. Potentially toxic cyanobacteria are often a concern in regulated water systems, however the Bulloo has an end-of-system flow for the catchment of 99% of pre-development flows (Cottingham, 1999). Cyanobacteria in South West catchments is expected to be similar to those recorded in Cooper Creek, which are mostly nontoxic species that represent an important part of the foodweb (Cottingham, 1999). **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated cyanobacteria. However, specific knowledge of the South West environment in terms of its response to elevated cyanobacteria could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Dissolved oxygen outside natural ranges	2	4	8	3	2	**Likelihood** Blackwater events in the Bulloo drainage basin were assessed by the expert panel as isolated events that are typically localised to a section of river or waterhole. They are unlikely to occur unless the factors that cause an event combine in extreme circumstances. Advice from South West NRM Ltd. (C. Alison pers. comm.) indicates that a blackwater event occurs in the Bulloo drainage basin approximately twice a year. Blackwater events have primarily been recorded by South West NRM Ltd. following a significant rainfall event, where organic material (predominately Eucalypt leaves) is carried from the riparian zone into the watercourse. If the vegetation matter enters a low and shallow stream or waterhole that contains optimal temperature conditions, a blackwater event can result. Blackwater events are a natural part of the ecology of lowland river systems, particularly during high flows. As the Bulloo drainage basin has an end-of-system flow of 99% of pre-development flows, the frequency of blackwater events is unlikely to increase as a result of water resource management. There is a rare likelihood of dissolved oxygen outside natural ranges as a result of micro-organisms consuming organic matter released from sewage treatment plants. The percentage of waste treatment and disposal in the Bulloo catchment is negligible (DSITIA, 2012). The low population growth, predicted to occur in the region, is likely to mitigate any potential occurrence of this water quality issue into the future. The population of the South West region was approximately 10 720 people in 2011 (ABS census). Forecast population growth is the lowest rate in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). The expert panel indicated that due to the low population and the limited likelihood of land use change and industry expansion, the occurrence of dissolved oxygen outside natural ranges

						is not expected to increase in the life of the plan. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent dissolved oxygen impacts. **Consequence** Advice from South West NRM Ltd. (C. Alison pers. comm.) indicates that blackwater events impact the local community through fish kills. Local fishers are particularly impacted by fish kills of yellow-belly (Macquaria ambigua). Specific knowledge of the South West environment in terms of its response to dissolved oxygen outside natural ranges could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated levels of pesticides, heavy metals and other toxic contaminants	1	4	4	3	2	**Likelihood** In the Bulloo catchment, land uses that produce elevated levels of pesticides and other contaminants (such as intensive animal production, manufacturing and industrial, perennial horticulture, and waste treatment and disposal) are negligible (DSITIA, 2012). The expert panel indicated that the current land uses that contribute to elevated levels of pesticides are not expected to increase in the South West region over the life of the plan due to predicted low population growth and minimal agricultural expansion (OESR, 2011). The likelihood of the following causes of elevated levels of pesticides, heavy metals and other toxic contaminates is assessed below: • pesticide spray drift—The Water Quality Technical Panel indicated there is a rare likelihood of this cause of water quality degradation occurring as land uses that implement pesticide sprays are negligible in the catchment. • allowing pesticides or other contaminants into surface water runoff—South West NRM Ltd. indicated that the majority of pesticides are used for cattle and sheep and these are no longer applied as dips, but rather as direct application (minimising runoff). • allowing pesticides or other contaminants to leach into groundwater—South West NRM Ltd. indicated most sheep dips have been non-commissioned and they are generally found in heavy clays where there is good containment of leachates. • allowing erosion of contaminated soil—The Water Quality Technical Panel indicated that this would be rare due to the negligible occurrence of contaminated soil in the catchment. • inappropriate disposal of pesticides—No evidence was presented to suggest inappropriate disposal of pesticides is occurring in the South West region. • inappropriate disposal and management of industrial and other waste (including from mining and coal-seam gas extraction)—No evidence was presented to suggest inappropriate disposal and

						management of industrial and other waste is occurring in the South West region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from elevated levels of heavy metals and other toxic contaminants. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated levels of pesticides and other contaminants. However, specific knowledge of the South West environment in terms of its response to elevated levels of contaminants could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Elevated pathogen counts	1	4	4	3	2	**Likelihood** The population of the South West region was approximately 10 720 people in 2011 (ABS census). Forecast population growth is the lowest rate in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). Due to the low population growth, increased sewage discharges from urban areas are not expected in the life of the plan. Intensive animal production and other point source discharge industries in the region are negligible (DSITIA, 2012). The expert panel indicated that due to the large land area, diffuse pathogen inputs from grazing lands are of low risk. **Consequence** There is some confidence in the score due to general knowledge about the impacts of elevated pathogen counts. However, specific knowledge of the South West environment in terms of its response to elevated pathogen counts could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
pH outside natural ranges	1	4	4	3	2	**Likelihood** Water chemistry in the Bulloo is generally alkaline (Choy et al, 2002). The expert panel indicated that oxidation of iron sulphide in the soil is of low risk in the Bulloo due to alkaline soils. Existing perennial horticulture in the area is negligible and agricultural practices that lead to the acidification of soils are not expected to increase in the life of the plan (DSITIA, 2012). High diurnal variation in pH as an indirect result of eutrophication is also of low risk due to the absence of land uses that input excessive nutrients into streams (DSITIA, 2012). Note: Monosulfides naturally occur in the saline lakes present in the Murray-Darling Basin (MDBA,

						2011). However, the expert panel indicated that the chance of development increasing in the Bulloo to disturb the soils of the saline lakes was deemed a low risk. **Consequence** There is some confidence in the score due to general knowledge about the impacts of pH outside natural ranges. However, specific knowledge of the South West environment in terms of its response to pH outside natural ranges could be improved. Dryland rivers are less well studied than rivers in more humid climates, often due to the low population densities of dryland catchments (Davies et al., 1994; Cottingham, 1999).
Water temperature outside natural ranges	1	4	4	3	2	**Likelihood** There are no water storages in the Bulloo basin that would generate a significant risk of altered water temperatures. The removal of shading riparian vegetation to the extent it would produce altered water temperatures was deemed a low risk by the expert panel. In the Bulloo catchment, 17% of riparian forest has been cleared since European settlement (Clark et al., 2015). Removal of riparian vegetation is not concurrent with natural resource management in the region. In 2010/11, 51% of agricultural businesses in the South West with creeks and rivers undertook activities to protect them (DSITIA, 2012b). The most popular protection activities were associated with protecting the riparian zone, including controlling livestock access, managing weeds and retaining native vegetation (DSITIA, 2012b). Riparian and wetland vegetation is also retained for its economic value as well as its biodiversity value. The local pastoral industry makes use of riparian and wetland vegetation such as water couch, channel miller and neverfail following floods (Cottingham, 1999). **Consequence** The consequence of water temperature outside natural ranges in the Bulloo system specifically is unknown, due to the lack of barriers to flow and the naturally low levels of vegetation in this semi-arid system (Clark et al., 2015; Van den berg et al., 2015). However, there is knowledge of the ecological consequences of vegetation removal and dam releases in other Australian river systems (For example, Rutherford et al, 2004 and EPA Victoria, 2004).
Pest fauna - land	4	3	12	3	3	**Likelihood** The expert panel indicated that due to the behaviour of feral pigs and other pest species, controlling land-based pest fauna will be an ongoing concern into the future. Of the land-based pest fauna, feral pigs represent the greatest risk to water quality. Feral pigs are present in at least 25-50% of the Bulloo catchment (DEEDI, 2007). Feral pigs are prolific breeders, with the population able to increase five fold in 12 months (Kirby, 2007a). As a result, feral pig control is a difficult and ongoing process. **Consequence** The impact of the aquatic impacts of feral pigs and other pest fauna in the South West region is well documented, not only in literature but also anecdotally from land managers

						(http://www.southwestnrm.org.au/ihub/nrm-topics/pigs). Feral pigs stay near water to drink and wallow, leading to fouling of water bodies, vegetation removal and erosion (Kirby, 2007a). The resulting damage to the aquatic ecosystem has economic, environmental and social implications. Rabbits and feral goats contribute to soil erosion and the subsequent siltation of aquatic ecosystems (Negus et al., 2012).
Pest fauna - aquatic	4	5	20	3	3	**Likelihood** Gambusia and goldfish are present in the Bulloo catchment. There is a high potential for carp and redclaw crayfish to move into this system (Negus et al, 2012). Natural resource management actions are being applied to try and prevent the spread of pest aquatic fauna into this system. As the Bulloo is a closed system, the expert panel indicated that the main risk of spread of carp is the use of the species by fishers for bait. Anecdotal evidence was also provided to suggest carp eggs could be carried into the system by waterbirds. **Consequence** The expert panel established that the consequence of this risk would be catastrophic due to the current absence of carp in the Bulloo system. The impact would be irreversible if carp were to access the system, as full eradication is not yet possible (Koehn et al, 2000). The social consequence would particularly be disastrous, as the community prides itself on the absence of this species in their catchment. If the redclaw crayfish was introduced to the Bulloo system, it is likely that it would compete with the native blueclaw crayfish (Cherax destructor) (Negus et al, 2012).
Pest flora - land	4	2	8	3	3	**Likelihood** Based on knowledge of the Bulloo system from land managers and the awareness of property infestations, the risk of terrestrial pest flora in the riparian zone is likely to occur into the future. The exotic weeds of concern in the Bulloo are Mesquite (Proposis flexuosa) and Parkinsonia (Parkinsonia aculeate) (South West NRM, 2012). **Consequence** The expert panel established that the consequence of land-based pest flora specifically for water quality is minor. Although land-based pest flora are damaging to the ecosystem, they can produce benefits to water quality by providing bank stabilisation and shade to the main channel (Ede & Hunt, 2008). There may be a risk of herbicide entering the channel if used in incorrect quantities to control pest flora. However, it is recommended that the use of herbicides near waterways is minimised and alternative techniques are adopted instead (Ainsworth & Bowcher, 2005).
Pest flora - aquatic	3	4	12	3	3	**Likelihood** Based on knowledge of the Bulloo system from land managers and research into pest flora species, outbreaks of water lettuce and other aquatic pest flora species is possible. Predictive weed maps by the

						Department of Agriculture, Fisheries and Forestry indicate that the climate suitability for water lettuce growth in the Bulloo is marginal, compared to the tropical conditions of the east coast (DAFF, 2011). However, as water lettuce prefers stationary or slow-moving streams, it has the potential to become established in most of Queensland (DEEDI, 2012). **Consequence** Outbreaks of water lettuce have many implications for the aquatic ecosystem including water loss through excessive transpiration, increased debris, sunlight inhibition and oxygen exchange prevention (Kirby, 2007b; DEEDI, 2012). This can lead to social, economic and environmental consequences such as preventing access to recreational areas, inhibiting stock watering and impeding native plant growth, respectively (DEEDI, 2012).
Climate change	1	4	4	2	2	**Likelihood** In the 10 year life of the plan, the risk that water quality impacts from climate change would occur is assumed to be rare. Based on CSIRO (2007), the 'best estimate 2030 climate scenario' for the Paroo identifies a 2% reduction in mean annual runoff for the region. Due to the similarities between the Paroo and Bulloo drainage basins, this figure is assumed to represent the potential change to the Bulloo climate. The CSIRO report (2007) states there is considerable uncertainty in the climate predictions for 2030 (different climate models and different global warming scenarios), meaning mean annual runoff could range from a 16% reduction to a 40% increase (CSIRO, 2007). **Consequence** The expert panel indicated that the South West landscape has evolved under an extreme climate, therefore a predicted 2% reduction in mean annual runoff for the Bulloo region under an applied 'best estimate 2030 climate scenario' is not expected to have major consequences for water quality. As indicated by CSIRO (2007), there is still uncertainty as to extent of climate change impacts. If climate change does increase the frequency and duration of extreme events, it is predicted that communities in South West Queensland may be better able to adapt to these conditions compared to communities that currently do not experience climate extremes on a regular basis (Queensland Government, 2009). South West NRM Ltd identified that the potential impacts of climate change in the Bulloo would cause a greater impact to community values than other drainage basins due to the largely undisturbed nature of the system. The consequence score was increased accordingly.

St George Alluvium - Shallow (WPBN) groundwater risk register						
Risk factor/source	Risk analysis			Confidence score		
	L	C	Level of Risk	L	C	Justification
Elevated levels of salinity	1	3	3	2	2	**Likelihood** Although clearing has occurred historically in the Nebine/Mungallala/Wallam catchment, irrigation is marginal (Clark et al., 2015; DSITIA, 2012). As a result, the expert panel indicated that there would be little change in the salt flux of the St George Alluvium (shallow)[48]. The expert panel also indicated that groundcover in pastures assists in keeping the risk of elevated levels of salinity low. The expert panel indicated that clearing is managed through Vegetation Management Act 1999 and that the area of clearing is not expected to increase to produce salinity consequences. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent salinity impacts. **Consequence** Existing poor water quality—not many users. Information relating specifically to groundwater SDL areas is limited and the majority of information available concerns the principal aquifer systems. The expert panel indicated that there is a lower confidence level due to lack of research in the shallow and deep alluvium. Generally water quality in aquifers in the Paroo and Warrego is relatively poor and only suitable only for stock and domestic use (CSIRO 2007a 2007 b). As the resource is not typically high use, the consequence to users will be less.
Elevated levels of suspended matter	Not assessed due to little to no significance to groundwater.					

[48] Note: The Basin Plan recognises the St George Alluvium groundwater aquifers in the plan area as a single SDL resource unit termed the St George Alluvium Warrego–Paroo-Nebine (GS63). However, under Queensland water resource planning, this resource unit is managed as the St George Alluvium (shallow) and the St George Alluvium (Deep).

Elevated levels of nutrients, including phosphorus and nitrogen	1	1	1	2	2	**Likelihood** The percentage land use of aquaculture, cropping, manufacturing and industrial, production forestry, and waste treatment and disposal in the Nebine/Mungallala/Wallam basin is negligible (DSITIA, 2012). There is a low likelihood in an increase in irrigated agriculture as development is capped by the SDL. The expert panel indicated that existing land uses that contribute to elevated nutrients that may infiltrate groundwater are not expected to change dramatically in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent nutrient impacts. **Consequence** The expert panel indicated that there is a lower confidence level due to lack of research in the shallow and deep alluvium. Generally water quality in aquifers in the Paroo and Warrego is relatively poor and only suitable only for stock and domestic use (CSIRO 2007a 2007 b). As the resource is not typically high use, the consequence to users will be less.
Elevated cyanobacteria cell counts or biovolume, toxins and odour compounds	Not assessed due to little to no significance to groundwater.					
Dissolved oxygen outside natural ranges	Not assessed due to little to no significance to groundwater.					
Elevated levels of pesticides, heavy metals and other toxic contaminants	1	1	1	2	2	**Likelihood** The percentage land use of aquaculture, cropping, manufacturing and industrial, production forestry, and waste treatment and disposal in the Nebine/Mungallala/Wallam basin is negligible (DSITIA, 2012). There is a low likelihood in an increase in irrigated agriculture as development is capped by the SDL. The expert panel indicated that existing land uses that contribute to elevated

						contaminants that may infiltrate groundwater are not expected to change dramatically in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from contaminants. **Consequence** The expert panel indicated that there is a lower confidence level due to lack of research in the shallow and deep alluvium. Generally water quality in aquifers in the Paroo and Warrego is relatively poor and only suitable only for stock and domestic use (CSIRO 2007a 2007 b). As the resource is not typically high use, the consequence to users will be less.
Elevated pathogen counts	1	1	1	2	2	**Likelihood** The percentage land use of aquaculture, cropping, manufacturing and industrial, production forestry, and waste treatment and disposal in the Nebine/Mungallala/Wallam basin is negligible (DSITIA, 2012). There is a low likelihood in an increase in irrigated agriculture as development is capped by the SDL. The expert panel indicated that existing land uses that contribute to elevated pathogens that may infiltrate groundwater are not expected to change dramatically in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from pathogens. **Consequence** The expert panel indicated that there is a lower confidence level due to lack of research in the shallow and deep alluvium. Generally water quality in aquifers in the Paroo and Warrego is relatively poor and only suitable only for stock and domestic use (CSIRO 2007a 2007 b). As the resource is not typically high use, the consequence to users will be less.
pH outside natural	Not assessed due to little to no significance to groundwater.					

ranges						
Water temperature outside natural ranges	Not assessed due to little to no significance to groundwater.					
Climate change	1	1	1	2	2	**Likelihood** The Nebine catchment is dealt with in the CSIRO sustainable yields report for the Condamine and Balonne (CSIRO, 2008). This report does not make specific reference to the SGA (deep or shallow) in terms of impacts from climate change, however it does make a general comment regarding the whole catchment, that rainfall recharge to groundwater could either increase or decrease as a result of climate change but this would not exceed 10 %. There is limited knowledge of the characteristics of the St George Alluvium. **Consequence** There is very limited knowledge of the characteristics of the SaGAB. Existing information describes a system with a very low level of use (only for stock and domestic purposes), and highly variable, low water quality (CSIRO 2007a 2007 b The expert panel indicated that the South West landscape has evolved under an extreme climate, therefore a change in water availability is unlikely to impact dramatically. As indicated by CSIRO sustainable yield reports (CSIRO 2007a 2007 b 2008), there is still uncertainty as to extent of climate change impacts. The expert panel indicated that recharge to systems in this region is dependent on the number of days of rain rather than changes in volume which is where climate change science to date has been focussed. If climate change does increase the frequency and duration of extreme events, it is predicted that communities in South West Queensland may be better able to adapt to these conditions compared to communities that currently do not experience climate extremes on a regular basis (Queensland Government, 2009).

St George Alluvium - Deep (WPBN) groundwater risk register						
Risk factor/source	Risk analysis			Confidence score		
	L	C	Level of Risk	L	C	Justification
Elevated levels of salinity	2	4	8	2	2	**Likelihood** The expert panel indicated that the St George Alluvium deep[49] aquifer is comprised of low salinity groundwater. Due to aquifer connectivity, the expert panel identified that, although unlikely, increased groundwater use from the St George Alluvium deep aquifer could result in elevated levels of salinity. This would result from infiltration of saline waters from the surrounding St George Alluvium shallow aquifer and the Great Artesian Basin. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent salinity impacts. **Consequence** If salinity is to increase it would cause complications for stock and domestic and other uses—impacting productivity in the region. Due to the importance of groundwater for sustaining the community in the dryland catchments of the South West region, the salinization of reserves would have a significant impact on local values and the ability to use water. Due to the slow process of infiltration and recharge, the aquatic ecosystem is predicted to take some time to recover if elevated levels of salinity were to occur.
Elevated levels of suspended matter	Not assessed due to little to no significance to groundwater.					

49 Note: The Basin Plan recognises the St George Alluvium groundwater aquifers in the plan area as a single SDL resource unit termed the St George Alluvium Warrego–Paroo-Nebine (GS63). However, under Queensland water resource planning, this resource unit is managed as the St George Alluvium (shallow) and the St George Alluvium (Deep).

Elevated levels of nutrients, including phosphorus and nitrogen	1	1	1	2	2	**Likelihood** The percentage land use of aquaculture, cropping, manufacturing and industrial, production forestry, and waste treatment and disposal in the Nebine/Mungallala/Wallam basin is negligible (DSITIA, 2012). There is a low likelihood in an increase in irrigated agriculture as development is capped by the SDL. The expert panel indicated that existing land uses that contribute to elevated nutrients that may infiltrate groundwater are not expected to change dramatically in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region (State of Queensland, 2012). As any additional nutrients would need to infiltrate through the St George Alluvium - Shallow aquifer before reaching the St George Alluvium—Deep aquifer, means that the likelihood of elevated nutrients in the deeper aquifer is even less. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent nutrient impacts. **Consequence** The expert panel indicated that there is a lower confidence level due to lack of research in the shallow and deep alluvium. Generally water quality in aquifers in the Paroo and Warrego is relatively poor and only suitable only for stock and domestic use (CSIRO 2007a 2007b). As the resource is not typically high use, the consequence to users will be less.
Elevated cyanobacteria cell counts or biovolume, toxins and odour compounds	Not assessed due to little to no significance to groundwater.					
Dissolved oxygen outside natural ranges	Not assessed due to little to no significance to groundwater.					
Elevated levels of pesticides, heavy metals and other	1	1	1	2	2	**Likelihood** The percentage land use of aquaculture, cropping, manufacturing and industrial, production forestry, and waste treatment and disposal in the Nebine/Mungallala/Wallam basin is negligible

toxic contaminants						(DSITIA, 2012). There is a low likelihood in an increase in irrigated agriculture as development is capped by the SDL. The expert panel indicated that existing land uses that contribute to elevated contaminants that may infiltrate groundwater are not expected to change dramatically in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region. As any additional nutrients would need to infiltrate through the St George Alluvium - Shallow aquifer before reaching the St George Alluvium—Deep aquifer, means that the likelihood of elevated contaminants in the deeper aquifer is even less. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from contaminants. **Consequence** The expert panel indicated that there is a lower confidence level due to lack of research in the shallow and deep alluvium. Generally water quality in aquifers in the Paroo and Warrego is relatively poor and only suitable only for stock and domestic use (CSIRO 2007a 2007b). As the resource is not typically high use, the consequence to users will be less.
Elevated pathogen counts	1	1	1	2	2	**Likelihood** The percentage land use of aquaculture, cropping, manufacturing and industrial, production forestry, and waste treatment and disposal in the Nebine/Mungallala/Wallam basin is negligible (DSITIA, 2012). There is a low likelihood in an increase in irrigated agriculture as development is capped by the SDL. The expert panel indicated that existing land uses that contribute to elevated pathogens that may infiltrate groundwater are not expected to change dramatically in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). In addition, suitable ambient water quality and access issues restrict the growth in water use in this region. As any additional nutrients would need to infiltrate through the St George Alluvium - Shallow aquifer before reaching the St George Alluvium—Deep aquifer, means that the likelihood of elevated pathogens in the deeper aquifer is even less. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from pathogens.

						Consequence The expert panel indicated that there is a lower confidence level due to lack of research in the shallow and deep alluvium. Generally water quality in aquifers in the Paroo and Warrego is relatively poor and only suitable only for stock and domestic use (CSIRO 2007a 2007b). As the resource is not typically high use, the consequence to users will be less.
pH outside natural ranges	Not assessed due to little to no significance to groundwater.					
Water temperature outside natural ranges	Not assessed due to little to no significance to groundwater.					
Climate change	1	1	1	2	2	**Likelihood** The Nebine catchment is dealt with in the CSIRO sustainable yields report for the Condamine and Balonne (CSIRO, 2008). This report does not make specific reference to the SGA (deep or shallow) in terms of impacts from climate change, however it does make a general comment regarding the whole catchment, that rainfall recharge to groundwater could either increase or decrease as a result of climate change but this would not exceed 10 %. There is limited knowledge of the characteristics of the St George Alluvium. **Consequence** There is very limited knowledge of the characteristics of the SaGAB. Existing information describes a system with a very low level of use (only for stock and domestic purposes), and highly variable, low water quality (CSIRO 2007a, 2007b). The expert panel indicated that the South West landscape has evolved under an extreme climate, therefore a change in water availability is unlikely to impact dramatically. As indicated by CSIRO sustainable yield reports (CSIRO 2007a 2007b 2008), there is still uncertainty as to extent of climate change impacts. The expert panel indicated that recharge to systems in this region are more dependent on the number of days rain rather than changes in volume which is where climate change science to date has been focussed. If climate change does increase the frequency and duration of extreme events, it is predicted that communities in South West Queensland may be better able to adapt to these conditions compared to communities that currently do not experience climate extremes on a regular basis (Queensland Government, 2009).

Sediments above the GAB (WPBN) groundwater risk register						
Risk factor/source	Risk analysis			Confidence score		
	L	C	Level of Risk	L	C	Justification
Elevated levels of salinity	1	1	1	3	2	**Likelihood** The expert panel indicated that it would be rare for elevated levels of salinity to occur in future in the SaGAB. The bore records from the Department of Natural Resources and Mines show very poor water quality in this aquifer (DNRM, 2013). The SaGAB is predominately naturally saline and can exceed TDS values of over 20 000 milligrams per litre. This results in minimal demand for the water resources contained in the sediments above the GAB (Ife & Skelt 2004). The South West also has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent salinity impacts. **Consequence** There is very limited knowledge of the characteristics of the SaGAB, with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the SaGAB. The CSIRO (2007a, 2007b) sustainable yields report for the Warrego and for the Paroo makes comment on water in all aquifers are not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes. Due to the naturally saline conditions, the expert panel assumed that further elevations of salinity in the SaGAB would be of insignificant consequence.
Elevated levels of suspended matter	Not assessed due to little to no significance to groundwater.					
Elevated levels of nutrients, including phosphorus and nitrogen	1	1	1	3	2	**Likelihood** The expert panel indicated that due to the hydraulics of the SaGAB (i.e. very slow recharge rates and large depth to water table) the likelihood that contamination would reach the aquifer is rare. In addition, sources of contamination such as sewage treatment plants and landfills are negligible across the area (DSITIA, 2012). The expert panel indicated that these sources of

						contamination are not expected to increase in the South West in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from nutrients. **Consequence** There is very limited knowledge of the characteristics of the SaGAB, with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the SaGAB. The CSIRO (2007a, 2007b) sustainable yields report for the Warrego and for the Paroo makes comment on water in all aquifers are not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes.
Elevated cyanobacteria cell counts or biovolume, toxins and odour compounds	Not assessed due to little to no significance to groundwater.					
Dissolved oxygen outside natural ranges	Not assessed due to little to no significance to groundwater.					
Elevated levels of pesticides, heavy metals and other toxic contaminants	1	1	1	3	2	**Likelihood** The expert panel indicated that due to the hydraulics of the SaGAB (i.e. very slow recharge rates and large depth to water table) the likelihood that contamination would reach the aquifer is rare. In addition, the percentage land use of intensive animal production, manufacturing and industrial, perennial horticulture, landfill, and waste treatment and disposal in the Bulloo basin is negligible (DSITIA, 2012). The expert panel indicated that these sources of contamination are not expected to increase in the South West in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at 0.35% p.a. until 2031 (OESR, 2011). The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years. However, with management actions implemented through Environmental Authorities it is assumed that contaminant impacts would be prevented.

						Consequence There is very limited knowledge of the characteristics of the SaGAB, with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the SaGAB, with only small livestock supplies (Ife & Skelt 2004). The CSIRO (2007a, 2007b) sustainable yields report for the Warrego and for the Paroo makes comment on water in all aquifers are not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes.
Elevated pathogen counts	1	1	1	3	2	**Likelihood** The expert panel indicated that due to the hydraulics of the SaGAB (i.e. very slow recharge rates and large depth to water table) the likelihood that contamination would reach the aquifer is rare. In addition, the percentage land use of intensive animal production, manufacturing and industrial, perennial horticulture, landfill, and waste treatment and disposal in the Bulloo basin is negligible (DSITIA, 2012). The expert panel indicated that these sources of contamination are not expected to increase in the South West in the life of the plan. The South West has the lowest population growth rate prediction in the QMDB at approximately 0.35% p.a. until 2031 (OESR, 2011). The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from pathogens. **Consequence** There is very limited knowledge of the characteristics of the SaGAB, with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the SaGAB, with only small livestock supplies (Ife & Skelt 2004). The CSIRO (2007a, 2007b) sustainable yields report for the Warrego and for the Paroo makes comment on water in all aquifers are not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes.
pH outside natural ranges	Not assessed due to little to no significance to groundwater.					
Water temperature outside natural ranges	Not assessed due to little to no significance to groundwater.					

Climate change	1	1	1	2	2	**Likelihood** The expert panel indicated that due to the hydraulics of the SaGAB (i.e. very slow recharge rates and large depth to water table) the likelihood that climate change would affect the aquifer is rare. The expert panel indicated recharge into the SaGAB occurs through infiltration through overlying geology (soils) and streamflow (alluvial systems). Infiltration through overlying soils is unlikely to change with minor changes in rainfall. The majority of rainfall results in runoff and evaporation rather than infiltration. The expert panel indicated that recharge from streamflow is not dependent on the volume passing. Rather, in both instances, recharge is primarily dependent on the frequency of rainfall rather than volume. As flow events in South West are typically periodic large events rather than frequent small events, recharge is slow. Climate change research has not indicated more frequent small events will occur in South West Queensland (Queensland Government, 2009). **Consequence** There are no assessments of the impact of climate change on the SaGAB. However, the CSIRO (2007a) sustainable yields report for the Warrego makes comment on 'shallow aquifers' which are considered to capture the SaGAB. There is very limited knowledge of the characteristics of the SaGAB. Existing information describes a system with a very low level of use (only for stock and domestic purposes), and highly variable, low water quality (CSIRO2007a, 2007b). The expert panel indicated that further extremes in climate are not expected to have major consequences for the water quality of the SaGAB. In these catchments groundwater recharge is more dependent on the number of days rain rather than the volume which is where climate change science to date has been focussed. If climate change does increase the frequency and duration of extreme events, it is predicted that communities in South West Queensland may be better able to adapt to these conditions compared to communities that currently do not experience climate extremes on a regular basis (Queensland Government, 2009). Risk analysis based primarily on the CSIRO sustainable yields report for the Warrego. This report, while based on the best available science is subject to significant uncertainty as illustrated by the large variation in extreme climate scenarios.

Warrego Alluvium (WPBN) groundwater risk register						
Risk factor/source	Risk analysis			Confidence score		
	L	C	Level of Risk	L	C	Justification
Elevated levels of salinity—ABOVE Wyandra	1	4	4	2	3	**Likelihood** The expert panel indicated that there is more development in the Warrego in comparison to the other South West basins; however in the context of the size of the basin the development is minimal. The expert panel indicated that in some areas of the Warrego the salt stores in the landscape are high and there is high evaporative demand. Irrigation close to major watercourses increases the likelihood of salt entering the stream. There is a high salt store (shallow, saline watertable) above Wyandra that could produce salinity consequences if irrigation is not conducted appropriately. As long as irrigators (currently around Cunnamulla) continue to implement water use efficient practices (e.g. trickle irrigation, lateral moves and pivot irrigation), the risk of elevated levels of salinity occurring in this area will be rare. In addition, due to the low population growth rate expected in the next ten years, an expansion of irrigation is not expected (OESR, 2011). Although groundwater availability has been identified in the Basin Plan through the SDLs (indicates a level well above the current limits), an expansion in development in the next 10 years is not anticipated due to this low population growth rate. There is lesser risk of elevated levels of salinity from irrigation around Charleville as a lower salt store occurs here. The expert panel indicated that the system above Wyandra flushes more frequently, providing more support to a low likelihood of elevated levels of salinity above Wyandra. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years. However, with management actions implemented through Environmental Authorities it is assumed that salinity impacts would be prevented. **Consequence** If irrigation is not conducted appropriately and the shallow, saline water tables in the lower Warrego alluvia discharge to land/stream, there is potential to cause major financial loss to irrigators. Other Environmental Values would also be adversely affected, but could recover in the medium term. The confidence in the consequence score of the impact of salinity in the Warrego landscape is largely derived from the salinity audit for this region (Power et al., 2007).
Elevated levels of salinity—BELOW Wyandra	1	4	4	1	2	**Likelihood** Although there is more salt store in the landscape downstream of Wyandra, development is required to trigger adverse salinity consequences. The expert panel indicated that groundwater

						below Wyandra is more saline and typically not usable. As a result, an increase in demand for the resource is not expected. Although groundwater availability has been identified in the Basin Plan through the SDLs (indicates a level well above the current limits), an expansion in development in the next 10 years is not anticipated due to the predicted low population growth rate (OESR, 2011). There is low confidence in the likelihood of where salinity could occur if it was triggered, as it depends on the soil composition at the location of irrigation. The expert panel indicated that current irrigation below Wyandra is not expected to increase. Although potential for inland acid sulphate soils (monosulfides) are found naturally in the Warrego Alluvium and in conjunction with irrigation development, the expert panel indicated that the likelihood of development increasing in the Warrego to disturb these soils was rare (MDBA, 2011). The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent salinity impacts. **Consequence** The expert panel indicated that further information is required on the tolerance of terrestrial groundwater dependent ecosystems to salinity. As the resource is not typically usable, the consequence to users will be less.
Elevated levels of suspended matter	Not assessed due to little to no significance to groundwater.					
Elevated levels of nutrients, including phosphorus and nitrogen—ABOVE Wyandra	2	3	6	2	2	**Likelihood** The percentage land use of cropping, effluent ponds, intensive animal production, irrigated agriculture, landfill, manufacturing and industrial, production forestry, residential, rural residential, and waste treatment and disposal in the Warrego basin is minimal (Approximately 1.2% of the landscape) (DSITIA, 2012). The expert panel indicated that there is the presence of stock and domestic above Wyandra. The expert panel indicated that the Warrego Alluvium above Wyandra is sandy—producing faster recharge and through flow (More permeable). If development were to increase, there is a possibility that elevated nutrient levels could occur, albeit unlikely. The town of Charleville presents a potential source of nutrients into groundwater, as well as major agricultural industries above Wyandra. However, growth in development is not expected due to the predicted low population growth rate (OESR, 2011). The potential for nutrients into the groundwater due to a sandier system is known in terms of first principles but has not been proven directly in the area.

						The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent nutrient impacts. **Consequence** There is limited knowledge of the characteristics of the aquifer with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the aquifer. The CSIRO (2007b) sustainable yields report for the Warrego makes comment that water in all aquifers is not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes.
Elevated levels of nutrients, including phosphorus and nitrogen—BELOW Wyandra	2	2	4	2	2	**Likelihood** The percentage land use of cropping, effluent ponds, intensive animal production, irrigated agriculture, landfill, manufacturing and industrial, production forestry, residential, rural residential, and waste treatment and disposal in the Warrego basin is minimal (Approximately 1.2% of the landscape) (DSITIA, 2012). The expert panel also indicated that there is not as much presence of stock and domestic below Wyandra. They specified that the Warrego Alluvium below Wyandra is less permeable and less transmissive due to clay content of the aquifer. The expert panel indicated that groundwater below Wyandra is more saline and typically not usable. As a result, an increase in demand for the resource is not expected. Although groundwater availability has been identified in the Basin Plan through the SDLs (indicates a level well above the current limits), an expansion in development in the next 10 years is not anticipated due to the predicted low population growth rate (OESR, 2011). The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent nutrient impacts. **Consequence** There is limited knowledge of the characteristics of the aquifer with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the aquifer. The CSIRO (2007b) sustainable yields report for the Warrego makes comment that water in all aquifers is not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes.
Elevated	Not assessed due to little to no significance to groundwater.					

cyanobacteria cell counts or biovolume, toxins and odour compounds						
Dissolved oxygen outside natural ranges	Not assessed due to little to no significance to groundwater.					
Elevated levels of pesticides, heavy metals and other toxic contaminants—ABOVE Wyandra	2	3	6	2	2	**Likelihood** The percentage land use of cropping, effluent ponds, intensive animal production, irrigated agriculture, landfill, manufacturing and industrial, production forestry, residential, rural residential, and waste treatment and disposal in the Warrego basin is minimal (Approximately 1.2% of the landscape) (DSITIA, 2012). The expert panel indicated that there is the presence of stock and domestic above Wyandra. The expert panel indicated that the Warrego Alluvium above Wyandra is sandy—producing faster recharge and throughflow (More permeable). If development were to increase, there is a possibility that elevated contaminant levels could occur, albeit unlikely. Industry around Charleville presents a potential source of contaminants into groundwater, as well as major agricultural industries above Wyandra. However, growth in development is not expected due to the predicted low population growth rate (OESR, 2011). The potential for contaminants into the groundwater due to a sandier system is known in terms of first principles but has not been proven directly in the area. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from contaminants. **Consequence** There is limited knowledge of the characteristics of the aquifer with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the aquifer. The CSIRO (2007b) sustainable yields report for the Warrego makes comment that water in all aquifers is not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes.
Elevated levels of pesticides, heavy	2	2	4	2	2	**Likelihood** The percentage land use of cropping, effluent ponds, intensive animal production, irrigated

metals and other toxic contaminants—BELOW Wyandra						agriculture, landfill, manufacturing and industrial, production forestry, residential, rural residential, and waste treatment and disposal in the Warrego basin is minimal (Approximately 1.2% of the landscape) (DSITIA, 2012). The expert panel also indicated that there is not as much presence of stock and domestic below Wyandra. They specified that the Warrego Alluvium below Wyandra is less permeable and less transmissive due to clay content of the aquifer. The expert panel indicated that groundwater below Wyandra is more saline and typically not usable. As a result, an increase in demand for the resource is not expected. Although groundwater availability has been identified in the Basin Plan through the SDLs (indicates a level well above the current limits), an expansion in development in the next 10 years is not anticipated due to the predicted low population growth rate (OESR, 2011). The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from contaminants. **Consequence** There is limited knowledge of the characteristics of the aquifer with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the aquifer. The CSIRO (2007b) sustainable yields report for the Warrego makes comment that water in all aquifers is not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes.
Elevated pathogen counts—ABOVE Wyandra	2	3	6	2	2	**Likelihood** The percentage land use of cropping, effluent ponds, intensive animal production, irrigated agriculture, landfill, manufacturing and industrial, production forestry, residential, rural residential, and waste treatment and disposal in the Warrego basin is minimal (Approximately 1.2% of the landscape) (DSITIA, 2012). The expert panel indicated that there is the presence of stock and domestic above Wyandra. The expert panel indicated that the Warrego Alluvium above Wyandra is sandy—producing faster recharge and throughflow (More permeable). If development were to increase, there is a possibility that elevated pathogen levels could occur, albeit unlikely. However, growth in development is not expected due to the predicted low population growth rate (OESR, 2011). The potential for elevated pathogen levels into the groundwater due to a sandier system is known in terms of first principles but has not been proven directly in the area. The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the

						Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from pathogens. **Consequence** There is limited knowledge of the characteristics of the aquifer with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the aquifer. The CSIRO (2007b) sustainable yields report for the Warrego makes comment that water in all aquifers is not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes.
Elevated pathogen counts—BELOW Wyandra	2	2	4	2	2	**Likelihood** The percentage land use of cropping, effluent ponds, intensive animal production, irrigated agriculture, landfill, manufacturing and industrial, production forestry, residential, rural residential, and waste treatment and disposal in the Warrego basin is minimal (Approximately 1.2% of the landscape) (DSITIA, 2012). The expert panel also indicated that there is not as much presence of stock and domestic below Wyandra. They specified that the Warrego Alluvium below Wyandra is less permeable and less transmissive due to clay content of the aquifer. The expert panel indicated that groundwater below Wyandra is more saline and typically not usable. As a result, an increase in demand for the resource is not expected. Although groundwater availability has been identified in the Basin Plan through the SDLs (indicates a level well above the current limits), an expansion in development in the next 10 years is not anticipated due to the predicted low population growth rate (OESR, 2011). The expert panel indicated that there is the possibility of mining expansion in the South West region in the next ten years, however it is not likely due to the low geological prospectivity outside of the Surat basin (Note that the Surat Basin extends from the Dalby region to the Nebine). If mining development were to occur, management actions would be implemented through Environmental Authorities to prevent impacts from pathogens. **Consequence** There is limited knowledge of the characteristics of the aquifer with bore data needed (Ife & Skelt 2004). To the extent of knowledge of the expert panel, there is little dependence on the water from the aquifer. The CSIRO (2007b) sustainable yields report for the Warrego makes comment that water in all aquifers is not considered to have good water quality relative to surface water, and as a result use is mainly for stock and domestic purposes.
pH outside natural ranges	Not assessed due to little to no significance to groundwater.					
Water temperature	Not assessed due to little to no significance to groundwater.					

outside natural ranges						
Climate change	1	1	1	2	2	**Likelihood** The expert panel indicated that due to the hydraulics of the Warrego Alluvium (i.e. deeper groundwater systems unconnected to shallow river systems) the likelihood that climate change would affect the aquifer is rare (CSIRO 2007b). Climate change research has not indicated more frequent small events will occur in South West Queensland (Queensland Government, 2009). **Consequence** Existing information describes a system with a very low level of use (only for stock and domestic purposes), and highly variable, low water quality (CSIRO 2007a 2007 b). The expert panel indicated that further extremes in climate are not expected to have major consequences for the water quality of the Warrego Alluvium (CSIRO 2007b). Risk analysis based primarily on the CSIRO sustainable yields report for the Warrego. This report, while based on the best available science is subject to significant uncertainty as illustrated by the large variation in extreme climate scenarios (CSIRO 2007b).

Appendix 6—Permanent Waterholes in the Warrego, Paroo, Bulloo and Nebine Drainage Basins

Source: Permanent Waterholes of the Murray-Darling Basin—South west Queensland region (Silcock, 2009).

Basin	Location	Waterhole	Lat	Long
Bulloo	Adavale Common	Adavale Waterholes	-25.915041	144.6146
Bulloo	Autumn Vale	Unknown	-27.830219	143.8526
Bulloo	Autumn Vale	Unknown	-27.836804	143.8573
Bulloo	Bullloo Lakes/Milo	15 Mile Hut Waterhole	-25.568635	144.3874
Bulloo	Bulloo Downs	Unknown	-28.514018	142.8899
Bulloo	Bulloo Downs	Unknown	-28.532074	142.954
Bulloo	Bulloo Downs	Unknown	-28.640592	142.5139
Bulloo	Bulloo Downs	Unknown	-28.663012	142.5222
Bulloo	Bulloo Downs	Unknown	-28.666964	142.6016
Bulloo	Bulloo Downs	Unknown	-28.682203	142.5861
Bulloo	Bulloo Downs	Unknown	-28.684154	142.4529
Bulloo	Bulloo Downs	Unknown	-28.687465	142.4787
Bulloo	Bulloo Downs	Unknown	-28.69933	142.4775
Bulloo	Bulloo Downs	Unknown	-28.705805	142.388
Bulloo	Bulloo Downs	Unknown	-28.730975	142.4532
Bulloo	Bulloo Downs	Unknown	-28.740461	142.7997
Bulloo	Bulloo Downs	Woonabootra Waterhole	-28.742004	142.526
Bulloo	Bulloo Lakes	Patchiemellum Waterhole	-25.467656	144.6294
Bulloo	Bulloo River	10 Mile Waterhole	-26.057302	144.3538
Bulloo	Bulls Gully	The Mule Waterhole	-25.980662	144.4597
Bulloo	Clyde	Thuringowa Waterhole	-28.16954	143.3771
Bulloo	Clyde	Unknown	-28.196829	143.34
Bulloo	Clyde	Unknown	-28.222734	143.3504
Bulloo	Clyde	Unknown	-28.279531	143.2952
Bulloo	Como/ Harrington	Como Fish Hole	-26.38074	144.2988
Bulloo	Comongin	Lake Young Woman	-26.504949	144.3273
Bulloo	Comongin/ Nickavilla	Yupal Waterhole	-26.449868	144.2991

Bulloo	Gilmore	3 Mile Waterhole	-25.434292	144.6571
Bulloo	Gilmore	Double Holes	-25.230317	144.6692
Bulloo	Gilmore	Gilmore House Hole	-25.364704	144.7044
Bulloo	Gilmore	Night Paddock Hole	-25.300475	144.6421
Bulloo	Gilmore	Reef & Hook Hole	-25.349145	144.7028
Bulloo	Gilmore	Supplejack Hole	-25.396053	144.6832
Bulloo	Gonda	Thargomindah Waterhole	-28.012145	143.8077
Bulloo	Gundary	Lily Hole	-25.930186	144.5061
Bulloo	Gundry	5 Mile Waterhole	-25.927369	144.5289
Bulloo	Gundry	Gundry Waterhole	-25.854894	144.4998
Bulloo	Gundry	Unnamed	-25.941586	144.4894
Bulloo	Hoomooloo Park	Gumbardo Creek Waterhole	-26.012328	144.6714
Bulloo	Hoomooloo Park	Gumbardo Creek Waterhole	-26.017502	144.6804
Bulloo	Kiandra	Suna Waterhole	-27.516602	144.0693
Bulloo	Kiandra	Unknown	-27.473168	144.071
Bulloo	Kiandra	Unknown	-27.601176	144.0414
Bulloo	Kulki (adjacent to)	Unknown	-28.018682	143.6946
Bulloo	Leopardwood Park	Big Fish Hole	-25.665398	144.5393
Bulloo	Leopardwood Park	Camp Hole	-25.723884	144.5317
Bulloo	Leopardwood Park	Leopardwood House Hole	-25.742755	144.5274
Bulloo	Leopardwood Park	Shearing Shed Waterhole	-25.756211	144.5258
Bulloo	Leopardwood Park	Steep Hole	-25.588502	144.5842
Bulloo	Leopardwood Park	Tambo Hole	-25.5597	144.5656
Bulloo	Leopardwood Park	Tea-Tree Hole	-25.732082	144.5154
Bulloo	Leopardwood Park	Warby Hole	-25.621156	144.5539
Bulloo	Maybe	Unnamed	-26.14164	144.337
Bulloo	Maybe	Unnamed	-26.144064	144.3381
Bulloo	Milo	12 Mile Waterhole	-25.64582	144.5296
Bulloo	Milo	Autumn Pond	-25.842879	144.2117
Bulloo	Milo	Hay Paddock Hut Waterhole	-25.752908	144.4294

Bulloo	Mogera	Gumbardo Creek Waterhole	-26.170096	144.8666
Bulloo	Molesworth (adjacent to)	Kooliatto Waterhole	-28.315047	143.1389
Bulloo	Mulianna	Pilkerie Waterhole	-27.389603	144.1401
Bulloo	Nyngarie	Blackfellow's Waterhole	-26.947318	144.3512
Bulloo	Orient	Unknown	-28.181361	143.3028
Bulloo	Patricia Park	20 Mile Waterhole	-25.705264	144.7459
Bulloo	Patricia Park	Patricia Park Waterhole	-25.843187	144.6701
Bulloo	Patricia Park	Sawpit Hole	-25.840177	144.6806
Bulloo	Patricia Park	Unknown	-25.801377	144.704
Bulloo	Patricia Park	Unknown	-25.842538	144.6896
Bulloo	Patricia Park	Unknown	-25.882707	144.6295
Bulloo	Pinkenetta	Pinkenetta Waterhole	-27.043765	144.337
Bulloo	Pinkenetta	Possamunga Waterhole	-27.019015	144.3458
Bulloo	Possamunga	Possamunga House Waterhole	-27.070394	144.3813
Bulloo	Quilpie Town Common	Wanko/ Quilpie Waterhole	-26.608873	144.2819
Bulloo	South Comongin	Bridge Waterhole	-26.876375	144.3261
Bulloo	South Comongin	South Comongin Waterhole	-26.8942	144.3402
Bulloo	The Pioneers	Unknown	-27.764741	143.9412
Bulloo	Tyangra	Unknown	-28.041431	143.551
Bulloo	Wakes Lagoon	40 Pound Hole	-25.526224	144.8486
Bulloo	Wakes Lagoon	Unknown	-25.542321	144.8999
Bulloo	Wakes Lagoon	Washpools	-25.686948	144.77
Bulloo	Wanko	Lake Dora Dora	-26.652614	144.3087
Bulloo	Wanko	Lake Houdraman	-26.585666	144.3076
Bulloo	Wanko/ Coolbinga	Unknown	-26.654025	144.5012
Bulloo	Wongetta (adjacent to)	Unknown	-28.058991	143.7723
Nebine/Mungallala/ Wallam creeks	Abbieglassie	Abbieglassie Waterhole	-27.251735	147.5811
Nebine/Mungallala/ Wallam creeks	Abbieglassie	One Mile Waterhole	-27.264125	147.5706
Nebine/Mungallala/ Wallam creeks	Aqua Downs	Aqua Downs Waterhole	-27.147676	146.9586
Nebine/Mungallala/ Wallam creeks	Glencoe	Bollon Waterhole	-28.031265	147.4808

Nebine/Mungallala/ Wallam creeks	Grassmere	Grassmere Waterhole	-27.481539	147.2988
Nebine/Mungallala/ Wallam creeks	Homeboin	Homeboin Waterhole	-27.624977	147.4478
Nebine/Mungallala/ Wallam creeks	Homeboin	Ida Waterhole	-27.563243	147.4463
Nebine/Mungallala/ Wallam creeks	Kenilworth	Kenilworth Waterhole	-27.415121	147.4633
Nebine/Mungallala/ Wallam creeks	Lussvale	Lussvale Waterhole	-27.160957	147.5928
Nebine/Mungallala/ Wallam creeks	Murra Murra	Murra Murra Waterhole	-28.264779	146.7912
Nebine/Mungallala/ Wallam creeks	Rutherglen	Pumpkin Bed Hole	-27.637038	147.6537
Nebine/Mungallala/ Wallam creeks	Tomoo	Tomoo Waterhole	-27.09261	147.3638
Nebine/Mungallala/ Wallam creeks	Tomoo	Unknown	-27.052974	147.3923
Nebine/Mungallala/ Wallam creeks	Tomoo	Unknown	-27.141829	147.3575
Nebine/Mungallala/ Wallam creeks	Woolerina	Andy's Crossing	-28.415331	147.4215
Paroo	Aldville	Aldville House Waterhole	-27.307588	145.1264
Paroo	Allambie	Allambie Waterhole	-26.938739	145.4443
Paroo	Allambie	Unknown	-26.960428	145.4641
Paroo	Alroy	Alroy Waterhole	-27.803552	144.7068
Paroo	Armoobilla	Unknown	-26.871498	145.1355
Paroo	Armoobilla	Unknown	-26.894074	145.1353
Paroo	Arranfield	Arranfield House Hole	-26.604413	145.2785
Paroo	Arranfield	Arranfield Waterhole	-26.609547	145.2772
Paroo	Arranfield	Emu Creek Waterhole	-26.596613	145.2243
Paroo	Arranfield	Unknown	-26.602451	145.2639
Paroo	Bierbank	Bierbank Waterhole	-26.776867	145.071
Paroo	Bierbank	Unknown	-26.791762	145.0867
Paroo	Bierbank	Unknown	-26.814923	145.1053
Paroo	Bierbank	Unknown	-26.836929	145.116
Paroo	Bingara/ Bundoona	Yowah Outstation Waterhole	-28.049072	144.7969
Paroo	Binya	Binya Waterhole	-28.834777	145.5447
Paroo	Binya	Booribooka Waterhole	-28.802393	145.5557
Paroo	Boobara	Boobara Waterhole	-27.524283	145.2284
Paroo	Boothulla	Blue Hole	-26.374695	145.234

Paroo	Boothulla	Unknown	-26.306384	145.2152
Paroo	Boothulla	Unknown	-26.364248	145.1973
Paroo	Boothulla	Unknown	-26.416382	145.2518
Paroo	Boothulla	Unknown	-26.533894	145.2284
Paroo	Boothulla	Unnamed	-26.310309	145.1951
Paroo	Bowra/ Moonjaree	Gum Holes Waterhole	-27.990442	145.5152
Paroo	Bundoona	8 (or 12) Mile Waterhole	-27.919682	144.7336
Paroo	Come-by-Chance	Come-by-Chance Waterhole	-27.313167	145.2743
Paroo	Cookara	Twidgello Waterhole	-27.816517	145.1634
Paroo	Cooladdi Park	Cooladdi Park Waterhole	-26.528492	145.4922
Paroo	Cooladdi Park	Unknown	-26.482491	145.4397
Paroo	Cooladdi Park	Unknown	-26.48681	145.455
Paroo	Cooladdi Park	Unknown	-26.516082	145.4767
Paroo	Cooladdi Park	Unknown	-26.521742	145.4824
Paroo	Cooladdi Park	Unknown	-26.537313	145.4963
Paroo	Cooladdi Park	Unknown	-26.579107	145.5026
Paroo	Cooladdi Park	Unknown	-26.616006	145.4888
Paroo	Currawinya NP	Benuka Waterhole	-28.764022	144.6287
Paroo	Currawinya NP	Caiwarro Waterhole	-28.742763	144.7302
Paroo	Currawinya NP	Carwarra Creek Waterholes	-28.735571	144.675
Paroo	Currawinya NP	Carwarra Creek Waterholes	-28.752917	144.6437
Paroo	Currawinya NP	Carwarra Waterhole	-28.723937	144.7416
Paroo	Currawinya NP	Corni Paroo Waterhole	-28.68209	144.7967
Paroo	Currawinya NP	Kyearing Waterhole	-28.677448	144.7936
Paroo	Currawinya NP	Lake Numalla	-28.731655	144.3258
Paroo	Currawinya NP	Ourimperee Waterhole	-28.882635	144.5124
Paroo	Currawinya NP	Shed Creek Waterhole	-28.723979	144.7826
Paroo	Doobibla	Buckenby Waterhole	-27.032163	145.4662
Paroo	Eulo Town Common	5 Mile Waterhole	-28.214919	144.985
Paroo	Eulo Town Common	Eulo Waterhole	-28.159424	145.0398

Paroo	Eulo Town Common	Ingemulla Waterhole	-28.128341	145.0634
Paroo	Fairlie	Fairlie Waterhole	-26.931209	145.1375
Paroo	Fairlie	Rock Hole	-26.963296	145.1331
Paroo	Farnham Plains	12 Mile Waterhole	-28.010249	145.1037
Paroo	Glencoe	Unknown	-28.270253	145.6479
Paroo	Glencoe	Unknown	-28.28809	145.6456
Paroo	Haredean	Munberry Waterhole	-26.586323	145.0217
Paroo	Hazelfield	Car Hole	-27.742334	145.1949
Paroo	Hazelfield	Unknown	-27.652444	145.2209
Paroo	Humeburn	Humeburn Waterhole	-27.404423	145.2151
Paroo	Killara/ Ginnebah	Cuttaburra Waterhole	-28.436051	145.5814
Paroo	Kywong	Kywong Waterhole	-28.924929	145.5568
Paroo	Lake Bindegolly NP	Lake Bindegolly	-28.052685	144.1747
Paroo	Lake Bindegolly NP	Lake Hutchinson	-27.924823	144.2137
Paroo	Lake Bindegolly NP	Lake Toomaroo	-27.980938	144.2052
Paroo	Lanherne	Lanherne Waterhole	-26.684497	145.0443
Paroo	Moonjaree	Moonjaree Creek Waterhole	-28.052125	145.3819
Paroo	Mowellan	Mowellan Waterhole	-28.534383	145.5225
Paroo	Mt Alfred	Mt Alfred Waterhole	-27.192819	145.3482
Paroo	Mt Alfred	Unknown	-27.16614	145.3725
Paroo	Munberry	Munberry Waterhole	-26.631262	145.0253
Paroo	Narraburra	Narraburra Waterhole	-27.867331	145.1445
Paroo	Narraburra	Unknown	-27.894482	145.1564
Paroo	Ningaling	Barrara Waterhole	-28.851914	144.6248
Paroo	Ningaling	Koolpitara Waterhole	-28.83645	144.6348
Paroo	Ningaling	Ningaling Waterhole	-28.895243	144.5871
Paroo	Ningaling	Thorlindah Waterhole	-28.951076	144.7022
Paroo	Ningaling	Yarrawilli Waterhole	-28.869141	144.6001
Paroo	Nooma	Nooma Waterhole	-27.352304	145.2471
Paroo	Pingine	10 Mile Waterhole	-26.495267	145.0072

Paroo	Pingine	12 Mile Waterhole	-26.463009	145.0105
Paroo	Pingine	13 Mile Waterhole	-26.451414	144.9951
Paroo	Pingine	6 Mile Waterhole	-26.569803	145.0081
Paroo	Pingine	Dave's Hole	-26.439483	144.9975
Paroo	Pingine	Pingine Waterhole	-26.419167	144.9954
Paroo	Pingine	Unknown	-26.394022	145.0702
Paroo	Pingine	Unknown	-26.414586	145.0592
Paroo	Pingine	Unknown	-26.432508	144.9961
Paroo	Pingine	Unknown	-26.434178	145.0523
Paroo	Pingine	Unknown	-26.521964	145.0117
Paroo	Pingine	Unknown	-26.552783	145.0084
Paroo	Quilpeta	Quilpeta Waterhole	-27.134777	145.0705
Paroo	Quilpeta	Ram Paddock Hole	-27.144893	145.083
Paroo	Quilpeta	Weroona Hole	-27.170012	145.0874
Paroo	Spring Creek	Brigalow Outstation Waterhole	-27.226577	145.3177
Paroo	Tinnenburra	Tinnenburra Waterhole	-28.728228	145.5526
Paroo	Turn Turn	28 Mile Waterhole	-28.490292	144.847
Paroo	Wandilla	Belyanna Waterhole	-28.288357	144.9017
Paroo	Yarronvale	Yarronvale Crossing Waterhole	-26.805065	145.3489
Paroo	Yarronvale/ Coolabah	Dumbells Waterhole	-26.833833	145.3628
Warrego	Alawoona	Retreat/Allawoona Waterhole	-27.40319	145.9165
Warrego	Alawoona	Retreat/Allawoona Waterhole	-27.410822	145.9123
Warrego	Alice Downs	Alice Downs Waterhole	-26.415795	146.8881
Warrego	Alice Downs	Angellala Crossing Waterhole	-26.412092	146.8863
Warrego	Alice Downs	Mountain Hole	-26.495283	146.7883
Warrego	Alice Downs	Unknown	-26.472173	146.8756
Warrego	Alice Downs	Unknown	-26.479369	146.8492
Warrego	Ambathala	Ambathala House Waterhole	-25.966542	145.3172
Warrego	Ambathala	Ambathala Waterhole	-25.989136	145.3307
Warrego	Ambathala	Ambathala Waterhole	-26.00618	145.337

Warrego	Androssan	Grave Hole	-27.574952	145.8328
Warrego	Androssan	Unknown	-27.567327	145.8362
Warrego	Arapinta	Arapinta Waterhole	-26.803405	146.0563
Warrego	Ardrossan	Ardossan Waterhole	-27.551996	145.865
Warrego	Authoringa	Authoringa House Hole	-26.665356	146.6128
Warrego	Authoringa	Unknown	-26.647417	146.6548
Warrego	Authoringa	Unknown	-26.698682	146.5571
Warrego	Baroona	Baroona Waterhole	-27.878533	145.6602
Warrego	Baykool	Baykool Waterhole	-25.626306	145.6662
Warrego	Baykool	Unknown	-25.679768	145.6364
Warrego	Bayrick	Bayrick Fish Hole	-25.481599	146.0602
Warrego	Binya	Red Hole	-28.858682	145.6301
Warrego	Bonella	Bonella Waterhole	-26.285095	145.9036
Warrego	Bonella	Unknown	-26.273172	145.8999
Warrego	Bullecourt	Bullecourt Waterhole	-25.595459	145.6726
Warrego	Charleville Common	2 and 6 Mile	-26.439864	146.23
Warrego	Charleville Common	6 Mile Waterhole	-26.348556	146.2877
Warrego	Charleville Common	Charleville Waterholes	-26.390113	146.2501
Warrego	Charleville Common	Charleville Waterholes	-26.402605	146.2301
Warrego	Claren Park	Claren Park Waterhole	-25.658836	146.5008
Warrego	Claverton	Claverton Waterhole	-27.44404	145.899
Warrego	Coolatah	Coolatah Waterhole	-25.849276	145.5699
Warrego	Cunnamulla Common	Cunnamulla Waterhole	-28.07867	145.6827
Warrego	Dillalah	Woolshed Creek Waterhole	-26.836644	146.0259
Warrego	Dillalah	Woolshed Creek Waterhole	-26.843843	146.0193
Warrego	Dillalah/ Barimornie	Dillalah/Barimornie Waterhole	-26.84011	146.0385
Warrego	Dillalah/ Barimornie	Dillalah/Barimornie Waterhole	-26.859748	146.0317
Warrego	Drensmaine	Drensmaine Waterhole	-25.20625	146.4849
Warrego	Drensmaine	Unknown	-25.189195	146.5001
Warrego	Gerah Plains	Gerah Plains Waterhole	-28.564755	145.6298

Warrego	Glanworth/ Bayswater	Glanworth Waterhole	-25.423489	145.7009
Warrego	Glen Yarran	Glen Yarron Waterhole	-26.339714	145.9458
Warrego	Glencoe	Glencoe Waterhole	-28.205163	145.7179
Warrego	Glencoe	Woggonorra Waterhole	-28.330963	145.6946
Warrego	Glenellen	Unknown	-27.951241	145.6843
Warrego	Goolburra	Goolburra Waterhole	-27.515511	145.86
Warrego	Helvetia Park	14 Mile Waterhole	-26.230858	146.3264
Warrego	Helvetia Park	18 Mile Waterhole	-26.196067	146.3738
Warrego	Holly Downs	Gidgeedell Waterhole	-25.841324	146.5948
Warrego	Holly Downs	Holly Downs House Hole	-25.838358	146.6209
Warrego	Killara	Killara Waterhole	-28.448051	145.64
Warrego	Killowen	Killowen Waterhole	-27.918549	145.6907
Warrego	Killowen	Tickleman Garden Hole	-27.84883	145.6883
Warrego	Killowen	Top Hole	-27.865381	145.6705
Warrego	Koreelah	Koreelah Waterhole	-26.030391	145.9598
Warrego	Langlo Downs	Scrubby Creek Waterhole	-25.546112	145.6598
Warrego	Lumeah	Pelican Hole	-25.373504	145.7178
Warrego	Lynton Hiils	Unknown	-26.140519	145.7035
Warrego	Malta	Long Waterhole	-24.913924	146.5587
Warrego	Mangalore	Mangalore Fish Hole	-26.782602	146.0849
Warrego	Maruga	Maruga Waterhole	-25.728663	145.5987
Warrego	Mean-Ta-Be	27 Mile Waterhole	-26.077999	146.4176
Warrego	Mirage Plains	Mirage Plains Waterhole	-28.641133	145.6042
Warrego	Mt Morris	Mt Morris Waterhole	-25.825672	145.5661
Warrego	Murweh/Yanna	Murweh Waterhole	-27.002443	145.9506
Warrego	Myendetta	Baker's Bend	-26.696666	146.1243
Warrego	Myendetta	Baker's Bend (south)	-26.706727	146.09
Warrego	New Farm	New Farm Waterhole	-26.376711	146.8733
Warrego	Nive Downs	Nive Downs Waterhole	-25.500388	146.5394
Warrego	Nombardie	Nombardie Waterhole	-27.46656	145.8851

Warrego	Nulla	Nulla Waterhole	-27.940749	145.6876
Warrego	Oak Park	Jack's Hut Waterhole	-25.948492	146.1147
Warrego	Oakwood	Oakwood Waterhole	-25.680191	146.1377
Warrego	Oakwood	Unknown	-25.680427	146.1249
Warrego	Old Coolabri	Old Coolabri Waterhole	-25.352637	146.577
Warrego	Old Gowrie	Ward Waterhole	-26.485313	146.0996
Warrego	Owangowan	Owangowan Waterhole	-28.906457	145.6754
Warrego	Pine Ridge	Red Hole	-28.179878	145.6738
Warrego	Quilberry	Quilberry - south	-27.09212	145.9183
Warrego	Quilberry	Quilberry Waterhole - north	-27.079463	145.9249
Warrego	Reserve	Langlo Crossing Waterhole	-26.126598	145.6682
Warrego	Reserve (Wallen)	Reserve Hole	-27.724071	145.8048
Warrego	Retreat	Autumn Creek Waterhole	-27.369077	145.8996
Warrego	Retreat	Retreat/Allawoona Waterhole	-27.383889	145.9171
Warrego	Retreat	Retreat/Allawoona Waterhole	-27.389402	145.9178
Warrego	Reynella	Yo Yo Creek Waterhole	-25.947249	146.4807
Warrego	Riversleigh	Riversleigh Waterhole	-26.706048	146.4016
Warrego	Riverview	Dillalah/Barimornie Waterhole	-26.875161	146.0306
Warrego	Riverview	Riverview House Waterhole	-26.890411	146.0308
Warrego	Riverview	Riverview Waterhole	-26.904749	146.0355
Warrego	Riverview	Unknown	-26.920172	146.016
Warrego	Riverview	Woolshed Creek Waterhole	-26.861783	145.9989
Warrego	Riverview	Woolshed Creek Waterhole	-26.865813	145.9869
Warrego	Rocksville	Rocksville Waterhole	-26.138739	145.9301
Warrego	Rocky	Big Hole	-28.37885	145.6943
Warrego	Rocky	Clear Hole	-28.363237	145.6161
Warrego	Rocky	Rocky Waterhole	-26.537242	146.7832
Warrego	Rocky (Reserve)	Soak Hole	-28.358982	145.7329
Warrego	Rosevale	Unknown	-27.173189	145.9095
Warrego	Rosevale	Unknown	-27.191046	145.917

Warrego	Rylstone/ Wardsdale	Rylstone Hole	-26.415434	145.9903
Warrego	South Riversleigh	Angellala Waterhole	-26.723013	146.485
Warrego	Tuen Plains	Tuen Waterhole	-28.556335	145.7137
Warrego	Victo/Wallen	19 Mile Creek Waterhole	-27.687345	145.8297
Warrego	Victo/Wallen	22 Mile Waterhole	-27.782746	145.7391
Warrego	Victo/Wallen	Bean's Beach	-27.750643	145.7662
Warrego	Victo/Wallen	Coongoola Waterhole	-27.649165	145.8244
Warrego	Wallal	Wallal Waterhole	-26.594027	146.1165
Warrego	Wallen	Sandy Beach	-27.663628	145.8198
Warrego	Wallen	Sandy Beach	-27.665942	145.8197
Warrego	Wallen	Wallen Waterhole	-27.619582	145.8291
Warrego	Wallen/Killowen	Black Hole	-27.792291	145.7255
Warrego	Wallen/Victo	Ram Hole	-27.649199	145.8206
Warrego	Wallen/Victo	Unknown	-27.697921	145.8186
Warrego	Wallen/Victo	Victo Hole	-27.635571	145.8315
Warrego	Wansey Downs	Shearing Shed Waterhole	-25.858207	146.1747
Warrego	Warrego Park	3 Mile Waterhole	-27.281457	145.9337
Warrego	Warrego Park	4 Mile Waterhole	-27.292123	145.9274
Warrego	Warrego Park	4 Mile Waterhole	-27.298895	145.9321
Warrego	Wyandra Common	Warrego River	-27.238502	145.9659
Warrego	Yanna	Yanna Waterhole	-26.933859	146.0041
Warrego	Yanna/Murweh	Murweh Waterhole	-26.991182	145.9551
Warrego	Yarrawonga	10 Mile Waterhole	-26.277209	146.3149