

# Sustainable Extraction Limits Derived from the Recharge Risk Assessment Method – Queensland

CSIRO and SKM

December 2010

Report to Murray-Darling Basin Authority

Water for a Healthy Country Flagship Report series ISSN: 1835-095X

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Citation: CSIRO and SKM (2010) Sustainable extraction limits derived from the Recharge Risk Assessment Method – Queensland. CSIRO: Water for a Healthy Country National Research Flagship. 77pp.



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Photographer: Greg Rinder

# Acknowledgments

Funding for this project was provided by the Murray-Darling Basin Authority under contract MD 1401.

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# Abbreviations

| | |
|---|---|
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DERM | Department of Environment and Resource Management |
| GL | Gigalitre |
| GMU | Groundwater Management Unit |
| GS1* | Groundwater SDL area 1 |
| $km^2$ | kilometres squared |
| m | metres |
| MDB | Murray-Darling Basin |
| MDBA | Murray-Darling Basin Authority |
| mg/L | Milligrams per Litre |
| mm | Millimetres |
| N/A | Not Applicable |
| RRAM | Recharge Risk Assessment Method |
| SDL | Sustainable Diversion Limit |
| SF | Sustainability Factor |
| SKM | Sinclair Knight Merz |
| TDS | Total Dissolved Solids |
| WAVES | Water Atmosphere Vegetation Energy Soil |

*The number at the end of the GS code is unique for each groundwater SDL area

# Executive Summary

The Murray-Darling Basin Authority has responsibility for development of the Basin Plan for the Murray-Darling Basin (MDB) as specified under the *Water Act 2007*. The Basin Plan must include a number of mandatory conditions, including the development of a sustainable diversion limit (SDL) for the MDB's water resources. SDLs must encompass both surface water and groundwater. The SDL will limit the take of water for consumptive uses and is expressed as a volume.

The Recharge Risk Assessment Method (RRAM) was developed to derive preliminary SDLs to inform the Basin Plan development process.

The RRAM is based on the requirements of the *Water Act 2007* and the expectation that SDLs will reflect an environmentally sustainable level of take. According to the RRAM, the level of take must not compromise the following characteristics of the resource; key environmental assets, key ecosystem functions, the productive base and key environmental outcomes. In general terms, the RRAM is based on setting an extraction limit by applying a sustainability factor to groundwater recharge. For more information regarding the methodology, refer to CSIRO (2010).

In summary, for Queensland, the preliminary RRAM derived extraction limits that were calculated to inform the Basin Plan included:

- extraction limits that were informed by both numerical modelling results and the RRAM results (i.e. the Upper Condamine Alluvium SDL area)
- extraction limits that equal the RRAM extraction limit volume (i.e. the Upper Condamine Basalts SDL area)
- extraction limits that are equal to current groundwater use (i.e. the Queensland Border Rivers Alluvium SDL area)
- extraction limits set to equal current groundwater use with a potential for further development up to the RRAM extraction limit, where an equivalent reduction in surface water is required to offset the additional groundwater take. This is on the basis of there being a 1:1 relationship between groundwater take and surface water streamflow reduction and occurred for areas such as the Condamine Fractured Rock SDL area
- extraction limits that are greater than the volume of current groundwater use and therefore there is a volume of unassigned water associated with such units. This applies (in a spatial sense) to the majority of Queensland, however generally represents the areas of poor groundwater quality.

 

# 1 Sustainable extraction limits derived from the RRAM – Queensland

## 1.1 Upper Condamine Alluvium (GS76)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the recharge risk assessment method (RRAM) for the Upper Condamine Alluvium sustainable diversion limit (SDL) area.

### 1.1.1 Background

The Upper Condamine Alluvium SDL area incorporates all Condamine alluvial groundwater management units (GMUs). The Upper Condamine Alluvium SDL area represents the sequence of alluvial sediments deposited by the Condamine River. The alluvial sediments range up to ~140 m thick in valleys formed on weathered Palaeozoic, Mesozoic and Tertiary bedrock. Huxley (1982) described the alluvial sediments of the Condamine as heterogeneous floodplain and sheetwash deposits. The division of the alluvial sediments is based upon differing depositional environments and results in a highly heterogeneous alluvial deposit, with sediments of vastly different characteristics juxtaposed within the broader unit.

The majority of groundwater flow in the upper Condamine occurs within the alluvial sediments. Groundwater also flows into the alluvium from the underlying and surrounding bedrock (Huxley, 1982; SKM, 1999). The alluvial aquifer is considered to vary from unconfined to semi-confined conditions.

The Upper Condamine Alluvium SDL area is partially represented by a numerical groundwater flow model; the Upper Condamine Model. The modelled area represents a region of 2693 $km^2$ which is approximately 30 percent of the total SDL area. The model area includes the alluvial plain of the upper Condamine River between Tummaville and Dalby and includes some of its tributaries such as Oakey Creek.

Total groundwater use in the Upper Condamine Alluvium SDL area is 117.1 GL/yr. Outside of the model domain, current groundwater use is 64.6 GL/year and this is based on metered and estimated groundwater use information provided by the Queenland DERM.

### 1.1.2 Salinity zoning

Inside and outside of the model domain, groundwater is characterised by three salinity zones, with groundwater ranging from 0 to 14,000 mg/L total dissolved solids (TDS). Within the model domain the portion represented by salinity class 3 is small (approximately 2 percent). It is considered appropriate to combine this small area with that of salinity class 2 groundwater. The groundwater salinity distribution can be seen in Figure 1 and is summarised in Table 1.

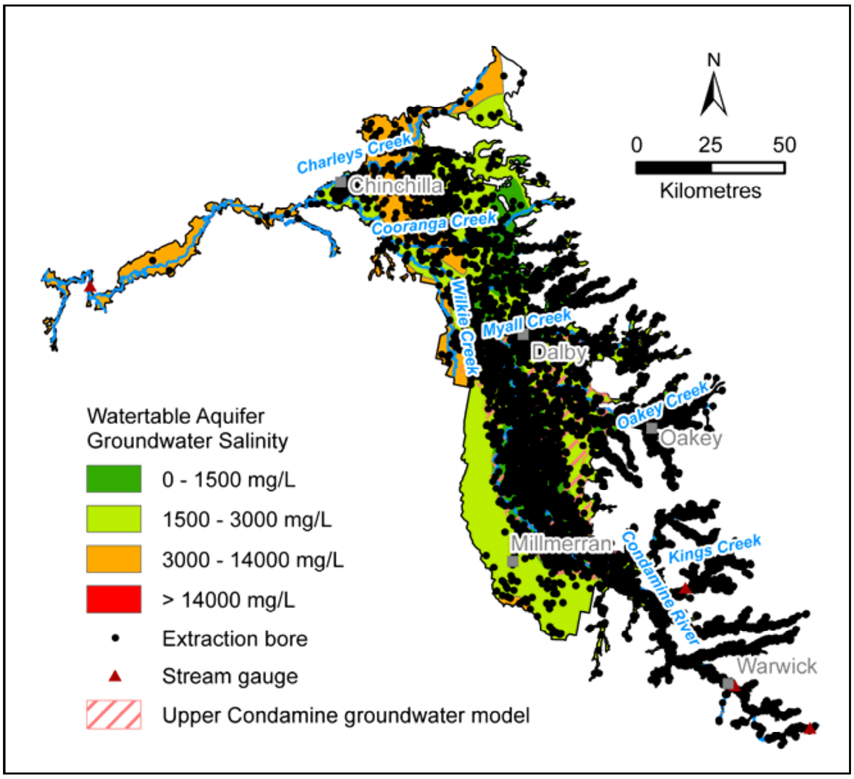


Figure 1. Upper Condamine Alluvium watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 1. Summary of salinity zones in the Upper Condamine Alluvium SDL area

| Watertable salinity zone | Portion of model area | Area | Portion of non-model area | Area |
|---|---|---|---|---|
| | percent | $km^2$ | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 55 | 1481 | 24 | 1669 |
| Zone 2 (1500–3000 mg/L TDS) | 43 | 1155 | 52 | 3806 |
| Zone 3 (3000–14,000 mg/L TDS) | 2 | 57 | 24 | 1854 |
| Zone 4 (>14,000 mg/L TDS) | N/A | N/A | N/A | N/A |
| **Total** | **100** | **2693** | **100** | **7329** |

### 1.1.3 Key environmental assets

There are no key environmental assets that have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment, that are associated with the Upper Condamine Alluvium SDL area.

### 1.1.4 Key ecosystem function

A large depression in the potentiometric surface of the alluvial aquifer exists in the vicinity of the North Branch of the Condamine River, such that river leakage occurs to the aquifer at a maximum rate (CSIRO, 2008a). This is likely to be the result of the large-scale groundwater extraction that has occurred in the area since the late 1960s. In this area there is only a low risk associated with the impact to surrounding ecosystems, as an increase in groundwater pumping cannot induce a greater rate of stream leakage.

In the historical, pre-development state, many of the tributaries of the Condamine River were recharged via groundwater baseflow. However, large-scale groundwater extraction has degraded this process since groundwater development intensified 50 years ago, to the point where most streams no longer receive significant groundwater discharge. For this reason, the risk to the key ecosystem function of the Upper Condamine Alluvium SDL area is considered a low risk, given that groundwater discharge to streams is a minor process in its current state.

### 1.1.5 Productive base

**Recharge**

Groundwater recharge in the modelled and non-modelled parts of the Upper Condamine Alluvium SDL area has been extrapolated from the recharge from the numerical model. The annual rate of recharge via rainfall infiltration and irrigation returns and recharge due to stream leakage was derived from the last 10 years of the calibration model (i.e. from 1990 to 2009). Rainfall and irrigation recharge occurred at an average rate of 6.4 mm/year, which equates to a total recharge rate of 17 GL/year for the modelled part of the unit and 47 GL/year across the non-modelled part of the unit.

Recharge via river leakage occurred at an average rate of 26 GL/year within the model domain and at a rate of 38 GL/year across the non-modelled part of the unit.

Total recharge within the modelled part of the unit is summarised in Table 2 and total recharge in the non-modelled part of the unit is summarised in Table 3.

Table 2. Recharge calculation – modelled part of the Upper Condamine Alluvium SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 1481 | 1212 | 0 | 0 |
| Dryland recharge and irrigation recharge (mm/yr) | 6.4 | 6.4 | N/A | N/A |
| Dryland recharge and irrigation recharge (GL/yr) | 9.5 | 7.8 | N/A | N/A |
| River leakage (GL/yr) | 14 | 12 | N/A | N/A |
| **Total recharge (GL/yr)** | **23** | **20** | **N/A** | **N/A** |

Table 3. Recharge calculation – non-modelled part of the Upper Condamine Alluvium SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 1669 | 3806 | 1854 | 0 |
| Dryland recharge and irrigation recharge (mm/yr) | 6.4 | 6.4 | 6.4 | N/A |
| Dryland recharge and irrigation recharge (GL/yr) | 11 | 24 | 12 | N/A |
| River leakage (GL/yr) | 8.6 | 20 | 10 | N/A |
| **Total recharge (GL/yr)** | **19** | **44** | **21** | **N/A** |

**Storage**

The specific yield of the alluvial aquifer ranged from 0.04 to 0.06 in the Upper Condamine numerical model. A specific yield of 0.05 has been adopted for the area represented by the model and has also been adopted for the area outside of the model, given a lack of information specific to the area outside of the model domain. The average saturated thickness of the alluvial aquifer in the model domain is 59 m. This thickness has also been adopted for the area outside of the model. Total storage of the alluvial aquifer is approximately 30,000 GL (Table 4).

Table 4. Storage calculation for the Upper Condamine Alluvium SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 3,150 | 4,961 | 1,911 | 0 |
| Saturated thickness (m) | 59 | 59 | 59 | N/A |
| Specific yield | 0.05 | 0.05 | 0.05 | N/A |
| **Total storage (GL)** | **9,293** | **14,635** | **5,638** | **N/A** |

#### Storage relative to recharge

The ratio of storage to recharge ranges from 221 to 268 for each of the saalinty zones. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

### 1.1.6 The risk matrix

Table 5 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of key environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked low risk in terms of ecosystem function, given that the Condamine River is largely disconnected from the adjacent groundwater aquifers in this SDL area
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio far exceeds 40
- there is a risk to key environmental outcomes (i.e. groundwater salinity)
- a high uncertainty exists for the non-modelled area and low uncertainty is associated with the modelled part of the area. This is because river leakage has been included for the modelled part of the unit, whereas no river leakage recharge component is included for the non-modelled part of the unit.

Table 5. Risk matrix

<table>
<tr><th>Risk ranking</th><th>Environmental assets (EAs)</th><th>OR</th><th>Ecosystem function</th><th>OR</th><th>Productive base</th><th>Sustainability factor (SF)</th><th>Key environmental outcome</th><th>Degree of uncertainty</th></tr>
<tr><td>High</td><td>EA that is highly groundwater dependent and highly sensitive to take</td><td rowspan="3"></td><td>In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion</td><td rowspan="3"></td><td>Storage/ recharge <20</td><td>0.10</td><td rowspan="3">Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br><br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br><br>Salinity class 1: reduce SF by 20%<br><br>Salinity class 2: reduce SF by 10%<br><br>Salinity classes 3 & 4: no reduction</td><td rowspan="2">Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50%</td></tr>
<tr><td>Medium</td><td>EA that is highly groundwater dependent and is moderately sensitive to take<br><br>EA that is moderately groundwater dependent and is highly sensitive to take</td><td>The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge 20–40</td><td>0.50</td></tr>
<tr><td>Low</td><td>EA that has a low groundwater dependence and low sensitivity to take<br><br>EAs do not exist in the SDL area</td><td>The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge >40</td><td>0.70</td><td>Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25%</td></tr>
</table>

## 1.1.7 Preliminary RRAM extraction limit

The preliminary estimated extraction limit resulting from the RRAM for the modelled part of the Upper Condamine Alluvium SDL area is 25 GL/year (Table 6). The RRAM extraction limit was based on the Upper Condamine Alluvium calibration model results as these provided the best available information at the time of the RRAM analysis.

The preliminary RRAM extraction limit for the modelled part of the Upper Condamine Alluvium SDL area has been superseded by more recent numerical modelling results (CSIRO, 2010b).

The extraction limit resulting from the RRAM for the non-modelled part of the Upper Condamine Alluvium SDL areas is 22 GL/year (Table 7).

Table 6. Preliminary extraction limit summary for the modelled part of the Upper Condamine Alluvium SDL area (with river leakage)

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 23 | 20 | 0 | 0 |
| Sustainability factor | 0.56 | 0.63 | N/A | N/A |
| **Extraction limit (GL/yr)** | **13** | **12** | **N/A** | **N/A** |

Table 7. Preliminary extraction limit summary for the non-modelled part of the Upper Condamine Alluvium SDL area (without river leakage)

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 11 | 24 | 12 | N/A |
| Sustainability factor | 0.42 | 0.47 | 0.53 | N/A |
| **Extraction limit (GL/yr)** | **4.5** | **11** | **6.3** | **N/A** |

 

## 1.2 Upper Condamine Basalts (GS77)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the Upper Condamine Basalts SDL area.

### 1.2.1 Background

The Upper Condamine Basalt SDL area incorporates the Toowoomba North, South and City Basalt , the Upper Hodgson Creek Basalt and the Warwick Area Basalt GMUs. These Tertiary basalts form the highlands in the eastern headwaters of the Upper Condamine system. They are an important source of good quality groundwater for the district and are used extensively for stock, domestic, irrigation, commercial and industrial purposes (Free, 2004). Total 2007/2008 groundwater extraction in this unit was 76 GL/year (Table 8). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

Table 8. Groundwater take summary for the Upper Condamine Basalts SDL area

| Upper Condamine Basalts SDL area | GL/yr* |
|---|---|
| **Total 2007/2008 entitlement** | **61** |
| Current use for entitlement bores | 61 |
| Estimated use for stock and domestic bores | 15 |
| **Total current use** | **76** |

*Entitlement and use volumes were provided by DERM.

### 1.2.2 Salinity zoning

Groundwater salinity zoning is based on the concentration of total dissolved solids (TDS) of the groundwater, which is a measure of all inorganic and organic substances that are suspended in the groundwater. Saline water is predominantly considered to comprise Na and Cl. It is however recognised that TDS measures all suspended substances when it is used to represent 'salinity' and therefore may cause different impacts than those that would be generated by NaCl-type groundwater salinity. This is particularly relevant to the basalt aquifer, as it is characterised by a high bicarbonate composition. In the absence of other groundwater salinity information, the basalt groundwater salinity has been mapped based on its TDS composition here. The Upper Condamine Basalt SDL area is characterised by two salinity classes (Figure 2 and Figure 3).

The salinity map indicates that most of the area is characterised by salinity class 1 groundwater and the remaining area is characterised by salinity class 2 groundwater. It should be noted that 5 percent of the area did not coincide with the salinity coverage and hence these areas were equally assigned to the two mapped salinity classes. A summary of the portion of the unit characterised by the two salinity zones is provided in Table 9.

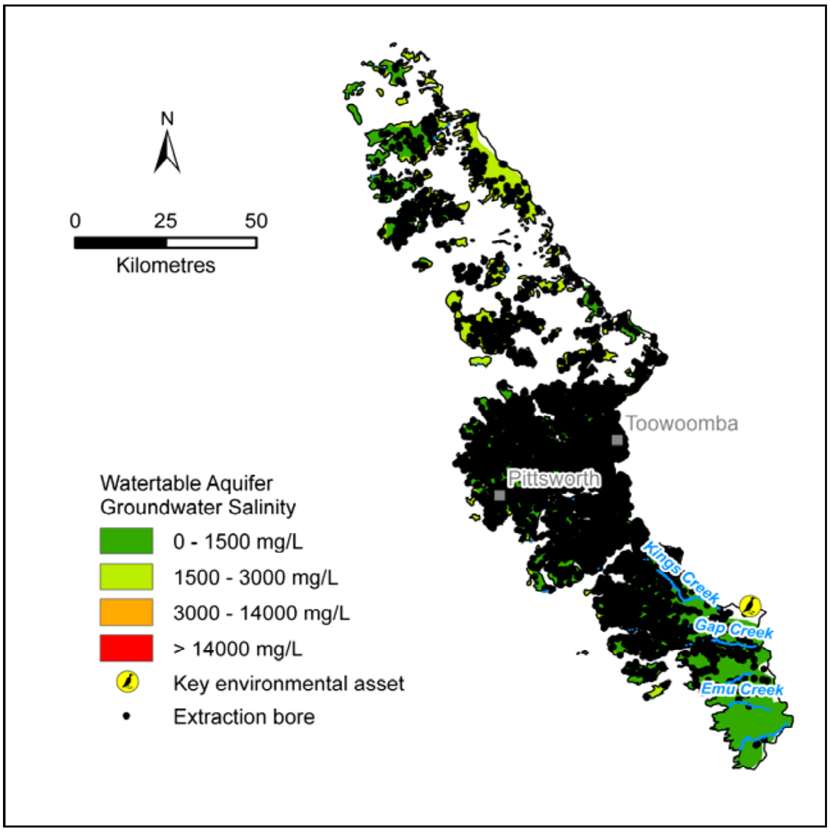


Figure 2. Upper Condamine Basalts watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

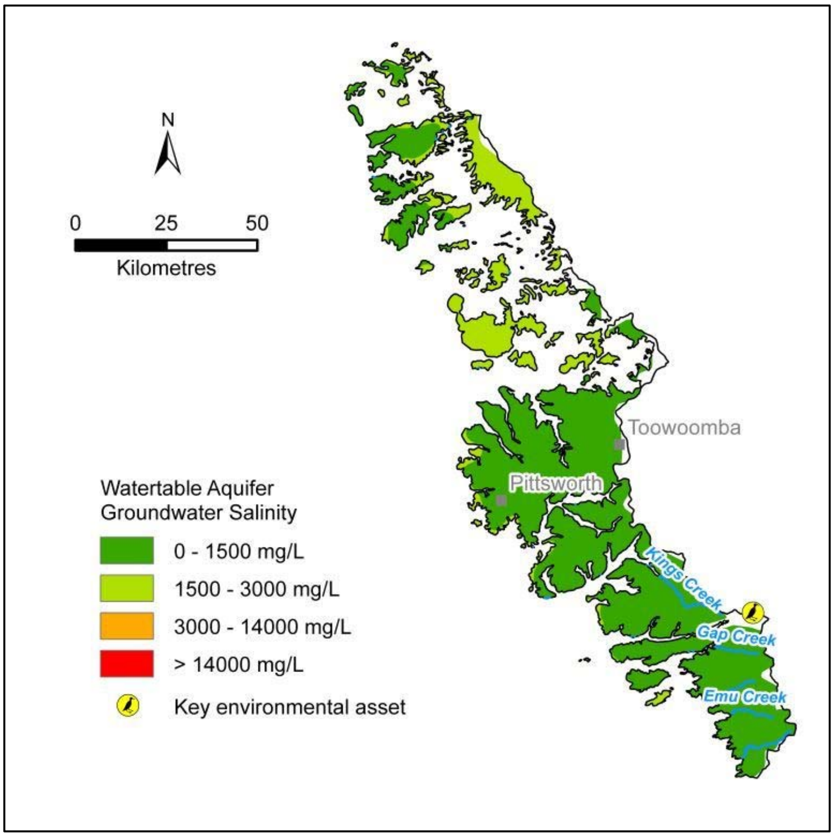


Figure 3. Upper Condamine Basalts watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset – without extraction bores (MDBA, 2000)

 

Table 9. Summary of salinity zones in the Upper Condamine Basalts SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 78 | 3530 |
| Zone 2 (1500–3000 mg/L TDS) | 22 | 1009 |
| Zone 3 (3,000–14,000 mg/L TDS) | 0 | 0 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| **Total** | **100** | **4538** |

## 1.2.3 Key environmental assets

The Dalrymple wetlands include seasonal and perennial creeks, waterfalls, cascades, gorges, waterholes and montane marshes. The extent of the wetland aggregate is approximately 878 hectares (DEWHA, 2009).

The Dalrymple catchment drains west from the Great Dividing Range, into the Condamine River. The streams start in rainforest marshes and springs, and turn into seasonal and perennial streams that pass over waterfalls, through gorges and deep valleys, and rocky waterholes. The creek systems drain a narrow plateau formed from Tertiary basalt. Soils on upper slopes and plateau are deep red-brown earths that are permeable clayey soils formed from basalt. The wetland function is maintained via stormwater and groundwater discharge (DEWHA, 2009).

Most of the wetlands exist within a national park area and are remote from significant groundwater take. Furthermore, the wetland resides on a catchment divide and naturally drains towards the eastern catchment of the Lockyer Valley (Department of Environment and Resource Management, February 2010, pers. comm.). Based on the concept shown in Figure 4, the Upper Condamine Basalts SDL area is considered low risk in terms of key environmental asset.

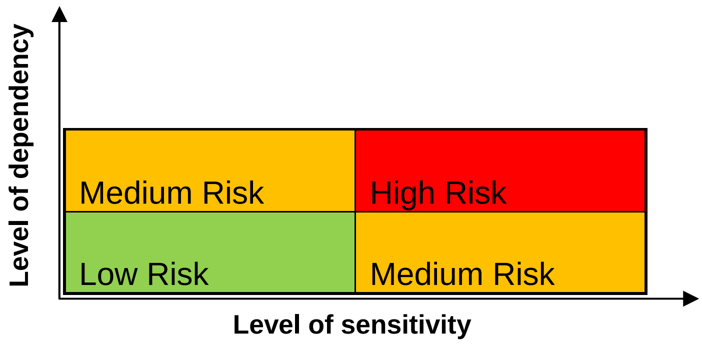


Figure 4. Key environmental asset – groundwater dependency versus sensitivity

## 1.2.4 Key ecosystem function

In the historical, pre-development state, tributaries of the Condamine River associated with the basalt were recharged via groundwater baseflow. However, large-scale groundwater extraction has degraded this process over the last 50 years, to the point where most streams no longer receive significant groundwater discharge. Furthermore, significant groundwater level declines across the area over the past decades suggest that the level of groundwater and surface water connectivity is also likely to be low across much of the area, such that the impact of groundwater extraction is likely to be less than 50 percent of the pumped volume. For this reason, the key ecosystem function of the Upper Condamine Basalt SDL area is considered at low risk.

## 1.2.5 Productive base

**Recharge**

Recharge to the Upper Condamine Basalts SDL area has been calculated by WAVES diffuse groundwater recharge modelling using the historical medium climate scenario. An allowance for irrigation derived recharge was also included, based on input from the Department of Environment and Resource Management. Total recharge to the unit was 115 GL/year (Table 10).

Table 10. Recharge calculation for the Upper Condamine Basalts SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 3530 | 1009 | 0 | 0 |
| Diffuse recharge (mm/yr) | 23 | 28 | N/A | N/A |
| Diffuse recharge (GL/yr) | 83 | 28 | N/A | N/A |
| Irrigation derived recharge (GL/yr) | 3.3 | 0.90 | N/A | N/A |
| **Total recharge (GL/yr)** | **86** | **29** | **N/A** | **N/A** |

**Storage**

A specific yield of 0.08 has been assigned to this unit, which is typical of a young basalt (Heath, 1983). Aquifers within the basalt occur at depths ranging from 2 m and 155 m below the surface. The average thickness of the aquifer is 30 m (ANRA, 2009). Total storage is 10,894 GL (Table 12).

Table 11. Storage calculation for the Upper Condamine Basalts SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 3530 | 1009 | 0 | 0 |
| Saturated thickness (m) | 30 | 30 | N/A | N/A |
| Specific yield | 0.08 | 0.08 | N/A | N/A |
| **Total storage (GL)** | **8472** | **2422** | **N/A** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge ranges from 84 to 99 for each of the salinity zones. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

## 1.2.6 The risk matrix

Table 12 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary;

- the SDL area is ranked low risk in terms of environmental assets, although the Dalrymple Creek wetlands exist in this unit, it is not sensitive to groundwater take
- the SDL area is ranked low risk in terms of ecosystem function, given that in its current state, groundwater discharge to streams is not a significant process
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio is far greater than 40
- there is no risk to the key environmental outcome (i.e. groundwater salinity), given that the basalts are geographically the highest point on the landscape and hydrologically not influenced by poorer quality groundwater laterally
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge from WAVES modelling only. It does not include other potential components of recharge, including river leakage, irrigation returns, throughflow etc.

 

Table 12. Risk matrix

| Risk ranking | Environmental assets (EAs) | OR | Ecosystem function | OR | Productive base | Sustainability factor (SF) | Key environmental outcome | Degree of uncertainty |
|---|---|---|---|---|---|---|---|---|
| High | EA that is highly groundwater dependent and highly sensitive to take | | In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion | | Storage/ recharge <20 | 0.10 | Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br>Salinity class 1: reduce SF by 20%<br>Salinity class 2: reduce SF by 10%<br>Salinity classes 3 & 4: no reduction | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50% |
| Medium | EA that is highly groundwater dependent and is moderately sensitive to take<br>EA that is moderately groundwater dependent and is highly sensitive to take | | The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years) | | Storage/ recharge 20–40 | 0.50 | | |
| Low | EA that has a low groundwater dependence and low sensitivity to take<br>EAs do not exist in the SDL area | | The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years) | | Storage/ recharge >40 | 0.70 | | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25% |

### 1.2.7 Preliminary RRAM extraction limit

The preliminary estimated extraction limit resulting from the RRAM for the Upper Condamine Basalts SDL area is 61 GL/year (Table 13).

Table 13. Preliminary extraction limit summary for the Upper Condamine Basalts SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 86 | 29 | 0 | 0 |
| Sustainability factor | 0.53 | 0.53 | N/A | N/A |
| **Extraction limit (GL/yr)** | **46** | **15** | **N/A** | **N/A** |

## 1.3 Queensland Border Rivers Alluvium (GS67)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the Border Rivers Alluvium (Qld) SDL area.

### 1.3.1 Background

The Border Rivers Alluvium (Qld) SDL area is located within the topographic depressions of the Border Rivers valley, where the parent rock has been eroded and riverine sediments deposited. Current groundwater use in this SDL area is 13 GL/year (Table 14). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

The SDL area incorporates two aquifers that overlie basement rock and are separated by an aquitard. The watertable aquifer consists of unconsolidated clay, sand and gravel about 10 to 30 m thick. It is unconfined and responds hydraulically to flooding. The aquitard comprises semi-impervious clay layers. The deeper aquifer is semi-confined and comprises consolidated clay, sandstone and gravel up to about 50 m thick and extends to about 50 to100 m below ground surface (Welsh, 2007).

Water level observations at nested observation sites (

Figure 5) indicate that in the Border Rivers Alluvium SDL area, the upper and lower alluvial aquifers are often in hydraulic connection. For this reason a single extraction limit (for both upper and lower aquifers) has been determined for the Border Rivers Alluvium.

Table 14. Groundwater take summary for the Border Rivers Alluvium (Qld) SDL area

| Border Rivers Alluvium SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **18** |
| Current use for entitlement bores** | 11 |
| Estimated use for stock and domestic bores* | 2.5 |
| **Total current use** | **13** |

*Entitlement and stock and domestic use figures were provide by DERM.
**Current use is equivalent to 60% of the entitlement volume.

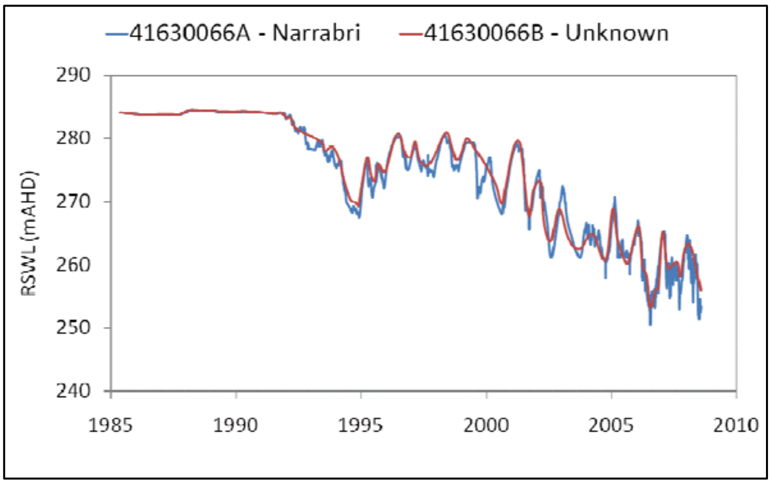


Figure 5. Hydrograph for bores screening the shallow and deep alluvial aquifers

 

### 1.3.2 Salinity zoning

The Border Rivers Alluvium (Qld) SDL area is characterised by three salinity classes that range from 0 to 14,000 mg/L TDS. The groundwater salinity distribution can be seen in Figure 6 and is summarised in Table 15.

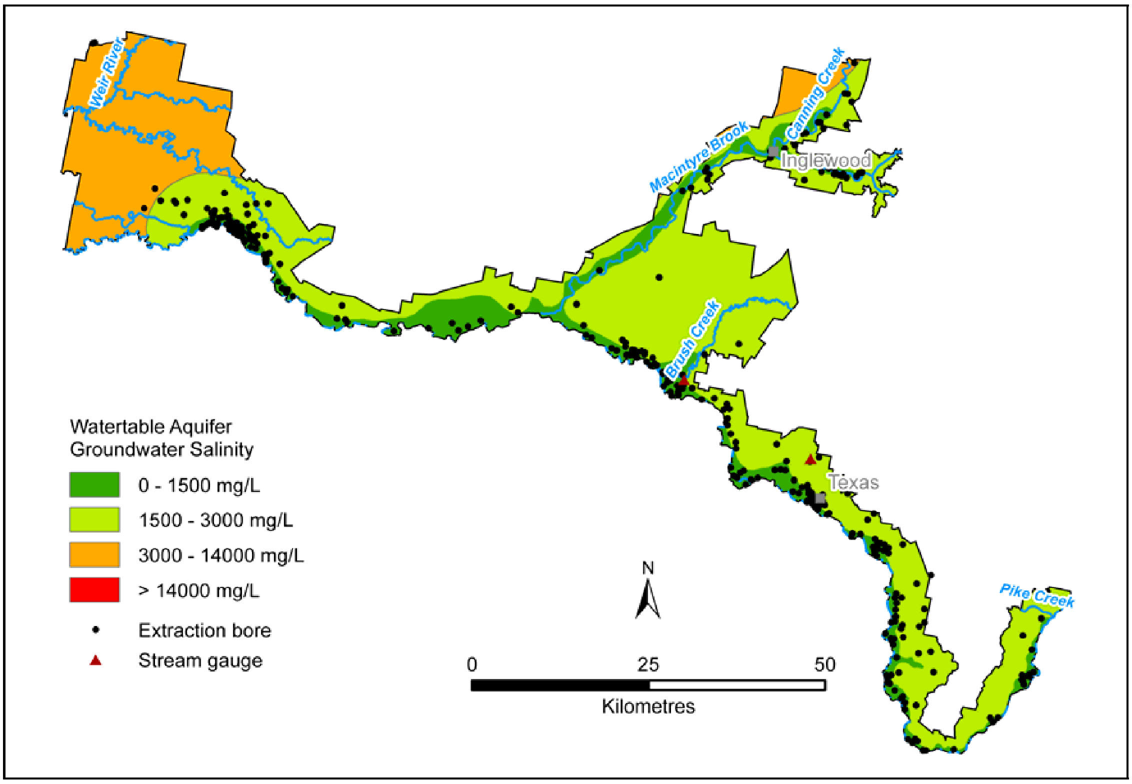


Figure 6. Border Rivers Alluvium (Qld) SDL area watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 15. Summary of salinity zones in the Border Rivers Alluvium (Qld) SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 16 | 346 |
| Zone 2 (1500–3000 mg/L TDS) | 59 | 1309 |
| Zone 3 (3000–14,000 mg/L TDS) | 25 | 552 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water bodies | 0 | 0 |
| **Total** | **100** | **2208** |

### 1.3.3 Key environmental assets

There are no key environmental assets, which have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment that are associated with the Border Rivers Alluvium (Qld) SDL area.

### 1.3.4 Key ecosystem function

Figure 7 shows the annual net river loss of the Dumaresq River, as indicated by the numerical model, under a historical climate and 2004/2005 pumping regime (Welsh, 2007). This indicates that when 11 GL/year was extracted from the alluvial aquifer, 5 GL/year was derived from the river, implying a connectivity of approximately 45 percent.

A study of the interaction between groundwater and surface water in the Border Rivers Catchment was undertaken by Baskaran et al. (2005) using environmental isotopes (including; major ions, stable isotopes and radon-222). The results of the hydrochemical and environmental isotope sampling indicated that the river and the shallow alluvial aquifers close to the river in the area upstream of Keetah have a close hydraulic relationship. In this upper catchment area, the streams are losing and recharge the shallow aquifers.

Based on this information, the Border Rivers Alluvium (Qld) SDL area is considered medium risk in terms of the key ecosystem function.

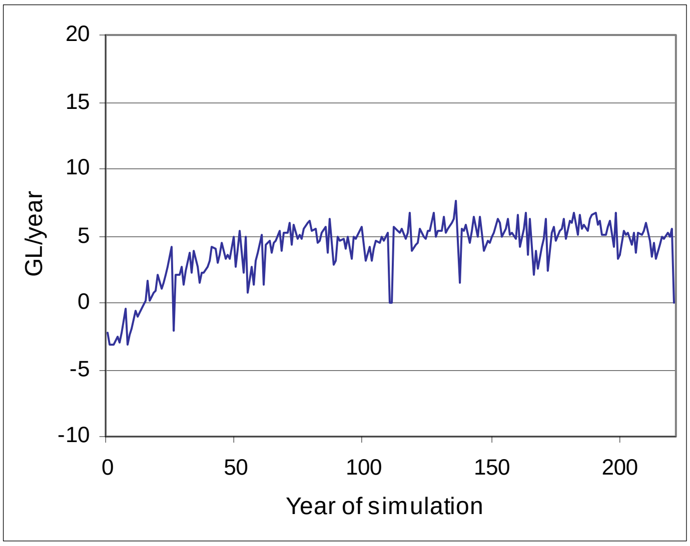


Figure 7. Annual net river loss of the Dumaresq River under a historical climate and 2004/2005 level of groundwater development (from Welsh, 2007)

## 1.3.5 Productive base

**Recharge**

Recharge to the Border Rivers Alluvium (Qld) has been derived from WAVES modelling and an allowance for irrigation recharge. River water pumping licences and pumping records could not be obtained within the time frame required to determine the SDL for this unit. In the absence of this information, half of the irrigation recharge volume from the Border Rivers groundwater model (under the 2004/2005 level of development) has been added to the WAVES recharge volume. This equates to 0.5 GL (Welsh, 2007).

WAVES modelling under the historical median scenario indicates recharge ranges from 7.9 mm/year to 69 mm/year across the SDL area.

Total recharge to the Border Rivers Alluvium (Qld) SDL area is 68 GL/year (Table 16).

Table 16. Recharge calculation for the Border Rivers Alluvium (Qld) SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 346 | 1309 | 552 | 0 |
| WAVES recharge (mm/yr) | 69 | 30 | 7.9 | N/A |
| WAVES recharge (GL/yr) | 24 | 39 | 4.4 | N/A |
| Irrigation recharge (GL/yr) | 0.08 | 0.30 | 0.13 | N/A |
| **Total recharge (GL/yr)** | **24** | **40** | **4.5** | **N/A** |

**Storage**

The specific yield of the unconfined shallow aquifer ranges between 0.007 and 0.051 (Welsh, 2007). For the purpose of this calculation, a specific yield of 0.03 has been used (the average of the range of specific yield values). An average thickness of 50 m has been estimated to represent the alluvial aquifers (Welsh, 2007). Estimated storage for this unit is 3,312 GL (Table 17).

Table 17. Storage calculation for the Border Rivers Alluvium (Qld) SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 346 | 1309 | 552 | 0 |
| Saturated thickness (m) | 50 | 50 | 50 | N/A |
| Specific yield | 0.03 | 0.03 | 0.03 | N/A |
| **Total storage (GL)** | **519** | **1964** | **829** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge ranges from 22 to 184 for each of the salinity zones. This indicates that there is a medium risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

### 1.3.6 The risk matrix

Table 18 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental essets, given none were identified as groundwater dependent in this area
- the SDL area is ranked medium risk in terms of ecosystem function, given that connectivity is close to 50 percent
- the SDL area is ranked medium risk in terms of the productive base, given that the storage/recharge ratio far exceeds 40
- there is no risk to key environmental outcomes (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge from WAVES modelling only. It does not include other potential components of recharge, including river leakage, irrigation returns, throughflow etc.

Table 18. Risk matrix

<table>
<tr><th>Risk ranking</th><th>Environmental assets (EAs)</th><th>OR</th><th>Ecosystem function</th><th>OR</th><th>Productive base</th><th>Sustainability factor (SF)</th><th>Key environmental outcome</th><th>Degree of uncertainty</th></tr>
<tr><td>High</td><td>EA that is highly groundwater dependent and highly sensitive to take</td><td rowspan="3"></td><td>In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion</td><td rowspan="3"></td><td>Storage/ recharge <20</td><td>0.10</td><td rowspan="3">Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br><br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br><br>Salinity class 1: reduce SF by 20<br><br>Salinity class 2: reduce SF by 10%<br><br>Salinity classes 3 & 4: no reduction</td><td rowspan="2">Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50%</td></tr>
<tr><td>Medium</td><td>EA that is highly groundwater dependent and is moderately sensitive to take<br><br>EA that is moderately groundwater dependent and is highly sensitive to take</td><td>The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge 20–40</td><td>0.50</td></tr>
<tr><td>Low</td><td>EA that has a low groundwater dependence and low sensitivity to take<br><br>EAs do not exist in the SDL area</td><td>The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge >40</td><td>0.70</td><td>Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25%</td></tr>
</table>

### 1.3.7 Preliminary RRAM extraction limit

The preliminary estimated extraction limit resulting from the RRAM for the Border Rivers Alluvium (Qld) SDL area is 17 GL/year. This extraction limit is to be superseded by the volume of current groundwater use occurring in this unit (i.e. 13 GL/year).

Table 19. Preliminary extraction limit for the Border Rivers Alluvium (Qld) SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 24 | 40 | 4.5 | 0 |
| Sustainability factor | 0.25 | 0.25 | 0.25 | N/A |
| **Extraction limit (GL/yr)** | **6.0** | **9.9** | **1.1** | **N/A** |

## 1.4 Condamine Fractured Rock (GS66)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the Condamine Fractured Rock SDL area.

### 1.4.1 Background

The Condamine Fractured Rock SDL area is dominated by the sandstones and mudstones of the Upper Devonian Texas Beds and Lower Triassic granites of the Herries Range (Olgers et al., 1972). Groundwater use is limited in the Condamine Fractured Rock SDL area, given that the alluvial systems associated with the major rivers and creeks in the Upper Condamine subcatchment provide a more viable groundwater resource. Current groundwater use in the Condamine Fractured Rock SDL area is 2.1 GL/year (Table 20). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

Table 20. Groundwater take summary for the Condamine Fractured Rock SDL area

| Condamine Fractured Rock SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **0.15** |
| Current use for entitlement bores** | 0.09 |
| Estimated use for stock & domestic bores* | 2.0 |
| **Total current use** | **2.1** |

*Entitlement and stock and domestic use figures were provide by DERM.
**Current use is equivalent to 60% of the entitlement volume.

### 1.4.2 Salinity zoning

The Condamine Fractured Rock SDL area is characterised by two salinity classes that range from 0 to 3000 mg/L TDS. The groundwater salinity distribution can be seen in Figure 8 and is summarised in Table 21.

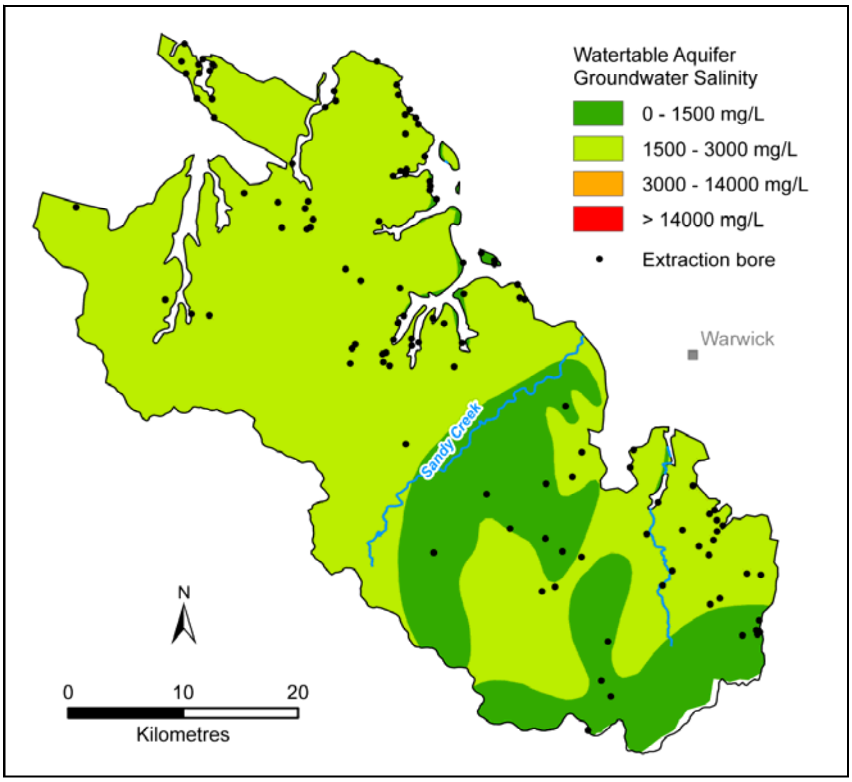


Figure 8. Condamine Fractured Rock SDL area watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 21. Summary of salinity zones in the Condamine Fractured Rock SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 24 | 412 |
| Zone 2 (1500–3000 mg/L TDS) | 76 | 1331 |
| Zone 3 (3000–14,000 mg/L TDS) | 0 | 0 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water bodies | 0.29 | 5 |
| **Total** | **100** | **1749** |

## 1.4.3 Key environmental assets

There are no key environmental assets that have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment, that are associated with the Condamine Fractured Rock SDL area.

## 1.4.4 Key ecosystem function

There are a number of tributaries of the Condamine River that commence in this SDL area and are unregulated river reaches and therefore the key ecosystem function of this unit is considered at high risk.

## 1.4.5 Productive base

**Recharge**

Diffuse rainfall recharge to the Condamine Fractured Rock SDL area has been calculated at 50 GL/year via WAVES modelling, under the historical dry climate scenario. The area is not extensively irrigated and hence no allowance has been made for irrigation derived recharge. Groundwater recharge to the SDL area is summarised in Table 22.

Table 22. Recharge calculation for the Condamine Fractured Rock SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 412 | 1331 | 0 | 0 |
| Diffuse recharge (mm/yr) | 40 | 25 | N/A | N/A |
| **Total recharge (GL/yr)** | **16** | **33** | **N/A** | **N/A** |

**Storage**

The thickness of the Palaeozoic fractured rock is unknown. A thickness of 100 m has been used for the purpose of this storage estimate. A specific yield of 0.01 has also been utilised, which is typical of fractured rock aquifer (Johnson, 1967). Estimated storage for the SDL area is 1743 GL (Table 23).

Table 23. Storage calculation for the Condamine Fractured Rock SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 412 | 1331 | 0 | 0 |
| Saturated thickness (m) | 100 | 100 | N/A | N/A |
| Specific yield | 0.01 | 0.01 | N/A | N/A |
| **Total storage (GL)** | **412** | **1331** | **N/A** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge ranges from 26 to 40 for each of the salinity zones. This indicates that there is a medium risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

### 1.4.6 The risk matrix

Table 24 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked high risk in terms of ccosystem function, given that tributaries of the Condamine River initiate in the Condamine Fractured Rock SDL area
- the SDL area is ranked medium risk in terms of the productive base, given that the storage/recharge ratio is between 20 and 40
- there is no risk to key environmental outcomes (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge from WAVES modelling only. It does not include other potential components of recharge, including river leakage, irrigation returns, throughflow etc.

Table 24. Risk matrix

| Risk ranking | Environmental assets (EAs) | OR | Ecosystem function | OR | Productive base | Sustainability factor (SF) | Key environmental outcome | Degree of uncertainty |
|---|---|---|---|---|---|---|---|---|
| High | EA that is highly groundwater dependent and highly sensitive to take | | In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion | | Storage/ recharge <20 | 0.10 | Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br>Salinity class 1: reduce SF by 20%<br>Salinity class 2: reduce SF by 10%<br>Salinity classes 3 & 4: no reduction | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50% |
| Medium | EA that is highly groundwater dependent and is moderately sensitive to take<br>EA that is moderately groundwater dependent and is highly sensitive to take | | The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years) | | Storage/ recharge 20–40 | 0.50 | | |
| Low | EA that has a low groundwater dependence and low sensitivity to take<br>EAs do not exist in the SDL area | | The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years) | | Storage/ recharge >40 | 0.70 | | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25% |

## 1.4.7 Preliminary RRAM extraction limit

The preliminary estimated extraction limit resulting from the RRAM for the Condamine Fractured Rock SDL area is 2.5 GL/year (Table 25). This is greater than the volume of current use (2.1 GL/year). However, given the high level of groundwater and surface water connectivity, the groundwater SDL will be set at current use. Further development of the groundwater system is feasible up to the RRAM-derived extraction limit of 2.5 GL/year, where an equivalent reduction in surface water is required to offset the additional groundwater take on the basis of a 1:1 relationship between groundwater take and surface water streamflow reduction.

 

Table 25. Preliminary extraction limit for the Condamine Fractured Rock SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 16 | 33 | 0 | 0 |
| Sustainability factor | 0.05 | 0.05 | N/A | N/A |
| **Extraction limit (GL/yr)** | **0.82** | **1.7** | **N/A** | **N/A** |

## 1.5 Queensland Border Rivers Fractured Rock (GS68)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the Border Rivers Fractured Rock SDL area.

### 1.5.1 Background

The Border Rivers Fractured Rock SDL area is dominated by the sandstones and mudstones of the Upper Devonian Texas Beds. Thin Quaternary alluvium associated with streams also occurs in the area (Mond et al., 1968).

These aquifers posses limited resource potential. Current groundwater use in the Border Rivers Fractured Rock SDL area is 6.8 GL/year (Table 26). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

Table 26. Groundwater take summary for the Border Rivers Fractured Rock SDL area

| Border Rivers Fractured Rock SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **0.56** |
| Estimated use for entitlement bores** | 0.33 |
| Estimated use for stock and domestic bores* | 6.5 |
| **Total current use** | **6.8** |

*Entitlement and stock and domestic use numbers were provided by DERM.
**Estimated use is equal to 60% of the entitlement volume.

### 1.5.2 Salinity zoning

The Border Rivers Fractured Rock SDL area is characterised by two salinity classes that range from 0 to 3000 mg/L TDS. A small portion of the area (approximately 0.1 percent) is characterised by groundwater salinity zone 3. This area has been incorporated into the area of groundwater salinity zone 2, as an SDL determination for such a small area is not considered feasible. Groundwater salinity distribution can be seen in Figure 9 and is summarised in Table 27.

 

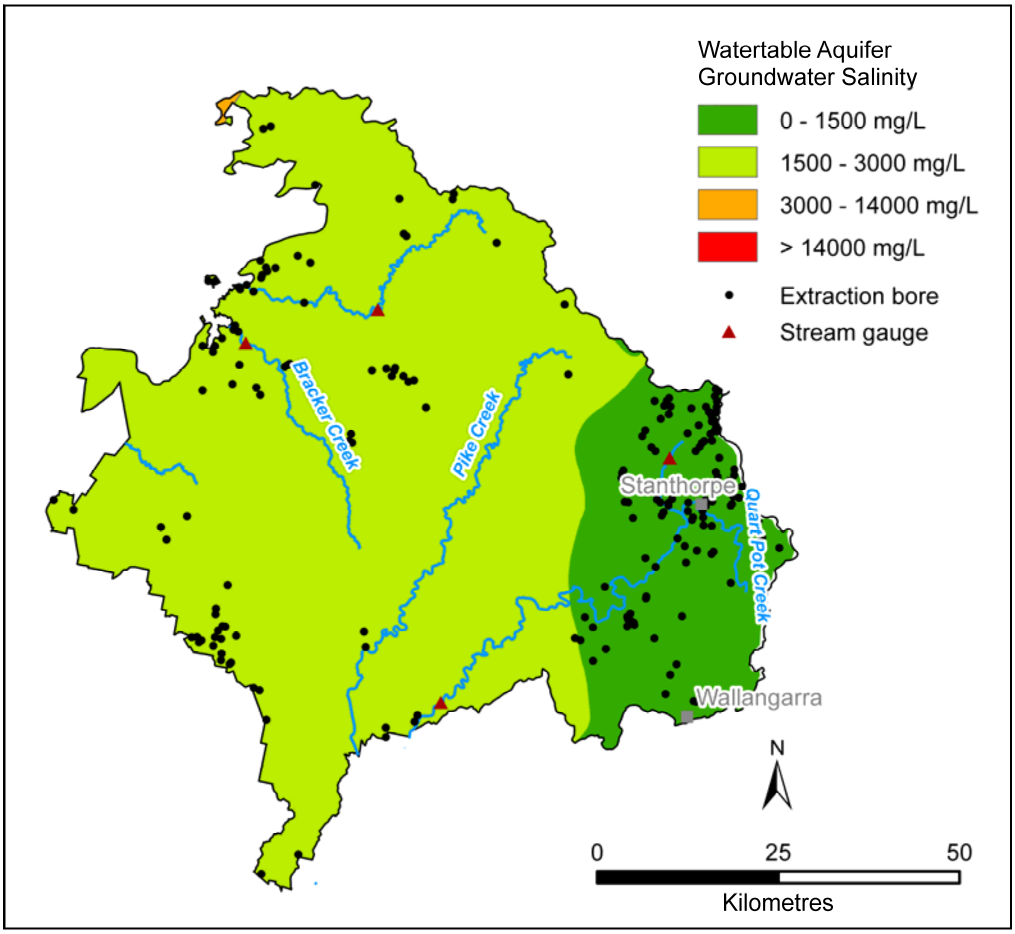


Figure 9. Border Rivers Fractured Rock SDL area watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 27. Summary of salinity zones in the Border Rivers Fractured Rock SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 19 | 1081 |
| Zone 2 (1500–3000 mg/L TDS) | 80 | 4504 |
| Zone 3 (3000–14,000 mg/L TDS) | 0 | 0 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water bodies | 0.3 | 14 |
| **Total** | **100** | **5599** |

## 1.5.3 Key environmental assets

There are no key environmental assets that have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment, that are associated with the Border Rivers Fractured Rock SDL area.

## 1.5.4 Key ecosystem function

There are a number of unregulated river reaches in the Border Rivers Fractured Rock SDL area. There is a low level of development in this area and hence it is likely that in its current state, groundwater discharge remains a significant process in this area. Therefore the key ecosystem function is considered to be at high risk.

## 1.5.5 Productive base

**Recharge**

Diffuse rainfall recharge to the Border Rivers Fractured Rock SDL area has been calculated at 171 GL/year via WAVES modelling, using the historical dry climate scenario. Groundwater recharge to the SDL area is summarised in Table 28.

Table 28. Recharge calculation for the Border Rivers Fractured Rock SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 1081 | 4504 | 0 | 0 |
| Diffuse recharge (mm/yr) | 63 | 23 | 0 | 0 |
| **Total recharge (GL/yr)** | **68** | **104** | **0** | **0** |

**Storage**

The thickness of the Upper Devonian fractured rock is unknown. A thickness of 100 m has been used for the purpose of this storage estimate. A specific yield of 0.01 has also been utilised, which is typical of a fractured rock aquifer (Johnson, 1967). Estimated storage for the SDL area is 5585 GL (Table 29).

Table 29. Storage calculation for the Border Rivers Fractured Rock SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 1081 | 4504 | 0 | 0 |
| Saturated thickness (m) | 100 | 100 | N/A | N/A |
| Specific yield | 0.01 | 0.01 | N/A | N/A |
| **Total storage (GL)** | **1081** | **4504** | **N/A** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge ranges from 16 to 43 for each of the salinity zones. This indicates that there is a high risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

## 1.5.6 The risk matrix

Table 30 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked high risk in terms of ecosystem function, given that a number of unregulated river reaches occur within it
- the SDL area is ranked high risk in terms of the productive base, given that the storage/recharge ratio is less than 20 in salinity zone 1
- there is no risk to key environmental outcomes (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge from WAVES modelling only. It does not include other potential components of recharge, including river leakage, irrigation returns, throughflow etc.

 

Table 30. Risk matrix

| Risk ranking | Environmental assets (EAs) | OR | Ecosystem function | OR | Productive base | Sustainability factor (SF) | Key environmental outcome | Degree of uncertainty |
|---|---|---|---|---|---|---|---|---|
| High | EA that is highly groundwater dependent and highly sensitive to take | | In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion | | Storage/ recharge <20 | 0.10 | Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br>Salinity class 1: reduce SF by 20%<br>Salinity class 2: reduce SF by 10%<br>Salinity classes 3 & 4: no reduction | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50% |
| Medium | EA that is highly groundwater dependent and is moderately sensitive to take<br>EA that is moderately groundwater dependent and is highly sensitive to take | | The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years) | | Storage/ recharge 20–40 | 0.50 | | |
| Low | EA that has a low groundwater dependence and low sensitivity to take<br>EAs do not exist in the SDL area | | The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years) | | Storage/ recharge >40 | 0.70 | | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25% |

## 1.5.7 Preliminary RRAM extraction limit

The preliminary estimated extraction limit resulting from the RRAM for the Border Rivers Fractured Rock SDL area is 8.6 GL/year (Table 31). This is greater than the volume of current use (6.8 GL/year). However, given the high level of groundwater and surface water connectivity, the groundwater SDL will be set at current use. Further development of the groundwater system is feasible up to the RRAM-derived extraction limit of 8.6 GL/year, where an equivalent reduction in surface water is required to offset the additional groundwater take on the basis of a 1:1 relationship between groundwater take and surface water streamflow reduction.

Table 31. Preliminary extraction limit for the Border Rivers Fractured Rock SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 68 | 103 | 0 | 0 |
| Sustainability factor | 0.05 | 0.05 | N/A | N/A |
| **Extraction limit (GL/yr)** | **3.4** | **5.2** | **N/A** | **N/A** |

 

## 1.6 Sediments Above the Great Artesian Basin: Moonie (GS71)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the Sediments Above GAB: Moonie SDL area.

### 1.6.1 Background

The Sediments Above GAB: Moonie SDL area incorporates the alluvial and shallow Tertiary sandstones that overlie the Great Artesian Basin (GAB). Current groundwater use in this unit is 0.16 GL/year (Table 32). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

The dominant source of groundwater in this area is from the underlying GAB Jurassic and Cretaceous confined sandstone aquifers. The groundwater in these aquifers is separated from the Sediments Above GAB: Moonie SDL aquifers, by thick confining beds of the Rolling Downs Group (Thomas and Reiser, 1967). This means there is little interaction between the deep GAB aquifers and the overlying surface water and shallow groundwater sources. The water resources within these deeper confined aquifers forms part of the GAB Water Resources and is specifically excluded from the Basin Water Resources by the *Water Act 2007*. Therefore they are not considered further in the RRAM assessment.

Recent groundwater investigations have found shallow, unconfined groundwater between 10 and 35 m below the surface (Mahawategge et al., 2003). These sources are generally used for stock and domestic purposes only.

Table 32. Groundwater take summary for the Sediments Above GAB: Moonie SDL area

| Sediments Above GAB: Moonie SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **0.02** |
| Current use for entitlement bores** | 0.012 |
| Estimated use for stock and domestic bores* | 0.15 |
| **Total current use** | **0.16** |

*Entitlement and stock and domestic use volumes were provided by DERM.
**Current use is 60% of the entitlement volume.

### 1.6.2 Salinity zoning

The Sediments Above GAB: Moonie SDL area is characterised by three salinity classes that range from 0 to 14,000 mg/L TDS. The salinity distribution is shown in Figure 10 and is summarised in Table 33.

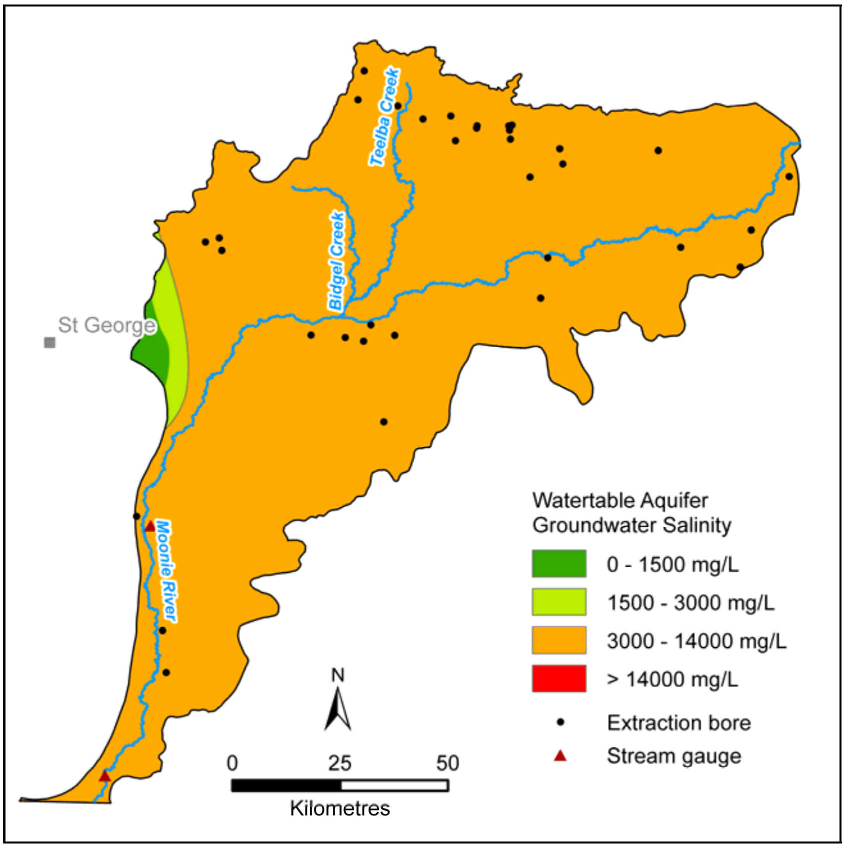


Figure 10. Sediments Above GAB: Moonie watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 33. Summary of salinity zones in the Sediments Above GAB: Moonie SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 0.76 | 88 |
| Zone 2 (1500–3000 mg/L TDS) | 1.5 | 175 |
| Zone 3 (3000–14,000 mg/L TDS) | 98 | 11,277 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| **Total** | **100** | **11,539** |

## 1.6.3 Key environmental assets

There are no key environmental assets that have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment, that are associated with the Sediments Above GAB: Moonie SDL area.

## 1.6.4 Key ecosystem function

The Moonie River is an unregulated river and annual surface water use is strongly influenced by the seasonal rainfall patterns that determine access by irrigators to supplementary water during periods of high river flow (CSIRO, 2008b). However, there is no contribution to baseflow from this system (Department of Environment and Resource Management , February 2010, pers. comm.) and hence the key ecosystem function has been assigned a low risk ranking.

 

### 1.6.5 Productive base

**Recharge**

Recharge to the Sediments Above GAB: Moonie SDL area has been calculated via WAVES modelling, under a historical dry climate scenario. Total recharge to the SDL area is 176 GL/year and is summarised for each salinity class in Table 34. The area is not extensively irrigated and hence no allowance has been made for irrigation derived recharge.

Table 34. Recharge calculation for the Sediments Above GAB: Moonie SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 88 | 175 | 11,277 | 0 |
| Diffuse recharge (mm/yr) | 14 | 14 | 15 | N/A |
| **Total recharge (GL)** | **1.2** | **2.5** | **172** | **N/A** |

**Storage**

The specific yield adopted for the Quaternary and Tertiary aquifer of the Sediments Above GAB: Moonie SDL area is 0.05, which is appropriate for the deeply weathered materials. The thickness of this unit is variable and an average thickness of 25 m has been adopted for this storage estimate. Storage of the Sediments Above GAB: Moonie SDL area is 14,425 GL (Table 35).

Table 35. Storage calculation for the Sediments Above GAB: Moonie SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 88 | 175 | 11,277 | 0 |
| Saturated thickness (m) | 25 | 25 | 25 | N/A |
| Specific yield | 0.05 | 0.05 | 0.05 | N/A |
| **Total storage (GL)** | **110** | **219** | **14,096** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge ranges from 82 and 92 for each of the salinity zones. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

### 1.6.6 The risk matrix

Table 36 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked low risk in terms of ecosystem function, given that interaction between the watertable aquifer and the Moonie River is thought to be negligible
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio is greater than 40
- there is no risk to the key environmental outcome (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge from WAVES modelling only. It does not include other potential components of recharge, including river leakage, irrigation returns, throughflow etc.

Table 36. Risk matrix

<table>
<tr><th>Risk ranking</th><th>Environmental assets (EAs)</th><th>OR</th><th>Ecosystem function</th><th>OR</th><th>Productive base</th><th>Sustainability factor (SF)</th><th>Key environmental outcome</th><th>Degree of uncertainty</th></tr>
<tr><td>High</td><td>EA that is highly groundwater dependent and highly sensitive to take</td><td rowspan="3"></td><td>In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion</td><td rowspan="3"></td><td>Storage/ recharge <20</td><td>0.10</td><td rowspan="3">Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br><br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br><br>Salinity class 1: reduce SF by 20%<br><br>Salinity class 2: reduce SF by 10%<br><br>Salinity classes 3 & 4: no reduction</td><td rowspan="2">Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50%</td></tr>
<tr><td>Medium</td><td>EA that is highly groundwater dependent and is moderately sensitive to take<br><br>EA that is moderately groundwater dependent and is highly sensitive to take</td><td>The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge 20–40</td><td>0.50</td></tr>
<tr><td>Low</td><td>EA that has a low groundwater dependence and low sensitivity to take<br><br>EAs do not exist in the SDL area</td><td>The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge >40</td><td>0.70</td><td>Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25%</td></tr>
</table>

## 1.6.7 Preliminary RRAM extraction limit

The preliminary estimated extraction limit resulting from the RRAM for the Sediments Above GAB: Moonie SDL area is 93 GL/year (Table 37).

Where the volume of unassigned water is greater than 50 GL/year and greater than one-hundred times the volume of current use, the preliminary RRAM-derived extraction limit is superseded by an extraction limit equivalent to the high sustainability factor applied to recharge for that particular SDL area. These conditions apply to the Sediments Above GAB: Moonie SDL area and the revised extraction limit is 8.8 GL/year (Table 38).

Table 37. Preliminary extraction limit summary for the Sediments Above GAB: Moonie SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 1.2 | 2.5 | 172 | N/A |
| Sustainability factor | 0.53 | 0.53 | 0.53 | N/A |
| **Extraction limit (GL/yr)** | **0.64** | **1.3** | **91** | **N/A** |

Table 38. Revised preliminary extraction limit summary for the Sediments Above GAB: Moonie SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 1.2 | 2.5 | 172 | N/A |
| Sustainability factor | 0.05 | 0.05 | 0.05 | N/A |
| **Extraction limit (GL/yr)** | **0.061** | **0.12** | **8.6** | **N/A** |

# 1.7 Sediments Above the Great Artesian Basin: Condamine-Balonne (GS70)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the Sediments Above GAB: Condamine-Balonne SDL area.

## 1.7.1 Background

The Sediments Above GAB: Condamine-Balonne SDL area incorporates the Cretaceous sandstone, siltstone and mudstone of the Griman Creek Formation. The Condamine-Balonne River alluvium sits on top of the Griman Creek Formation (Thomas and Reiser, 1967). Current groundwater use in this unit is 0.34 GL/year and is dominated by stock and domestic use (Table 39). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010).

The dominant source of groundwater in this area is from the underlying GAB Jurassic and Cretaceous confined sandstone aquifers. The groundwater in these aquifers is separated from the Sediments Above GAB: Condamine-Balonne SDL aquifers, by thick confining beds. This means there is little interaction between the deep GAB aquifers and the overlying surface water and shallow groundwater sources. The water resources within these deeper confined aquifers forms part of the GAB Water Resources and is specifically excluded from the Basin Water Resources by the Water Act. Therefore they are not considered further in the RRAM assessment.

Table 39. Groundwater take summary for the sediments Above GAB: Condamine-Balonne SDL area

| Sediments Above GAB: Condamine-Balonne SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **0.068** |
| Current use for entitlement bores** | 0.041 |
| Estimated use for stock and domestic bores* | 0.30 |
| **Total current use** | **0.34** |

*Entitlement volumes and stock and domestic use volumes were provided by DERM.
**Current use is equal to 60% of entitlement.

## 1.7.2 Salinity zoning

The Sediments Above GAB: Condamine-Balonne SDL area is characterised by three salinity classes that range from 0 to 14,000 mg/L TDS. The groundwater salinity distribution can be seen in Figure 11 and is summarised in Table 40.

 

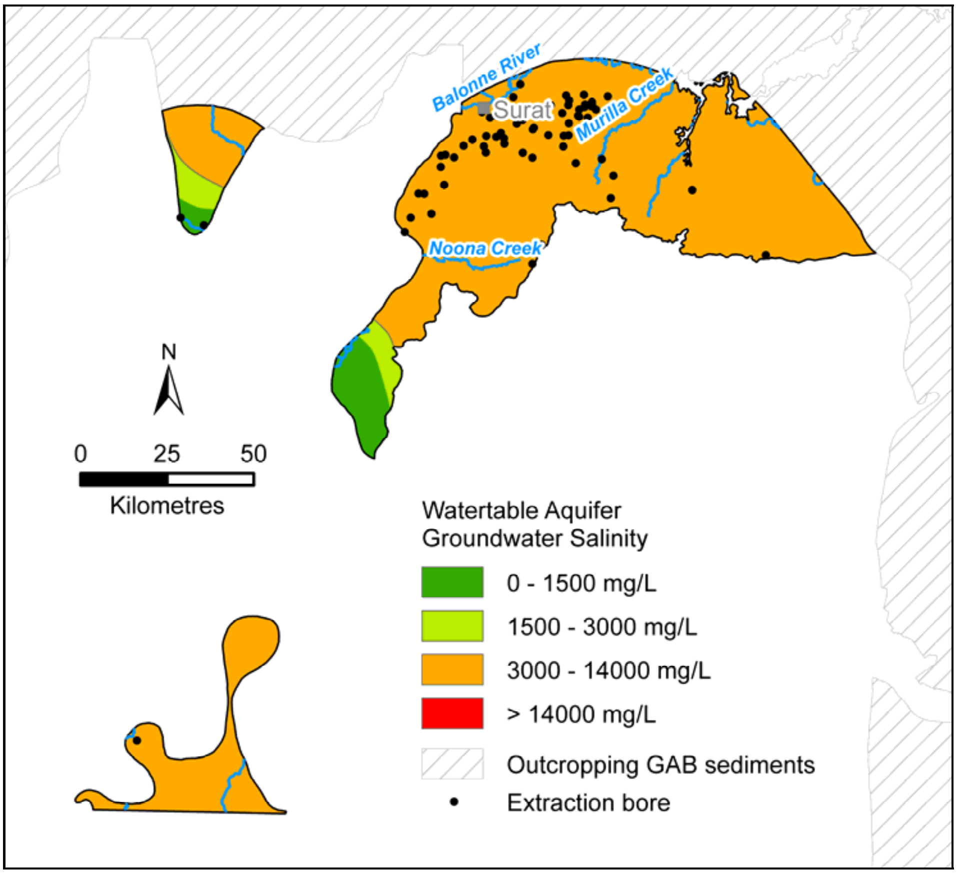


Figure 11. Sediments Above GAB: Condamine-Balonne watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 40. Summary of salinity zones in the Sediments Above GAB: Condamine-Balonne SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 5 | 418 |
| Zone 2 (1500–3000 mg/L TDS) | 3 | 250 |
| Zone 3 (3000–14,000 mg/L TDS) | 92 | 7279 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water bodies | 0 | 0 |
| **Total** | **100** | **7947** |

## 1.7.3 Key environmental assets

There are no key environmental assets that have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment, that are associated with the Sediments Above GAB: Condamine-Balonne SDL area.

## 1.7.4 Key ecosystem function

A basin-scale review of river–aquifer connectivity was conducted by REM (2004) that indicated that middle reaches of the Condamine-Balonne River was disconnected from the underlying aquifer systems. Although this review was conducted at a basin scale and hence there is an inherent uncertainty when considering the results of the assessment on an SDL-area scale, this supports the hydrogeological conceptualisation that the key ecosystem function in this area would be at low risk within the SDL area.

### 1.7.5 Productive base

**Recharge**

Recharge to the Sediments Above GAB: Condamine-Balonne SDL area has been calculated at 96 GL/year via WAVES modelling using a historical dry climate scenario (Table 41). The area is not extensively irrigated and hence no allowance has been made for irrigation derived recharge.

Table 41. Recharge calculation for the Sediments Above GAB: Condamine-Balonne SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 418 | 250 | 7279 | 0 |
| Diffuse recharge (mm/yr) | 17 | 20 | 12 | N/A |
| **Total recharge (GL/yr)** | **7.0** | **5.0** | **84** | **N/A** |

**Storage**

The specific yield adopted for the Griman Creek Formation and Quaternary sediments that reside above the GAB in this SDL area is estimated at 0.05. The Surat geological map indicates the Griman Creek Formation has an average thickness of approximately 100 m in this area (Thomas and Reiser, 1967). A saturated thickness of 100 m has been adopted for this storage estimate. Storage of the Sediments Above GAB: Condamine-Balonne SDL area is approximately 39,735 GL (Table 42).

Table 42. Storage calculation for the Sediments Above GAB: Condamine-Balonne SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 418 | 250 | 7,279 | 0 |
| Saturated thickness (m) | 100 | 100 | 100 | N/A |
| Specific yield | 0.05 | 0.05 | 0.05 | N/A |
| **Total storage (GL)** | **2,090** | **1,250** | **36,395** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge ranges from 250 to 433 for each of the salinity zones. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

### 1.7.6 The risk matrix

Table 43 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked low risk in terms of ecosystem function, given that the middle reaches of the Condamine-Balonne have a low connectivity with the surrounding aquifers
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio far exceeds 40
- there is no risk to the key environmental outcome (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge from WAVES modelling only. It does not include other potential components of recharge, including river leakage, irrigation returns, throughflow etc.

 

Table 43. Risk matrix

<table>
<tr><th>Risk ranking</th><th>Environmental assets (EAs)</th><th>OR</th><th>Ecosystem function</th><th>OR</th><th>Productive base</th><th>Sustainability factor (SF)</th><th>Key environmental outcome</th><th>Degree of uncertainty</th></tr>
<tr><td>High</td><td>EA that is highly groundwater dependent and highly sensitive to take</td><td></td><td>In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion</td><td></td><td>Storage/ recharge <20</td><td>0.10</td><td rowspan="3">Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br><br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br><br>Salinity class 1: reduce SF by 20%<br><br>Salinity class 2: reduce SF by 10%<br><br>Salinity classes 3 & 4: no reduction</td><td rowspan="2">Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50%</td></tr>
<tr><td>Medium</td><td>EA that is highly groundwater dependent and is moderately sensitive to take<br><br>EA that is moderately groundwater dependent and is highly sensitive to take</td><td></td><td>The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years)</td><td></td><td>Storage/ recharge 20–40</td><td>0.50</td></tr>
<tr><td>Low</td><td>EA that has a low groundwater dependence and low sensitivity to take<br><br>EAs do not exist in the SDL area</td><td></td><td>The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years)</td><td></td><td>Storage/ recharge >40</td><td>0.70</td><td>Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25%</td></tr>
</table>

## 1.7.7 Preliminary RRAM extraction limit

The preliminary estimated extraction limit resulting from the RRAM for the Sediments Above GAB: Condamine-Balonne SDL area is 51 GL/year (Table 44).

Where the volume of unassigned water is greater than 50 GL/year and greater than one-hundred times the volume of current use, the preliminary RRAM-derived extraction limit is superseded by an extraction limit equivalent to the high sustainability factor applied to recharge for that particular SDL area. These conditions apply to the Sediments Above GAB: Condamine-Balonne SDL area and the revised extraction limit is 4.8 GL/year (Table 45).

Table 44. Preliminary extraction limit summary for the Sediments Above GAB: Condamine-Balonne SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 7.0 | 5.0 | 84 | N/A |
| Sustainability factor | 0.53 | 0.53 | 0.53 | N/A |
| **Extraction limit (GL/yr)** | **3.7** | **2.7** | **44** | **N/A** |

Table 45. Revised preliminary extraction limit summary for the Sediments Above GAB: Condamine-Balonne SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 7.0 | 5.0 | 84 | N/A |
| Sustainability factor | 0.05 | 0.05 | 0.05 | N/A |
| **Extraction limit (GL/yr)** | **0.35** | **0.25** | **4.2** | **N/A** |

 

## 1.8 Sediments Above the Great Artesian Basin: Border Rivers (GS69)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the Sediments Above GAB: Border Rivers SDL area.

### 1.8.1 Background

The Sediments Above GAB: Border Rivers SDL area incorporates the shallow Quaternary alluvium and undifferentiated Tertiary and Quaternary clastics that overlie the GAB, to the west of the Border Rivers catchment (Senior and Senior, 1969). Current groundwater use for this SDL area is limited to stock and domestic use and totals 0.10 GL/year (Table 46). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

The dominant source of groundwater in this area is from the underlying GAB Jurassic and Cretaceous confined sandstone aquifers. The groundwater in these aquifers is separated from the Sediments Above GAB: Border Rivers SDL aquifers, by thick confining beds. This means there is little interaction between the deep GAB aquifers and the overlying surface water and shallow groundwater sources. The water resources within these deeper confined aquifers forms part of the GAB Water Resources and is specifically excluded from the Basin Water Resources by the Water Act. Therefore they are not considered further in the RRAM assessment.

Table 46. Groundwater take summary for the Sediments Above GAB: Border Rivers SDL area

| Sediments Above GAB: Border Rivers SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **0.0** |
| Current use for entitlement bores** | 0.0 |
| Estimated use for stock and domestic bores* | 0.10 |
| **Total current use** | **0.10** |

*Entitlement and stock and domestic volumes were provided by DERM.
**Current use is equivalent to 60% of the entitlement volume.

### 1.8.2 Salinity zoning

The Sediments Above GAB: Border Rivers SDL area is predominantly characterised by groundwater ranging between 3,000 and 14,000 mg/L TDS. There is a very small area of salinity class 4 groundwater along the south-east edge of the unit, however given that this salinity class represents less than 5 percent of the entire area, it has been incorporated into the salinity class 3 groundwater, in order to simplify this assessment. The groundwater salinity distribution can be seen in Figure 12 and is summarised in Table 47.

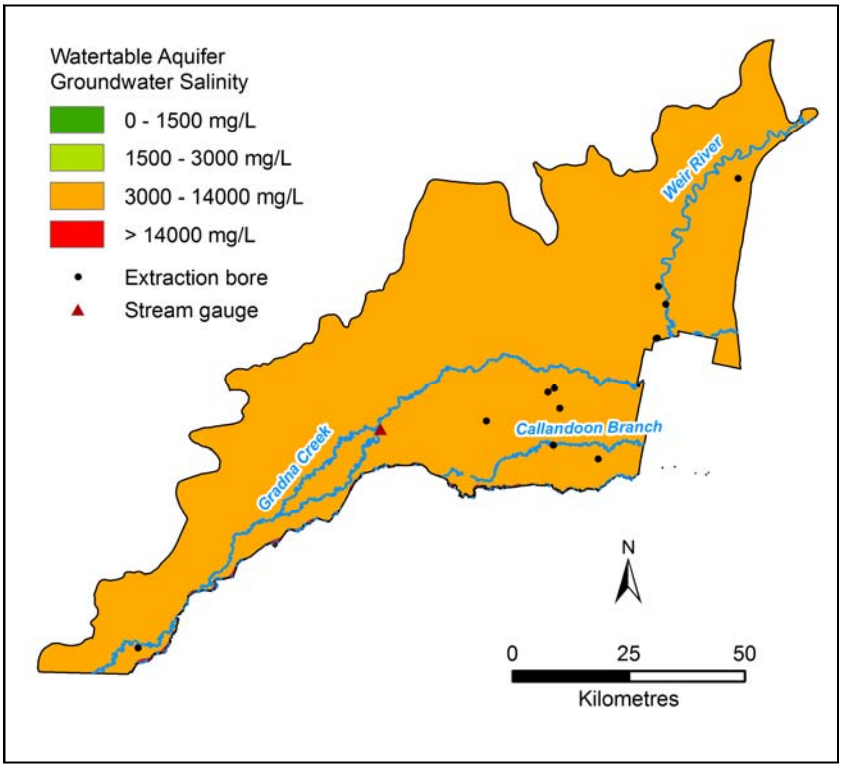


Figure 12. Sediments Above GAB: Border Rivers watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 47. Summary of salinity zones in the Sediments Above GAB: Border Rivers SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 0 | 0 |
| Zone 2 (1500–3000 mg/L TDS) | 0 | 0 |
| Zone 3 (3000–14,000 mg/L TDS) | 100 | 6801 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water body | 0 | 0 |
| **Total** | **100** | **6801** |

### 1.8.3 Key environmental assets

There are no key environmental assets that have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment, that are associated with the Sediments Above GAB: Border Rivers SDL area.

### 1.8.4 Key ecosystem function

A basin-scale review of river–aquifer connectivity was conducted by REM (2004) that indicated that the Weir River was disconnected from the underlying aquifer systems. Although this review was conducted at a basin scale and hence there is an inherent uncertainty when considering the results of the assessment on an SDL-area scale, this supports the hydrogeological conceptualisation that the key ecosystem function in this area would be at low risk within the SDL area.

### 1.8.5 Productive base

**Recharge**

Recharge to the Sediments Above GAB: Border Rivers SDL area has been calculated at 79 GL/year via WAVES modelling using a historical dry climate scenario. A breakdown of recharge to each salinity zone is summarised in Table 48.

Table 48. Recharge calculation for the Sediments Above GAB: Border Rivers SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 0 | 0 | 6801 | 0 |
| Diffuse recharge (mm/yr) | N/A | N/A | 12 | N/A |
| **Total recharge (GL/yr)** | **N/A** | **N/A** | **79** | **N/A** |

**Storage**

The specific yield adopted for the Quaternary and Tertiary aquifer of the Sediments Above GAB: Border Rivers SDL area is 0.05. The thickness of this unit is variable and an average thickness of 25 m has been adopted for this storage estimate. Storage of the Sediments Above GAB: Border Rivers SDL area is 8501 GL (Table 49).

Table 49. Storage calculation for the Sediments Above GAB: Border Rivers SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 0 | 0 | 6801 | 0 |
| Saturated thickness (m) | N/A | N/A | 25 | N/A |
| Specific yield | N/A | N/A | 0.05 | N/A |
| **Total storage (GL)** | **N/A** | **N/A** | **8501** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge is 108 for this SDL area. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

## 1.8.6 The risk matrix

Table 50 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked low risk in terms of ecosystem function, given that groundwater and surface water connectivity is conceptualised as less than 50 percent
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio far exceeds 40
- there is no risk to the key environmental outcome (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge derived from WAVES modelling only. It does not include other potential components of groundwater recharge, including river leakage, irrigation returns, throughflow etc.

Table 50. Risk matrix

<table>
<tr><th>Risk ranking</th><th>Environmental assets (EAs)</th><th>OR</th><th>Ecosystem function</th><th>OR</th><th>Productive base</th><th>Sustainability factor (SF)</th><th>Key environmental outcome</th><th>Degree of uncertainty</th></tr>
<tr><td>High</td><td>EA that is highly groundwater dependent and highly sensitive to take</td><td rowspan="3"></td><td>In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion</td><td rowspan="3"></td><td>Storage/ recharge <20</td><td>0.10</td><td rowspan="3">Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br><br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br><br>Salinity class 1: reduce SF by 20%<br><br>Salinity class 2: reduce SF by 10%<br><br>Salinity classes 3 & 4: no reduction</td><td rowspan="2">Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50%</td></tr>
<tr><td>Medium</td><td>EA that is highly groundwater dependent and is moderately sensitive to take<br><br>EA that is moderately groundwater dependent and is highly sensitive to take</td><td>The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge 20–40</td><td>0.50</td></tr>
<tr><td>Low</td><td>EA that has a low groundwater dependence and low sensitivity to take<br><br>EAs do not exist in the SDL area</td><td>The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge >40</td><td>0.70</td><td>Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25%</td></tr>
</table>

## 1.8.7 Preliminary RRAM extraction limit

The extraction limit resulting from the RRAM for the Sediments Above GAB: Border Rivers SDL area is 42 GL/year (Table 51). This is greater than the volume of current use (0.10 GL/year). This means that most of the SDL is unassigned water.

Table 51. Preliminary extraction limit summary for the Sediments Above GAB: Border Rivers SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 0 | 0 | 79 | 0 |
| Sustainability factor | N/A | N/A | 0.53 | N/A |
| **Extraction limit (GL/yr)** | **N/A** | **N/A** | **42** | **N/A** |

 

# 1.9 Sediments Above the Great Artesian Basin: Warrego-Paroo-Nebine (GS72)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the Sediments Above GAB: Warrego-Paroo-Nebine SDL area.

## 1.9.1 Background

The Sediments Above GAB: Warrego-Paroo-Nebine SDL area incorporates the shallow Quaternary and Tertiary sediments that overlie the GAB. Recent Quaternary alluvium of fluviatile origin occurs along the Paroo River and extends up to 100 m depth. Older Quaternary deposits of undifferentiated alluvium deposited under fluviatile, sheetwash and aeolian environments, extend over the flatter areas and are up to 20 m thick (CSIRO, 2007).

The Tertiary Glendower Formation comprises silicified quartzose sandstone (Senior and Thomas, 1968). Outcrops of the Glendower Formation are generally less than 15 m thick but may be as thick as 70 m (CSIRO, 2007). Current groundwater use is 1.1 GL/year (Table 52). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

The dominant source of groundwater in this area is from the underlying GAB Jurassic and Cretaceous confined sandstone aquifers. The groundwater in these aquifers is separated from the Sediments Above GAB: Warrego-Paroo-Nebine SDL aquifers, by thick confining beds. This means there is little interaction between the deep GAB aquifers and the overlying surface water and shallow groundwater sources. The water resources within these deeper confined aquifers forms part of the GAB Water Resources and is specifically excluded from the Basin Water Resources by the Water Act. Therefore they are not considered further in the RRAM assessment.

Table 52. Groundwater take summary for the Sediments Above GAB: Warrego-Paroo-Nebine SDL area

| Sediments Above GAB: Warrego-Paroo-Nebine SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **0.10** |
| Current use for entitlement bores** | 0.06 |
| Estimated use for stock and domestic bores* | 1.0 |
| **Total 2007/2008 use** | **1.1** |

*Entitlement volumes and stock and domestic use volumes were provided by DERM.
**Current use is equal to 60% of the entitlement volume.

## 1.9.2 Salinity zoning

The Sediments Above GAB: Warrego-Paroo-Nebine SDL area is characterised by three salinity classes, ranging from 0 to 14,000 mg/L TDS. The groundwater salinity distribution can be seen in Figure 13 and is summarised in Table 53.

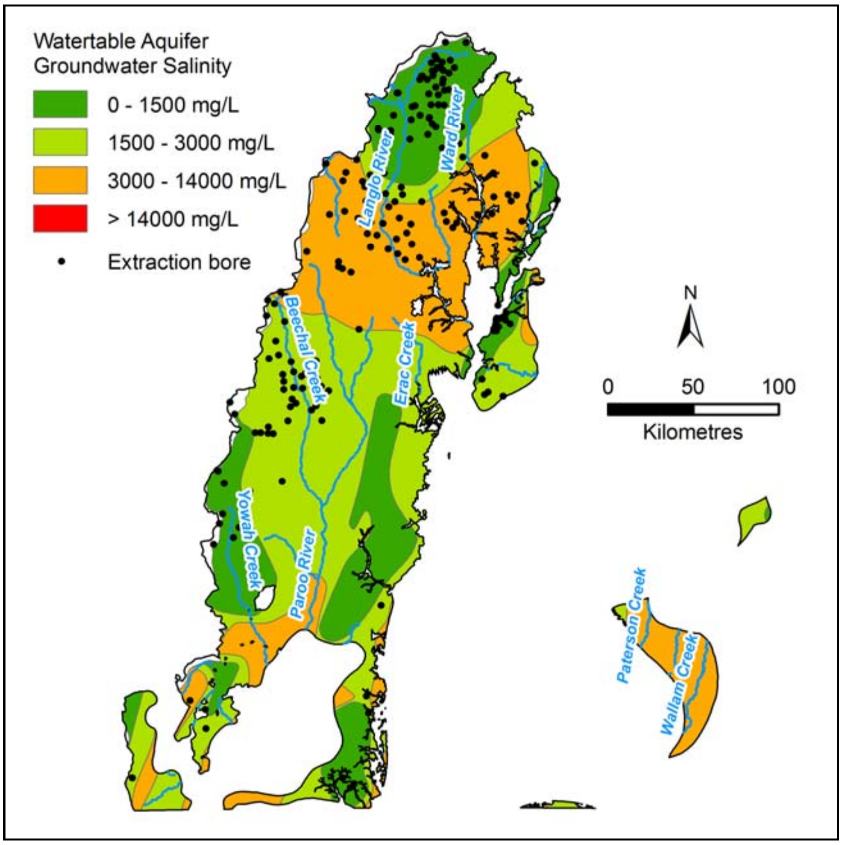


Figure 13. Sediments Above GAB: Warrego-Paroo-Nebine watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 53. Summary of salinity zones in the Sediments Above GAB: Warrego-Paroo-Nebine SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 25 | 12,187 |
| Zone 2 (1500–3000 mg/L TDS) | 42 | 20,296 |
| Zone 3 (3000–14,000 mg/L TDS) | 31 | 15,266 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water body | 2 | 934 |
| **Total** | **100** | **48,683** |

## 1.9.3 Key environmental assets

There are no key environmental assets that have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment, that are associated with the Sediments Above GAB: Warrego-Paroo-Nebine SDL area.

## 1.9.4 Key ecosystem function

The Eulo Artesian Springs group in the lower reaches of the Paroo River, cause mixing and discharge of groundwater from the GAB and from the Sediments Above GAB. There has been a suggestion that the lower reaches of the river may be gaining from these discharges (Jolly, 1989) but this has not been assessed. Water quality in the streams, however, is good (<100 mg/L) suggesting interaction is minimal.

Given that the Paroo River is the only unregulated river in the MDB and that there is potential groundwater discharge to the river, the key ecosystem function is considered at high risk.

 

## 1.9.5 Productive base

**Recharge**

Recharge to the Sediments Above GAB: Warrego-Paroo-Nebine SDL area has been calculated at 555 GL/year via WAVES modelling using the historical dry climate scenario (Table 54).

Table 54. Recharge calculation for the Sediments Above GAB: Warrego-Paroo-Nebine SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area (km$^2$) | 12,187 | 20,296 | 15,266 | 0 |
| Diffuse recharge (mm/yr) | 10 | 11 | 13 | N/A |
| **Total recharge (GL/yr)** | **122** | **229** | **204** | **N/A** |

**Storage**

The specific yield adopted for the Quaternary and Tertiary aquifer of the Sediments Above GAB: Warrego-Paroo-Nebine SDL area is 0.05. The thickness of this unit is highly variable, ranging from 0 to 100 m. An average thickness of 25 m has been adopted here. Storage of the Sediments Above GAB: Warrego-Paroo-Nebine SDL area is 59,686 GL (Table 55).

Table 55. Storage calculation for the Sediments Above GAB: Warrego-Paroo-Nebine SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area (km$^2$) | 12,187 | 20,296 | 15,266 | 0 |
| Saturated thickness (m) | 25 | 25 | 25 | N/A |
| Specific yield | 0.05 | 0.05 | 0.05 | N/A |
| **Total storage (GL)** | **15,234** | **25,370** | **19,083** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge ranges from 94 to 125 for each of the salinity classes. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change the short-term over extraction of the groundwater resource.

## 1.9.6 The risk matrix

Table 56 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked high risk in terms of ecosystem function, given the presence of the spring group and the unregulated nature of the Warrego River
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio exceeds 40 for each of the salinity zones
- there is a risk to the key environmental outcome (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge derived from WAVES modelling only. It does not include other potential components of groundwater recharge, including river leakage, irrigation returns, throughflow etc.

Table 56. Risk matrix

<table>
<tr><th>Risk ranking</th><th>Environmental assets (EAs)</th><th>OR</th><th>Ecosystem function</th><th>OR</th><th>Productive base</th><th>Sustainability factor (SF)</th><th>Key environmental outcome</th><th>Degree of uncertainty</th></tr>
<tr><td>High</td><td>EA that is highly groundwater dependent and highly sensitive to take</td><td rowspan="3"></td><td>In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion</td><td rowspan="3"></td><td>Storage/ recharge <20</td><td>0.10</td><td rowspan="3">Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br><br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br><br>Salinity class 1: reduce SF by 20%<br><br>Salinity class 2: reduce SF by 10%<br><br>Salinity classes 3 & 4: no reduction</td><td rowspan="2">Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50%</td></tr>
<tr><td>Medium</td><td>EA that is highly groundwater dependent and is moderately sensitive to take<br><br>EA that is moderately groundwater dependent and is highly sensitive to take</td><td>The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge 20–40</td><td>0.50</td></tr>
<tr><td>Low</td><td>EA that has a low groundwater dependence and low sensitivity to take<br><br>EAs do not exist in the SDL area</td><td>The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge >40</td><td>0.70</td><td>Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25%</td></tr>
</table>

## 1.9.7 Preliminary RRAM extraction limit

The extraction limit resulting from the RRAM for the Sediments Above GAB: Warrego-Paroo-Nebine SDL area is 25 GL/year (Table 57). This is greater than the volume of current use (1.1 GL/year). This means there is a volume of unassigned water (24 GL/year) associated with this unit.

Table 57. Preliminary extraction limit summary for the Sediments Above GAB: Warrego-Paroo-Nebine SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 122 | 229 | 204 | 0 |
| Sustainability factor | 0.04 | 0.045 | 0.05 | N/A |
| **Extraction limit (GL/yr)** | **4.9** | **10** | **10** | **N/A** |

 

## 1.10 Warrego Alluvium (GS78)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the Warrego Alluvium SDL area.

### 1.10.1 Background

The Warrego Alluvium SDL area incorporates the alluvial sediments associated with the Warrego River. Current groundwater use in the Warrego Alluvium SDL area is 0.68 GL/year (Table 58). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

The dominant source of groundwater in this area is from the underlying GAB Jurassic and Cretaceous confined sandstone aquifers. The groundwater in these aquifers is separated from the Warrego Alluvium aquifer, by thick confining beds. This means there is little interaction between the deep GAB aquifers and the overlying surface water and shallow groundwater sources. The water resources within these deeper confined aquifers forms part of the GAB Water Resources and is specifically excluded from the Basin Water Resources by the Water Act. Therefore they are not considered further in the RRAM assessment.

Table 58. Groundwater take summary for the Warrego Alluvium SDL area

| Warrego Alluvium SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **0.30** |
| Current use for entitlement bores** | 0.18 |
| Estimated use for stock and domestic bores* | 0.50 |
| **Total current use** | **0.68** |

*Entitlement and stock and domestic use volumes were provided by DERM.
**Current use is 60% of the entitlement volume.

### 1.10.2 Salinity zoning

The Warrego Alluvium SDL area is characterised by three salinity classes that range from 0 to 14,000 mg/L TDS. The groundwater salinity can be seen in Figure 14 and is summarised in Table 59.

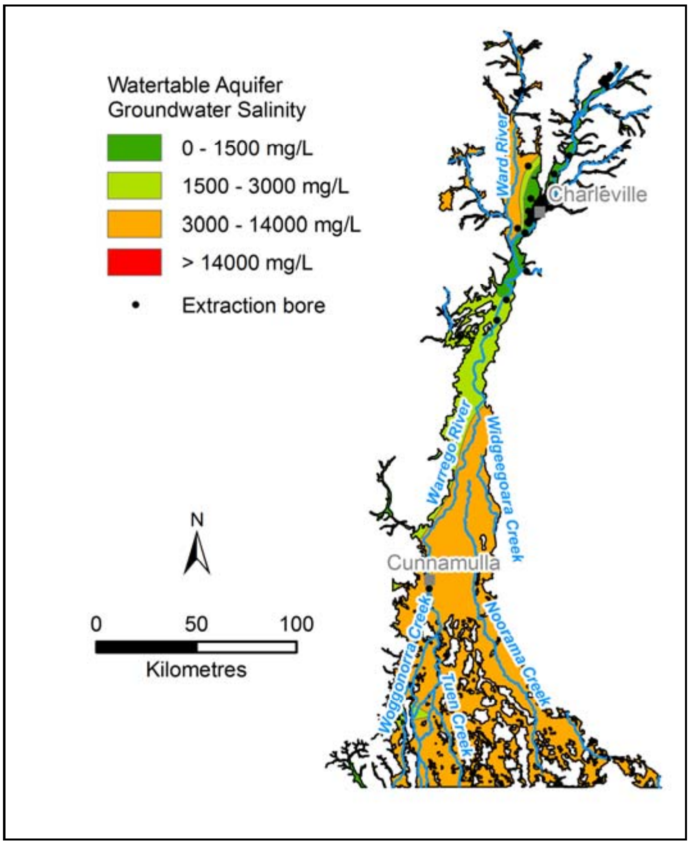


Figure 14. Warrego Alluvium watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 59. Summary of salinity zones in the Warrego Alluvium SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 8 | 964 |
| Zone 2 (1500–3000 mg/L TDS) | 16 | 1,778 |
| Zone 3 (3000–14,000 mg/L TDS) | 76 | 8,762 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water body | 0 | 0 |
| **Total** | **100** | **11,503** |

## 1.10.3 Key environmental assets

The freshwater, semi-permanent Warrego River Waterholes and Yantabulla Swamp are generally believed to be replenished by floodwater, and existing information makes no reference to the role of groundwater in their hydrology (DECCW, 2009). Therefore it is considered that there are no groundwater dependent key environmental assets that are sensitive to groundwater extraction, associated with the Warrego Alluvium SDL area.

## 1.10.4 Key ecosystem function

A basin-scale review of river–aquifer connectivity was conducted by REM (2004) that indicated that the Warrego River was disconnected from the underlying aquifer systems. Although this review was conducted at a basin scale and hence there is an inherent uncertainty when considering the results of the assessment on an SDL-area scale, this supports the hydrogeological conceptualisation that the key ecosystem function in this area would be at low risk within the SDL area.

 

## 1.10.5 Productive base

**Recharge**

Recharge to the Warrego Alluvium SDL area has been calculated at 54 GL/year via WAVES modelling, using the historical dry climate scenario. Recharge to each salinity zone is summarised in Table 60. The area is not extensively irrigated and hence no allowance has been made for irrigation derived recharge.

Table 60. Recharge calculation for the Warrego Alluvium SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 964 | 1778 | 8762 | 0 |
| Diffuse recharge (mm/yr) | 12 | 7.3 | 3.4 | N/A |
| **Total recharge (GL/yr)** | **11** | **13** | **30** | **N/A** |

**Storage**

Stratigraphic logs for three bores in the Warrego Alluvium SDL area boundary (42320169, 42320170 and 42320171) indicate the alluvial thickness in this area ranges from 17 m to 28 m below the natural surface. Time series waterlevel information for 42320169 indicates an average reading of 18 m below natural surface, for a recorded period of 1972 to 2004. Based on this information, an aquifer saturated thickness of 10 m has been used to estimate the storage of the alluvial aquifer.

Given that the Warrego Alluvium dominantly comprises fine sand and clay, a specific yield of 0.1 has been used to estimate the storage of the alluvial aquifer (Johnson, 1967). Estimated storage for the Warrego Alluvium is 11,504 GL (Table 61).

Table 61. Storage calculation for the Warrego Alluvium SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 964 | 1778 | 8762 | 0 |
| Saturated thickness (m) | 10 | 10 | 10 | N/A |
| Specific yield | 0.10 | 0.10 | 0.10 | N/A |
| **Total storage (GL)** | **964** | **1778** | **8762** | **0** |

**Storage relative to recharge**

The ratio of storage to recharge ranges between 88 and 292 for each salinity zone. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

## 1.10.6 The risk matrix

Table 62 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked low risk in terms of ecosystem function, with connectivity less than 50 percent
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio exceeds 40 for each of the salinity zones
- there is a risk to the key environmental outcome (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge derived from WAVES modelling only. It does not include other potential components of groundwater recharge, including river leakage, irrigation returns, throughflow etc.

Table 62. Risk matrix

| Risk ranking | Environmental assets (EAs) | OR | Ecosystem function | OR | Productive base | Sustainability factor (SF) | Key environmental outcome | Degree of uncertainty |
|---|---|---|---|---|---|---|---|---|
| High | EA that is highly groundwater dependent and highly sensitive to take | | In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion | | Storage/ recharge <20 | 0.10 | Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br>Salinity class 1: reduce SF by 20%<br>Salinity class 2: reduce SF by 10%<br>Salinity classes 3 & 4: no reduction | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50% |
| Medium | EA that is highly groundwater dependent and is moderately sensitive to take<br>EA that is moderately groundwater dependent and is highly sensitive to take | | The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years) | | Storage/ recharge 20–40 | 0.50 | | |
| Low | EA that has a low groundwater dependence and low sensitivity to take<br>EAs do not exist in the SDL area | | The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years) | | Storage/ recharge >40 | 0.70 | | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25% |

## 1.10.7 Preliminary RRAM extraction limit

The extraction limit resulting from the RRAM for the Warrego Alluvium SDL area is 27 GL/year (Table 63). This is greater than the volume of current use (0.68 GL/year). This means there is a volume of unassigned water (26 GL/year) associated with this unit.

Given that the Warrego River is a key environmental asset in its entirety, if the unassigned water is to be used in this unit, more work needs to be done to establish the level of connectivity between groundwater and surface water.

Table 63. Preliminary extraction limit summary for the Warrego Alluvium SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 11 | 13 | 30 | 0 |
| Sustainability factor | 0.42 | 0.47 | 0.53 | 0 |
| **Extraction limit (GL/yr)** | **4.6** | **6.1** | **16** | **0** |

# 1.11 St George Alluvium: Moonie (GS74)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the St George Alluvium: Moonie SDL area.

## 1.11.1 Background

The St George Alluvium: Moonie SDL area incorporates the small portion (approximately 5 percent) of the St George Alluvium GMU (Q71) that resides in the Moonie catchment. Current groundwater use is 0.50 GL/year and is limited to stock and domestic purposes (Table 64). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

The St George Alluvium comprises two aquifer systems. The shallow Quaternary aquifer consists of multiple unconsolidated fine to very coarse sand beds up to 4 m thick, that are present to 30 m depth (Free, 2004).

A leaky aquitard separates the Quaternary aquifer from the deeper unconsolidated coarse Tertiary sand beds and gravel layers that occur at irregular intervals forming a trough aligned in a north-east to south-west direction. The aquifer occurs between 60 and 220 m below surface and can be up to 30 m thick. The Tertiary sediments provide a greater potential as a source of water supply with yields of up to 120 L/s achievable from production bores (Free, 2004).

Water level observations during pumping tests suggest that the two aquifers are hydraulically connected (Free, 2004) and therefore they have been considered one unit in terms of this RRAM assessment.

Table 64. Groundwater take summary for the St George Alluvium: Moonie SDL area

| St George Alluvium: Moonie SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **0.0** |
| Current use for entitlement bores** | 0.0 |
| Estimated use for stock and domestic bores* | 0.50 |
| **Total current use** | **0.50** |

*Entitlement volumes and stock and domestic use volumes were provided by DERM.
**Current use is equal to 60% of the volume of entitlement.

## 1.11.2 Salinity zoning

The St George Alluvium: Moonie SDL area is characterised by three salinity classes, with groundwater salinity ranging from 0 to 14,000 mg/L TDS. Figure 15 shows the salinity distribution and Table 65 provides a summary of the distribution.

 

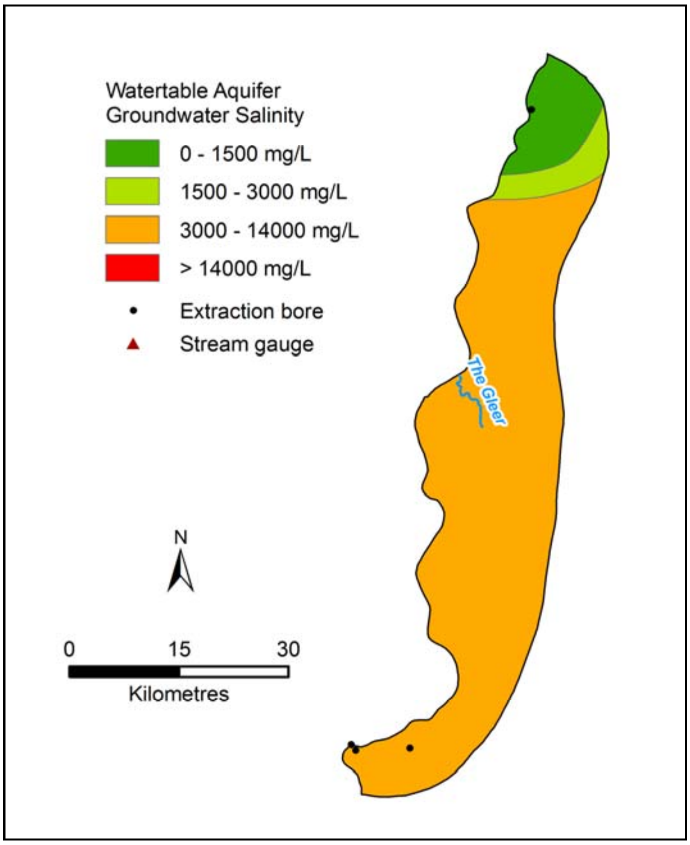


Figure 15. St George Alluvium: Moonie SDL area watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 65. Summary of salinity zones in the St George Alluvium: Moonie SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 9 | 131 |
| Zone 2 (1500–3000 mg/L TDS) | 5 | 71 |
| Zone 3 (3000–14,000 mg/L TDS) | 86 | 1205 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water bodies | 0 | 0 |
| **Total** | **100** | **1407** |

## 1.11.3 Key environmental assets

There are no key environmental assets that have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment, that are associated with the St George Alluvium: Moonie SDL area.

## 1.11.4 Key ecosystem function

There are no major rivers in the St George Alluvium: Moonie SDL area. Therefore there is no risk to the key ecosystem function.

## 1.11.5 Productive base

**Recharge**

Diffuse rainfall recharge to the St George Alluvium: Moonie SDL area has been calculated at 3.3 GL/year via WAVES modelling of a historical dry climate scenario (Table 66).

Table 66. Recharge calculation for the St George Alluvium: Moonie SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 131 | 71 | 1205 | 0 |
| Diffuse recharge (mm/yr) | 2.3 | 4.6 | 2.2 | N/A |
| **Total recharge (GL/yr)** | **0.30** | **0.33** | **2.7** | **N/A** |

**Storage**

A specific yield adopted for the sand and gravel aquifer of the St George Alluvium: Moonie SDL area is 0.25 (Johnson, 1967). An average aquifer thickness of 20 m has been used to estimate the storage of the alluvial aquifer. Estimated storage for this unit is 7034 GL (Table 67).

Table 67. Storage calculation for the St George Alluvium: Moonie SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 131 | 71.2 | 1205 | 0 |
| Saturated thickness (m) | 20 | 20 | 20 | N/A |
| Specific yield | 0.25 | 0.25 | 0.25 | N/A |
| **Total storage (GL)** | **655** | **356** | **6023** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge ranges from 1,079 to 2,231 for each of the salinity zones. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

## 1.11.6 The risk matrix

Table 68 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked low risk in terms of ecosystem function
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio far exceeds 40
- there is no risk to the key environmental outcome
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge derived from WAVES modelling only. It does not include other potential components of groundwater recharge, including river leakage, irrigation returns, throughflow etc.

 

Table 68. Risk matrix

<table>
<tr><th>Risk ranking</th><th>Environmental assets (EAs)</th><th>OR</th><th>Ecosystem function</th><th>OR</th><th>Productive base</th><th>Sustainability factor (SF)</th><th>Key environmental outcome</th><th>Degree of uncertainty</th></tr>
<tr><td>High</td><td>EA that is highly groundwater dependent and highly sensitive to take</td><td rowspan="3"></td><td>In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion</td><td rowspan="3"></td><td>Storage/ recharge <20</td><td>0.10</td><td rowspan="3">Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br><br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br><br>Salinity class 1: reduce SF by 20%<br><br>Salinity class 2: reduce SF by 10%<br><br>Salinity classes 3 & 4: no reduction</td><td rowspan="2">Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50%</td></tr>
<tr><td>Medium</td><td>EA that is highly groundwater dependent and is moderately sensitive to take<br><br>EA that is moderately groundwater dependent and is highly sensitive to take</td><td>The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge 20–40</td><td>0.50</td></tr>
<tr><td>Low</td><td>EA that has a low groundwater dependence and low sensitivity to take<br><br>EAs do not exist in the SDL area</td><td>The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge >40</td><td>0.70</td><td>Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25%</td></tr>
</table>

## 1.11.7 Preliminary RRAM extraction limit

The extraction limit resulting from the RRAM for the St George Alluvium: Moonie SDL area is 1.7 GL/year (Table 69). This is greater than the volume of current use (0.50 GL/year). This means there is a volume of unassigned water (1.2 GL/year) associated with this unit.

Table 69. Preliminary extraction limit summary for the St George Alluvium: Moonie SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 0.30 | 0.33 | 2.7 | 0.0 |
| Sustainability factor | 0.53 | 0.53 | 0.53 | N/A |
| **Extraction limit (GL/yr)** | **0.16** | **0.17** | **1.4** | **N/A** |

# 1.12 St George Alluvium: Condamine-Balonne (GS73)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the St George Alluvium: Condamine-Balonne SDL area.

## 1.12.1 Background

The St George Alluvium: Condamine-Balonne SDL area incorporates the largest portion (approximately 65 percent) of the St George Alluvium GMU (Q71), relative to that incorporated in the Moonie and Warrego-Paroo-Nebine SDL areas. The St George Alluvium comprises two aquifer systems. The shallow Quaternary aquifer consists of multiple unconsolidated fine to very coarse sand beds up to 4 m thick, that are present to 30 m depth. Supplies from the shallow aquifer are generally only suitable for stock and domestic purposes with low yields and variable, but generally poor, water quality (Free, 2004).

A leaky aquitard separates the Quaternary aquifer from the deeper unconsolidated coarse Tertiary sand beds and gravel layers that occur at irregular intervals forming a trough aligned in a north-east to south-west direction. The aquifer occurs between 60 and 220 m below surface and can be up to 30 m thick. The Tertiary sediments provide a greater potential as a source of water supply with yields of up to 120 L/s achievable from production bores (Free, 2004).

Groundwater entitlements for the deeper aquifer total 13 GL/year in this unit. Although there is no metered use information available, it has been recognised that groundwater use has never approached the level of allocation (Free, 2004). Groundwater use is estimated at 2.5 GL/year in the shallow aquifer and is restricted to stock and domestic use only (A Mckay, 24 May 2010, pers. comm.).

This RRAM assessment applies to the shallow Quaternary Aquifer only. For the deeper aquifer, the extraction limit is equal to the current volume of entitlements (i.e. there will be an embargo on new entitlements). Studies specific to the deeper aquifer in this unit are currently underway and the results of these studies will inform a revised extraction limit in the future.

## 1.12.2 Salinity zoning

The St George Alluvium: Condamine-Balonne SDL area is characterised by three salinity classes ranging from 0 to 14,000 mg/L TDS. The groundwater salinity distribution can be seen in Figure 16 and is summarised in Table 70.

 

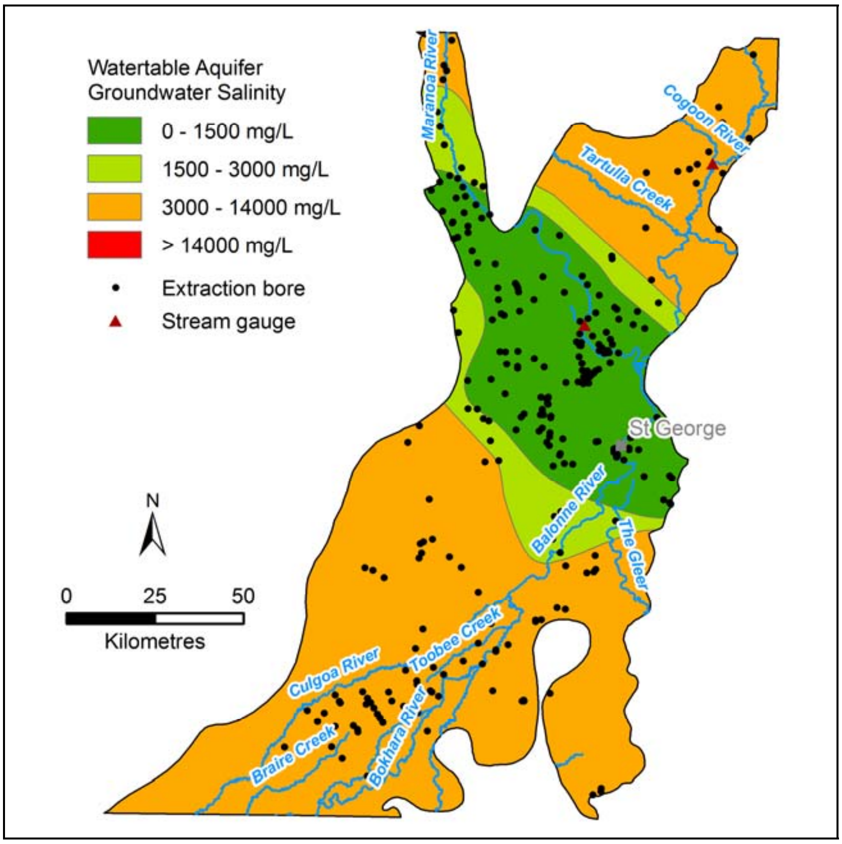


Figure 16. St George Alluvium: Condamine-Balonne SDL area watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 70. Summary of salinity zones in the St George Alluvium: Condamine-Balonne SDL area

| Watertable salinity zone | Portion of total area | Area |
|---|---|---|
| | percent | $km^2$ |
| Zone 1 (0–1500 mg/L TDS) | 22 | 3,711 |
| Zone 2 (1500–3000 mg/L TDS) | 10 | 1,726 |
| Zone 3 (3000–14,000 mg/L TDS) | 68 | 11,389 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water body | 0 | 0 |
| **Total** | **100** | **16,826** |

## 1.12.3 Key environmental assets

The Water Act requires that assessment of environmental water needs of the MDB must encompass key environmental assets, including water-dependent ecosystems, ecosystem services, and sites with ecological significance.

The Murray-Darling Basin Authority has identified 18 key environmental asset–hydrologic indicator sites that drive the environmental hydrology of the MDB (MDBA, 2010). These 18 assets have been assessed to determine the objectives, targets and flow regimes required to sustain them. This information was input to the generation of an estimate of the long-term average sustainable diversion limits that will not compromise the water requirements for the rivers, wetlands and floodplains of the MDB.

The St George Alluvium: Condamine-Balonne SDL area encompasses the Lower Balonne River Floodplain System, which is one of the 18 key environmental asset–hydrologic indicator sites identified by the Murray-Darling Basin Authority.

The Lower Balonne Floodplain System supports the largest number of wetlands in the MDB. This wetland complex is not considered groundwater dependent or sensitive to take. Therefore there is a low risk to the key environmental asset in this unit.

### 1.12.4 Key ecosystem function

A basin-scale review of river–aquifer connectivity was conducted by REM (2004) that indicated that the Balonne River was disconnected from the underlying aquifer systems. Although this review was conducted at a basin scale and hence there is an inherent uncertainty when considering the results of the assessment on an SDL-area scale, this supports the hydrogeological conceptualisation that the key ecosystem function in this area would be at low risk within the SDL area, given a low connectivity between groundwater and surfacewater.

### 1.12.5 Productive base

**Recharge**

The current understanding of the aquifers associated with the St George Alluvium, is that diffuse recharge is not a significant process and that the aquifers are primarily recharged during exceptional flood events (Ray Evans, June 2010, pers. comm.). However, given that alternate recharge rates were not available at the time of the RRAM calculation, the WAVES method has been used.

Diffuse rainfall recharge to the St George Alluvium: Condamine-Balonne SDL area has been calculated via WAVES modelling, using the historical dry climate scenario. South of St George is the St George Irrigation Area, covering approximately 300 km$^2$. This defined area uses surface water, supplied from the EJ Beardmore Dam, for the large-scale irrigation of cotton. CSIRO (2008a) reported an annual surface water diversion volume of 139 GL/year which includes unsupplemented usage and floodplain harvesting.

For this reason, irrigation recharge has been incorporated into the recharge calculation for this unit. Additional recharge from groundwater and surface water irrigation was estimated by:

- allowing 10 percent of the groundwater use (i.e. approximately 10 GL *0.1) volume to re-enter the groundwater system
- allowing 10 percent of the average annual surface water diversions (i.e. 139 GL * 10 percent) to enter the groundwater system.

Groundwater recharge to the SDL area is summarised in Table 71 and totals 173 GL/year. .

Table 71. Recharge calculation for the St George Alluvium: Condamine-Balonne SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area (km$^2$) | 3,711 | 1,726 | 11,389 | 0 |
| Diffuse recharge (mm/yr) | 16 | 13 | 6.8 | N/A |
| Diffuse recharge (GL/yr) | 59 | 23 | 77 | N/A |
| Surface water irrigation additional recharge (GL/yr) | 3.1 | 1.4 | 9.4 | N/A |
| Groundwater irrigation additional recharge (GL/yr) | 0.20 | 0.10 | 0.70 | N/A |
| **Total recharge (GL/yr)** | **62** | **24** | **87** | **N/A** |

**Storage**

A specific yield adopted for the sand and gravel aquifer of the St George Alluvium: Condamine-Balonne SDL area is 0.25 (Johnson, 1967). An average aquifer thickness of 20 m has been used to estimate the storage of the alluvial aquifer. Estimated storage for this unit is 84,130 GL (Table 72).

Table 72. Storage calculation for the St George Alluvium: Condamine-Balonne SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area (km$^2$) | 3,711 | 1,726 | 11,389 | 0 |
| Saturated thickness (m) | 20 | 20 | 20 | N/A |
| Specific yield | 0.25 | 0.25 | 0.25 | N/A |
| **Total storage (GL)** | **18,554** | **8,631** | **56,945** | **N/A** |

 

#### Storage relative to recharge

The ratio of storage to recharge ranges from 299 and 655 for each salinity zone. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

### 1.12.6 The risk matrix

Table 73 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked low risk in terms of ecosystem function
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio far exceeds 40
- there is a risk to the key environmental outcome (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge from WAVES modelling and an estimate of irrigation returns only. It does not include other potential components of recharge, including river leakage and throughflow etc.

Table 73. Risk matrix

| Risk ranking | Environmental assets (EAs) | OR | Ecosystem function | OR | Productive base | Sustainability factor (SF) | Key environmental outcome | Degree of uncertainty |
|---|---|---|---|---|---|---|---|---|
| High | EA that is highly groundwater dependent and highly sensitive to take | | In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion | | Storage/ recharge <20 | 0.10 | Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br><br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br><br>Salinity class 1: reduce SF by 20%<br><br>Salinity class 2: reduce SF by 10%<br><br>Salinity classes 3 & 4: no reduction | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50% |
| Medium | EA that is highly groundwater dependent and is moderately sensitive to take<br><br>EA that is moderately groundwater dependent and is highly sensitive to take | | The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years) | | Storage/ recharge 20–40 | 0.50 | | |
| Low | EA that has a low groundwater dependence and low sensitivity to take<br><br>EAs do not exist in the SDL area | | The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years) | | Storage/ recharge >40 | 0.70 | | Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25% |

## 1.12.7 Preliminary RRAM extraction limit

The preliminary extraction limit resulting from the RRAM for St George Alluvium: Condamine Balonne SDL area is 84 GL/year for the shallow aquifer (Table 74). This is greater than the volume of current use (2.5 GL/year). This means there is a volume of unassigned water (82 GL/year) associated with this unit.

Where the volume of unassigned water is greater than 50 GL/year and greater than ten times the volume of current use, the preliminary RRAM-derived extraction limit is superseded by an extraction limit equivalent to the medium risk ranking sustainability factor applied to recharge for that particular SDL area. These conditions apply to the St George Alluvium: Condamine-Balonne SDL area and the revised extraction limit is 40 GL/year (Table 75) with an unassigned water volume of 38 GL/year.

The recommended extraction limit for the deeper aquifer corresponds to an embargo on new licences. This is based on the fact that detailed groundwater investigations are currently underway in this area and hence the results of these investigations will inform a potential revision in the future. This new information may require a revision of the extraction limit for the shallow aquifer, as information relating to the volume of leakage from the shallow to the deep aquifer can be taken into account.

Table 74. Preliminary extraction limit summary for the St George Alluvium: Condamine-Balonne SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 62 | 24 | 87 | 0.00 |
| Sustainability factor | 0.42 | 0.47 | 0.53 | N/A |
| **Extraction limit (GL/yr)** | **26** | **11** | **46** | **N/A** |

Table 75. Preliminary extraction limit summary for the St George Alluvium: Condamine-Balonne SDL area – revised

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 62 | 24 | 87 | 0.00 |
| Sustainability factor | 0.2 | 0.23 | 0.25 | N/A |
| Extraction limit (GL/yr) | 12 | 5.5 | 22 | N/A |

# 1.13 St George Alluvium: Warrego-Paroo-Nebine (GS75)

This chapter describes the derivation of the preliminary estimated extraction limit resulting from the RRAM for the St George Alluvium: Warrego-Paroo-Nebine SDL area.

## 1.13.1 Background

The St George Alluvium: Warrego-Paroo-Nebine SDL area incorporates the moderate portion (approximately 30 percent) of the St George Alluvium GMU (Q71) that resides in the Warrego-Paroo-Nebine catchment. Current groundwater use is 0.25 GL/year and is limited to stock and domestic use only (Table 76). For more information regarding the source of the entitlement and use information, refer to CSIRO (2010a).

The St George Alluvium comprises two aquifer systems. The shallow Quaternary aquifer consists of multiple unconsolidated fine to very coarse sand beds up to 4 m thick, that are present to 30 m depth (Free, 2004).

A leaky aquitard separates the Quaternary aquifer from the deeper unconsolidated coarse Tertiary sand beds and gravel layers that occur at irregular intervals forming a trough aligned in a north-east to south-west direction. The aquifer occurs between 60 and 220 m below surface and can be up to 30 m thick. The Tertiary sediments provide a greater potential as a source of water supply with yields of up to 120 L/s achievable from production bores (Free, 2004).

Water level observations during pumping tests suggest that the two aquifers are hydraulically connected (Free, 2004) and therefore they have been considered one unit in terms of this RRAM assessment.

Table 76. Groundwater take summary for the St George Alluvium: Warrego-Paroo-Nebine SDL area

| St George Alluvium: Warrego-Paroo-Nebine SDL area | GL/yr |
|---|---|
| **Total 2007/2008 entitlement*** | **0.0** |
| Current use for entitlement bores** | 0.0 |
| Estimated use for stock and domestic bores* | 0.25 |
| **Total current use** | **0.25** |

*Entitlement volumes and stock and domestic use volumes were provided by DERM.
**Current use is equal to 60% of the entitlement volume.

## 1.13.2 Salinity zoning

The St George Alluvium: Warrego-Paroo-Nebine SDL area is characterised by three salinity classes that range from 0 to 14,000 mg/L TDS. The groundwater salinity distribution can be seen in Figure 17 and is summarised in Table 77.

 

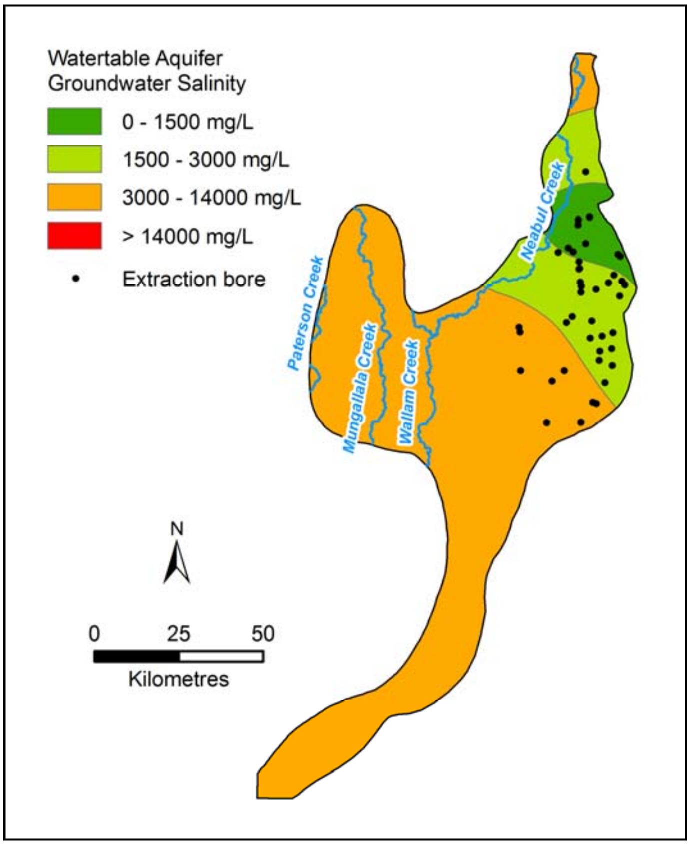


Figure 17. St George Alluvium: Warrego-Paroo-Nebine SDL area watertable aquifer salinity distribution, from the shallow salinity layer of the MDBA Basin in a Box dataset (MDBA, 2000)

Table 77. Summary of salinity zones in the St George Alluvium: Warrego-Paroo-Nebine SDL area

| Watertable salinity zone | Portion of total area | Area () |
|---|---|---|
| | percent | km$^2$ |
| Zone 1 (0–1500 mg/L TDS) | 5 | 421 |
| Zone 2 (1500–3000 mg/L TDS) | 17 | 1384 |
| Zone 3 (3000–14,000 mg/L TDS) | 78 | 6253 |
| Zone 4 (>14,000 mg/L TDS) | 0 | 0 |
| Water bodies | 0 | 0 |
| **Total** | **100** | **8057** |

## 1.13.3 Key environmental assets

There are no key environmental assets that have been identified as groundwater dependent and sensitive to groundwater extraction as part of this RRAM assessment, that are associated with the St George Alluvium: Warrego-Paroo-Nebine SDL area.

## 1.13.4 Key ecosystem function

There are no major rivers in the St George Alluvium: Warrego-Paroo-Nebine SDL area. Therefore there is no risk to the key ecosystem function.

## 1.13.5 Productive base

**Recharge**

Diffuse rainfall recharge to the St George Alluvium: Warrego-Paroo-Nebine SDL area has been calculated at 133 GL/year via WAVES modelling under the historical dry climate scenario (Table 78).

Table 78. Recharge calculation for the St George Alluvium: Warrego-Paroo-Nebine SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 421 | 1384 | 6253 | 0 |
| Diffuse recharge (mm/yr) | 19 | 20 | 16 | N/A |
| **Total recharge (GL/yr)** | **8.1** | **28** | **97** | **N/A** |

**Storage**

A specific yield adopted for the sand and gravel aquifer of the St George Alluvium: Warrego-Paroo-Nebine SDL area is 0.25 (Johnson, 1967). An average aquifer thickness of 20 m has been used to estimate the storage of the alluvial aquifer. Estimated storage for this unit is 40,287 GL (Table 79).

Table 79. Storage calculation for the St George Alluvium: Warrego-Paroo-Nebine SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Area ($km^2$) | 421 | 1,384 | 6,253 | 0 |
| Saturated thickness (m) | 20 | 20 | 20 | N/A |
| Specific yield | 0.25 | 0.25 | 0.25 | N/A |
| **Total storage (GL)** | **2,104** | **6,919** | **31,264** | **N/A** |

**Storage relative to recharge**

The ratio of storage to recharge ranges from 247 to 322 for each of the salinity zones. This indicates that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term over extraction of the groundwater resource.

## 1.13.6 The risk matrix

Table 80 provides a summary of the risk ranking associated with: key environmental assets, key ecosystem function, the productive base, the key environmental outcome and the uncertainty inherent in the RRAM calculation. In summary:

- the SDL area is ranked low risk in terms of environmental assets, given none were identified as groundwater dependent in this area
- the SDL area is ranked low risk in terms of ecosystem function
- the SDL area is ranked low risk in terms of the productive base, given that the storage/recharge ratio far exceeds 40
- there is a risk to the key environmental outcome (i.e. groundwater salinity)
- there is a high level of uncertainty given that the RRAM is derived from diffuse groundwater recharge derived from WAVES modelling only. It does not include other potential components of groundwater recharge, including river leakage, irrigation returns, throughflow etc.

 

Table 80. Risk matrix

<table>
<tr><th>Risk ranking</th><th>Environmental assets (EAs)</th><th>OR</th><th>Ecosystem function</th><th>OR</th><th>Productive base</th><th>Sustainability factor (SF)</th><th>Key environmental outcome</th><th>Degree of uncertainty</th></tr>
<tr><td>High</td><td>EA that is highly groundwater dependent and highly sensitive to take</td><td rowspan="3"></td><td>In the current state, groundwater discharge provides baseflow to the unregulated river reach. Groundwater extraction is likely to result in stream flow depletion</td><td rowspan="3"></td><td>Storage/ recharge <20</td><td>0.10</td><td rowspan="3">Where there is no risk to the key environmental outcome (i.e. uniform groundwater salinity) there is no reduction to the SF for any of the salinity classes<br><br>Where there is a risk to the key environmental outcome, as a measure to reduce risk to groundwater quality, the following reductions are made:<br><br>Salinity class 1: reduce SF by 20%<br><br>Salinity class 2: reduce SF by 10%<br><br>Salinity classes 3 & 4: no reduction</td><td rowspan="2">Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 50%</td></tr>
<tr><td>Medium</td><td>EA that is highly groundwater dependent and is moderately sensitive to take<br><br>EA that is moderately groundwater dependent and is highly sensitive to take</td><td>The rivers in the SDL area are regulated and they are highly connected to the groundwater system (i.e. >50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge 20–40</td><td>0.50</td></tr>
<tr><td>Low</td><td>EA that has a low groundwater dependence and low sensitivity to take<br><br>EAs do not exist in the SDL area</td><td>The rivers in the SDL area are regulated or unregulated and they have low-moderate connection with the groundwater system (i.e. <50% impact of pumping on streamflow within 50 years)</td><td>Storage/ recharge >40</td><td>0.70</td><td>Where the uncertainty is low (e.g. good quality time series data, recharge well understood, metered extraction) there is no further reduction to the SF<br><br>Where there is high uncertainty associated with the SDL (e.g. no numerical model available for comparison, uncertain hydrogeology, poor extraction data) the SF is further reduced by 25%</td></tr>
</table>

## 1.13.7 Preliminary RRAM extraction limit

The preliminary estimated extraction limit resulting from the RRAM for the St George Alluvium: Warrego-Paroo-Nebine SDL area is 68 GL/year (Table 81).

Where the volume of unassigned water is greater than 50 GL/year and greater than one-hundred times the volume of current use, the preliminary RRAM-derived extraction limit is superseded by an extraction limit equivalent to the high sustainability factor applied to recharge for that particular SDL area. The St George Alluvium: Warrego-Paroo-Nebine SDL area falls into this category and the revised extraction limit is 6.5 GL/year (Table 82).

Table 81. Preliminary extraction limit summary for the St George Alluvium: Warrego-Paroo-Nebine SDL area

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 8.1 | 28 | 97 | 0 |
| Sustainability factor | 0.42 | 0.47 | 0.53 | N/A |
| **Extraction limit (GL/yr)** | **3.4** | **13** | **52** | **N/A** |

Table 82. Preliminary extraction limit summary for the St George Alluvium: Warrego-Paroo-Nebine SDL area – revised

| | Salinity zone 1 | Salinity zone 2 | Salinity zone 3 | Salinity zone 4 |
|---|---|---|---|---|
| Recharge (GL/yr) | 8.1 | 28 | 97 | 0 |
| Sustainability factor | 0.04 | 0.045 | 0.05 | 0.05 |
| **Extraction limit (GL/yr)** | **0.32** | **1.3** | **4.9** | **N/A** |

 

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