Baseline Diversion Limit for the South Australian Murray SDL Resource Unit (SS11)
Disclaimer

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EXECUTIVE SUMMARY

This report documents and reviews the approach, policies and assumptions used by the Murray–Darling Basin Authority (MDBA) to prepare the baseline diversion limit (BDL) model and associated Basin Plan (MDBA 2012) BDL estimate for the SA Murray SDL resource unit (SS11). From this, revised BDL assumptions have been outlined and used to prepare a revised BDL model and estimate.

A revised BDL estimate of 681.056 GL has been determined for the four South Australian Cap valleys under Schedule E of the Murray–Darling Basin Agreement (2008):

- Metropolitan Adelaide Cap valley
- Lower Murray Swamps Cap valley
- Country Towns Cap valley
- All Other Purposes Cap valley

The revised BDL assumptions are summarised in the table below.

A revised BDL description is also proposed, to enable the explicit addition of basic rights for stock and domestic purposes to the BDL estimate. To take effect, the change would need to be part of a future amendment to the Basin Plan. Following this, the BDL estimate can be increased for this form of take.
### Summary of Revised BDL Assumptions

<table>
<thead>
<tr>
<th>Revised Assumption No.</th>
<th>Category</th>
<th>Conditions</th>
<th>Report Section</th>
<th>Description of Revised Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water rights</td>
<td>Cap</td>
<td>5.4</td>
<td>Volume of water rights (excluding stock, domestic and industrial) held in the AOP Cap valley is 499.8 GL.</td>
</tr>
<tr>
<td>2</td>
<td>Water rights</td>
<td>Cap / BDL</td>
<td>5.5</td>
<td>Volume of water rights for stock, domestic and industrial purposes is as shown in Table 4 (column 2).</td>
</tr>
<tr>
<td>3</td>
<td>Water rights</td>
<td>Cap / BDL</td>
<td>5.6</td>
<td>Metropolitan Adelaide maximum allocation variable is 215 GL, reflecting the maximum demand under BDL conditions.</td>
</tr>
<tr>
<td>4</td>
<td>Water rights</td>
<td>BDL</td>
<td>5.7</td>
<td>Volume of water rights held in the LMS Cap valley is 52.69 GL.</td>
</tr>
<tr>
<td>5</td>
<td>Water rights</td>
<td>BDL</td>
<td>5.7</td>
<td>Volume of water rights held in the AOP Cap valley is 577.36 GL.</td>
</tr>
<tr>
<td>6</td>
<td>Cap adjustment</td>
<td>BDL</td>
<td>5.8</td>
<td>Updated AOP Cap adjustment of +32.421 GL and LMS Cap adjustment of -41.509 GL.</td>
</tr>
<tr>
<td>7</td>
<td>SA Entitlement allocation priorities</td>
<td>BDL</td>
<td>6.4</td>
<td>First 348 GL is provided for loss purposes followed by 335.4 GL for dilution. Initial allocation provision of 2 per cent (12.6 GL) for irrigation purposes from the 696 GL Dilution and Loss Entitlement. Initial allocation provision is ‘repaid’ after the provision of water for CHWN.</td>
</tr>
<tr>
<td>8</td>
<td>SA Entitlement allocation priorities</td>
<td>BDL</td>
<td>6.4</td>
<td>Once the irrigation allocation reaches 62 per cent, pro-rata increases are made to Country Towns and irrigation allocations.</td>
</tr>
<tr>
<td>9</td>
<td>SA Entitlement allocation priorities</td>
<td>BDL</td>
<td>6.4</td>
<td>Metropolitan Adelaide allocation is increased to the maximum demand (if required) once allocations for Country Towns and irrigation reach 100 per cent.</td>
</tr>
<tr>
<td>10</td>
<td>SA Entitlement allocation priorities</td>
<td>BDL</td>
<td>6.4</td>
<td>Once the initial 2 per cent (12.6 GL) allocation from the Dilution and Loss Entitlement is repaid, increase the allocation for irrigation purposes to 62 per cent; then pro-rata with the allocation to Country Towns.</td>
</tr>
<tr>
<td>11</td>
<td>SA Entitlement allocation priorities</td>
<td>BDL</td>
<td>6.4</td>
<td>Unallocated part of South Australia’s Entitlement is provided once all water users reach a 100 per cent allocation.</td>
</tr>
<tr>
<td>12</td>
<td>Metropolitan Adelaide allocation</td>
<td>Cap / BDL</td>
<td>6.6</td>
<td>Projected maximum annual diversion for Metropolitan Adelaide (based on the total diversion to the end of each month from August to March) is calculated. The CHWN allocation is reduced accordingly (if irrigation allocations less than 100 per cent) and reassigned in accordance with revised allocation framework (Table 8).</td>
</tr>
<tr>
<td>13</td>
<td>CHWN Reserve</td>
<td>Cap / BDL</td>
<td>6.7</td>
<td>Turn off the CHWN Reserve provisions.</td>
</tr>
<tr>
<td>Revised Assumption No.</td>
<td>Category</td>
<td>Conditions</td>
<td>Report Section</td>
<td>Description of Revised Assumption</td>
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<td>-----------------------</td>
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<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>14</td>
<td>SA Entitlement allocation rules</td>
<td>Cap / BDL</td>
<td>6.8</td>
<td>Remove rules that share water resource availability improvements between irrigation and dilution (unallocated Entitlement) based on water levels in the Lower Lakes; and remove the restriction to increasing irrigation allocations after March.</td>
</tr>
<tr>
<td>15</td>
<td>Water use</td>
<td>Cap / BDL</td>
<td>7.3</td>
<td>Annual AOP Use is equal to the lesser of the maximum annual water use permitted under the AOP Cap model and the AOP allocation volume.</td>
</tr>
<tr>
<td>16</td>
<td>Water use</td>
<td>Cap / BDL</td>
<td>7.5</td>
<td>Annual LMS Use is equal to the LMS allocation volume.</td>
</tr>
<tr>
<td>17</td>
<td>Water use</td>
<td>Cap / BDL</td>
<td>7.7</td>
<td>Annual Country Towns Use is equal to the CT allocation volume.</td>
</tr>
<tr>
<td>18</td>
<td>Water use</td>
<td>Cap / BDL</td>
<td>7.9</td>
<td>Annual Metropolitan Adelaide Use is equal to the Annual MA Cap Demand, if the allocation permits. Revised monthly distribution pattern.</td>
</tr>
<tr>
<td>19</td>
<td>Basic rights</td>
<td>Cap / BDL</td>
<td>7.11</td>
<td>Separate use for basic rights from AOP allocation and calculate explicitly as a fixed annual use.</td>
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<tr>
<td>20</td>
<td>Data correction</td>
<td>Cap / BDL</td>
<td>8.1</td>
<td>Updated rainfall data at the Berri station.</td>
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# ABBREVIATIONS AND ACRONYMS

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<td>All Other Purposes Cap valley</td>
<td>AOP Cap valley</td>
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<tr>
<td>baseline diversion limit</td>
<td>BDL</td>
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<tr>
<td>Central Irrigation Trust</td>
<td>CIT</td>
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<td>Country Towns Cap valley</td>
<td>CT Cap valley</td>
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<tr>
<td>critical human needs</td>
<td>CHN</td>
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<td>critical human water needs</td>
<td>CHWN</td>
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<td>Department for Environment and Water</td>
<td>DEW</td>
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<td>Department of Environment, Water and Natural Resources</td>
<td>DEWNR</td>
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<td>Environment Land Management Allocations</td>
<td>ELMA</td>
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<tr>
<td>gigalitre</td>
<td>GL</td>
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<td>Independent Audit Group</td>
<td>IAG</td>
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<td>Lower Murray Swamps Cap valley</td>
<td>LMS Cap valley</td>
</tr>
<tr>
<td>metres relative to Australian height datum</td>
<td>mAHD</td>
</tr>
<tr>
<td>Murray–Darling Basin</td>
<td>MDB</td>
</tr>
<tr>
<td>Murray–Darling Basin Agreement (Schedule 1 of the Water Act 2007 Cth)</td>
<td>the Agreement</td>
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<td>MDBA</td>
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<td>Murray–Darling Basin Commission</td>
<td>MDBC</td>
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<td>Murray Simulation Model</td>
<td>MSM</td>
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<td>natural resources management</td>
<td>NRM</td>
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<td>NRM Act</td>
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<td>River Murray Catchment Water Management Board</td>
<td>RMCMWMB</td>
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<tr>
<td>Source Murray Model</td>
<td>SMM</td>
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<tr>
<td>South Australia</td>
<td>SA</td>
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<tr>
<td>South Australia Murray–Darling Basin Natural Resources Management Board</td>
<td>SA MDB NRMB</td>
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<td>sustainable diversion limit</td>
<td>SDL</td>
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<td>The Living Murray</td>
<td>TLM</td>
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<td>Water Act 2007 (Cth)</td>
<td>Water Act</td>
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<td>water resource plan</td>
<td>WRP</td>
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1 PURPOSE

This report documents and reviews the approach, policies and assumptions used by the Murray–Darling Basin Authority (MDBA) to prepare the baseline diversion limit (BDL) model and associated Basin Plan (2012) BDL estimate for the SA Murray SDL resource unit (SS11). Where necessary, these policies and assumptions have been updated to ensure that they reflect state water management arrangements at 30 June 2009 and are outlined for the purposes of establishing a revised BDL model and BDL estimate.

2 BACKGROUND

The Basin Plan established a BDL for each sustainable diversion limit (SDL) resource unit. Schedule 3 of the Basin Plan describes the BDL for each surface water SDL resource unit, with a volumetric ‘estimate’ included as a note. The actual description and estimate depend on the management arrangements in the individual unit but, in most cases, each BDL is the estimate of the current level of take or the existing limits on take as at 30 June 2009.

The BDL estimates were determined by the MDBA when the Basin Plan was prepared\(^1\), but may be updated where improved information becomes available. The process for setting an alternative estimate of a surface water BDL, including criteria for establishing whether a revision is necessary and how that revision will be assessed, is outlined in Position Statement 3D – Changes to BDL (MDBA 2015a). The criteria for determining the necessity of a revision include whether the alternative estimate is scientifically robust, reflects the best available information and is an improvement on current methods. Assessment criteria for the revised method and alternative estimate relate to meeting the description of the BDL under Schedule 3, documentation and model review.

The SDL is the long-term average volume of water that may be sustainably extracted from an SDL resource unit. The Basin Plan BDLs provide the reference points from which SDLs are calculated, as follows:

\[
SDL = BDL - local \ reduction \ amount - shared \ reduction \ amount + SDL \ adjustment
\]

Ensuring that a BDL is appropriately described and estimated is therefore a critical part of the transition to SDLs and ongoing SDL compliance through a water resource plan (WRP).

The current BDL description and estimate for the SA Murray SDL resource unit (SS11) have been reviewed by the Department for Environment and Water when preparing the South Australian River Murray WRP. This review has identified a number of required updates to the current BDL description and estimate that are currently included in Schedule 3.

This report has been structured as follows:

- Section 3 – BDL description
- Section 4 – BDL model development (modelling sequence and key steps)
- Section 5 – Water rights and Cap adjustments
- Section 6 – Allocation priorities, policies and rules
- Section 7 – Annual water use
- Section 0 – Other updates due to errors in climate data
- Section 9 – Revised BDL model and estimate

\(^1\) Refer to Appendix A for a general overview of the methods used to determine BDLs.
Throughout this report, the following terminology is used:

- **current BDL / current BDL model** – refers to the current description and estimate of the BDL in Schedule 3 the Basin Plan, including the assumptions, policies and model used by the MDBA to determine that estimate.

- **revised BDL / revised BDL model** – refers to the revised description and estimate of the BDL from this review, including the assumptions, policies and model used to determine that estimate.
3 BDL DESCRIPTION

3.1 Current BDL Description

Schedule 3 of the Basin Plan states that ‘...the BDL for the SA Murray SDL resource unit (SS11) is the long-term average limit on the quantity of water that can be taken from watercourses calculated by:

(i) Summing the quantity of water that would have been taken by that form of take in accordance with Schedule E to the Agreement as at 30 June 2009 for each year of the historical climate conditions (but excluding water recovered under The Living Murray Initiative); and

(ii) Dividing that quantity by all the years of the historical climate conditions.

Note: The Authority estimates this to be 665 GL per year. The details of modelling assumptions and system set up used for making this estimate are documented in MDBA Technical Report 2010/20 and MDBA Technical Report 2011/01.’

3.2 Murray–Darling Basin Cap on Diversions

The current BDL description for the SA Murray SDL resource unit only includes water taken in accordance with the Murray–Darling Basin (MDB) Cap on Diversions under Schedule E of the Agreement.

The development and components of each long-term Cap limit applied in South Australia are described in this section. This information supports the revised BDL description in Section 3.4, and the review of the current BDL estimate.

3.2.1 Overview of Cap on Diversions

The MDB Cap on Diversions was agreed by Ministerial Council in 1996 and came into effect from 1 July 1997. It is a long-term limit on the volume of surface water that can be used for consumptive purposes in river valleys in the MDB.

Compliance occurs on an annual basis with respect to an annual diversion target. These targets are mainly derived from analytical models that represent the relationship between water availability, climate and use. The models have been developed over a defined climate sequence – the Cap reference period – and the average of the modelled annual diversion targets over that reference period is the long-term diversion Cap. Under Schedule E, the Cap reference period was initially set as 1891–92 to 1996–97 but was extended to 1891–92 to 2001–02 during development of the Cap models.² Because it is a long-term average, each Cap determined over this 111-year period is explicitly linked to this period.³

² The relevant climate sequence for the development of analytical Cap models was initially set as the period from 1891–92 to 1996–97, as per sch E cl 11(4)(e)(ii). This was the longest climate sequence available on 1 July 1997 when the Cap began. However, another period as approved by the Authority may also be used, as per sch E cl 11(4)(e)(ii). By the time the first Cap model was developed, the climate sequence from 1891–92 was able to be extended to the end of 2001–02. This extended sequence was then adopted, based on a recommendation of the Independent Auditor in the Audit Report for the Lachlan Cap Model, when the first Cap model was approved by the MDBC under Schedule E (then Schedule F).

³ Any average is only applicable to the period over which it was calculated. Each Cap was intended to provide security, and an explicit long-term right to take, for holders of the group of entitlements that are managed and accounted for under that limit. Changing the time period changes the climate and water availability sequence. To preserve the same rights to take, the existing volumetric Cap cannot just be applied over a new period. If the Cap reference period changes, the existing rules and relationships between water availability, climate and use will be applied over the new period and yield a different long-term average, and hence long-term Cap volume.
Each state that is party to the Agreement has a number of defined major river valleys for which long-term diversion Caps have been defined and within which diversions must be managed. These major river valleys are commonly referred to as ‘Cap valleys’.

There are four Cap valleys defined for South Australia under Schedule E as follows:

1. Metropolitan Adelaide and Associated Country Areas
2. Lower Murray Swamps (LMS)
3. Country Towns (CT)
4. All Other Purposes (AOP)

### 3.2.2 Metropolitan Adelaide and Associated Country Areas

The Metropolitan Adelaide and Associated Country Areas long-term diversion Cap (Metropolitan Adelaide Cap) covers diversions for water supply purposes that are delivered through the Swan Reach–Stockwell, Mannum–Adelaide and Murray Bridge–Onkaparinga pipeline systems.

Schedule E applies the following limit and conditions on diversions from the Metropolitan Adelaide Cap valley:

- The limit is 650 GL over any period of five consecutive years [sch E cl 7(1)(a)].
- No part of any Entitlement created in South Australia with respect to this Cap can be used, or transferred for use, for any purpose other than use in Metropolitan Adelaide and associated country areas [sch E cl 7(2)(a)].

The flexibility provided by the ‘rolling’ provision was agreed due to the highly variable nature of the Mount Lofty Ranges, which at the time was Metropolitan Adelaide’s only other water supply source. To balance the flexibility of the Cap, the trade limitation was imposed.

### 3.2.3 Lower Murray Swamps

The Lower Murray Swamps (LMS) long-term diversion Cap covers diversions in the Lower Murray Reclaimed Irrigation Area (LMRIA). The LMRIA is located between the townships of Mannum and Wellington and was formerly a series of wetlands that were permanently connected to the River Murray. The wetlands were reclaimed for irrigation in the early 1900s and the area has historically been used for dairy farming.

Schedule E applies the following limits and conditions for the LMS Cap valley:

- Diversions do not exceed 94.2 GL per year [sch E cl 7(1)(b)].
- At least 22.2 GL of diversions are reserved for environmental purposes and are not transferable [sch E cl 7(2)].

The 22.2 GL is the upper limit of the volume of Environmental Land Management Allocations (ELMA) that are provided to landholders in the LMRIA to minimise the impacts of highly saline groundwater levels on irrigated pasture, or on land that has been retired from irrigation. The ELMA entitlements (and associated allocations) cannot be traded. The remaining 72 GL of entitlements (and associated allocations) can be permanently or temporarily traded and the annual diversion target is adjusted accordingly.

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4 Whilst Schedule E states that the 22.2 GL is for ‘environmental purposes’, the correct purpose is for ‘environmental land management’, as defined in the 2002 River Murray WAP (RMCWMB 2002).
The Cap for the LMS was set separately to those on other irrigation diversions, primarily because the flood irrigation in this region did not have reliable metering at the time. The LMS Cap was set equal to the volume of entitlements that were issued for the LMRIA, which themselves were based solely on an estimate of historical use. The final LMS Cap of 94.2 GL/year was agreed by Ministerial Council in March 2008 and is the *unrestricted LMS Cap*.

Metering was implemented over time after the Cap was set. Although it was generally completed by 2008–09, limited metered water use data was available before 2011–12 due to restricted access resulting from major riverbank cracking and slumping issues. Until 2007–08, it was assumed that available allocations were fully used and hence the annual diversion target and the actual annual diversion were assumed to equal the Cap. No Cap credits or debits were accumulated until this time.

### 3.2.4 Country Towns

The Country Towns Cap covers diversions for South Australian Country Towns that are not covered by the Metropolitan Adelaide Cap. This includes towns adjacent to the River Murray as well as those on the Yorke and Eyre Peninsulas.

Schedule E limits diversions from the Country Towns Cap valley to an annual maximum of 50 GL per year [sch E cl 7(1)(c)]. This is the *unrestricted CT Cap*.

Allocations against the Entitlement held and accounted for under this Cap can be traded and the annual diversion limit is adjusted accordingly.

### 3.2.5 All Other Purposes

The first three South Australian Caps cover water diversions via specific infrastructure, for specific purposes and/or for specific geographical areas. The fourth – the All Other Purposes (AOP) Cap – covers all other licensed River Murray water use including irrigation, stock and domestic, recreation and industrial.\(^5\)

Schedule E of the Agreement limits diversions from the AOP Cap valley to a long-term average of 449.9 GL per year [sch E cl 7(1)(d)]. This is the *unrestricted AOP Cap*.

The AOP Cap was set at an average of 440.6 GL/year, which was 90 per cent of the 489.6 GL of pumped irrigation entitlements held at the time (MDBMC 1996b). This allowed for an increase in licensed irrigation diversions of 69 GL over 1993–94 levels of development and use. The allowance for growth was recommended by the Independent Audit Group (IAG) given the conservative water resources management practices adopted in South Australia over the previous 25 years (MDBMC 1996a), and it was agreed by Ministerial Council (MDBMC 1996b).

The transfer of 9.3 GL of highland irrigation entitlements from the LMS Cap valley in March 2008 increased the AOP Cap to an average of 449.9 GL/year.

Diversions to be accounted for under a given Cap are required by sch E cl 4(1) to be defined in a Diversion Formula Register. For the AOP Cap, diversions are explicitly defined as:

\[
\text{The sum of all licensed diversions } [\text{Pumped Irrigation diversions (metered)} + \text{Pumped Irrigation diversions ( unmetered)} + \text{Recreation & Environmental diversions} + \text{Industrial diversions} + \text{Stock & Domestic licensed diversions}] \text{ from the River Murray in South Australia (including water transported by SA Water on behalf of other licensees via the Metro-Adelaide system or Country Town pipelines), obtained from the Database system of the responsible state agency. (MDBA 2018)}
\]

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\(^5\) Including water transported by SA Water on behalf of other licensees via the Metro-Adelaide system or Country Town pipelines.
Compliance is assessed against an annual diversion limit, which is generated by the accredited AOP Cap model in accordance with sch E cl 11(3). The AOP Cap model is a regression model that was developed using historical monthly use (1983–84 to 1999–00) and climate data (Prasad and Foreman 2004). The annual demands generated by the model are scaled to ensure that the average annual use over the period from 1891–92 to 2001–02 is equal to the agreed AOP Cap. The scaling factor is referred to as the AOP scaling factor.

Allocations and entitlements under this Cap can be traded and the annual diversion limit is adjusted accordingly. Appendix B includes further background on the AOP Cap and model, including adjustments for permanent trade.

### 3.3 Unlicensed Stock and Domestic Diversions

Section 1.07(a) of the Basin Plan defines basic right as a right under State water management law to take water for domestic or stock purposes. In South Australia, basic rights to take water for stock and domestic purposes are statutory rights under section 124(4) of the Natural Resources Management Act 2004 (SA) (NRM Act). This take is not licensed or metered.

Section 124(4) of the NRM Act provides an occupier of land with a general right to take water for use for domestic purposes or for watering stock, where the land has a watercourse adjoining to, or running through it; or has a lake that adjoins or is on the land.

Basic rights to take water for stock and domestic purposes from the River Murray in South Australia have been a right under state water resources management law for many decades. They were originally part of ‘riparian rights’ to take water but became statutory rights once the River Murray became a proclaimed watercourse in 1978 under the Water Resources Act 1976 (SA).²

This take constitutes a ‘basic right’ under section 1.07 of the Basin Plan. Hence, it is a form of take under section 1.07 of the Basin Plan, which must be accounted for in the method for determining the annual permitted take under section 10.10.

Schedule 3 of the Basin Plan defines the BDL for the SA Murray SDL resource unit (SS11) as the quantity of water taken, in accordance with Schedule E of the Agreement, as at 30 June 2009. A review of Schedule E, and reports and Ministerial Council minutes that supported the development of the Cap, clearly indicates that take for basic rights (unlicensed stock and domestic purposes):

- was not included under any of the four South Australian long-term diversion Caps under Schedule E of the Agreement, including in any of the associated formulae in the Diversion Formula Register (required to be used to calculate annual diversion targets and annual actual use).
- was not included or estimated during the development of any of the four South Australian long-term diversion Caps.³

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² Now the River Murray Prescribed Watercourse under the NRM Act. These statutory rights have been defined under previous legislation, including section 32(b) of the Water Resources Act 1990 (SA) and as a prescribed watercourse under section 7(5) of the Water Resources Act 1997 (SA).

³ Excluding take under basic rights from the Cap on Diversions in South Australia is consistent with the setting of the New South Wales and Victorian Murray Caps. The annual Cap limits in New South Wales and Victoria are the volumes of water that would have been used with the infrastructure (pumps, dams, channels, areas developed for irrigation, management rules etc.) that existed in 1993–94, assuming similar climatic and hydrological conditions to those experienced in the year in question (MDBMC, 1996a; MDBC 2004). This definition could include take under basic rights, but this is not the case given the BDL descriptions under Schedule 3.
Neither the current BDL description nor estimate include take for basic rights. The principles of the Cap do not support the inclusion and accounting of additional forms of take under the same volumetric limit. Implementation of the Basin Plan itself should also have no effect on the existing reliability.

In the case of the BDL for the SA Murray SDL resource unit, basic rights were omitted from the original description in the Basin Plan. However, this right to take was in place as at 30 June 2009 and consequently should be added to the BDL. [Accordingly, the Government of South Australia and MDBA have agreed that the BDL description and estimate should be revised and adjusted to include unlicensed stock and domestic diversions (refer Sections 3.4 and 7.11), as part of a future amendment to the Basin Plan.]

Appendix C provides supporting evidence for a change to the Basin Plan to explicitly and separately include basic rights in a revised BDL description for the SA Murray SDL resource unit. Following this, an explicit increase to the BDL estimate for this form of take can be made.

### 3.4 Revised BDL Description

The MDBA requires that an alternative BDL estimate must meet the definition of the BDL in Schedule 3 of the Basin Plan (MDBA 2015a). Therefore, in order update the current BDL estimate to account for basic rights for unlicensed stock and domestic purposes, the current BDL description needs to be updated.

#### Revised BDL description for the SA Murray SDL resource unit (SS11):

The BDL is the sum of:

(a) the long-term average limit on the quantity of water that can be taken from watercourses (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take in accordance with Schedule E to the Agreement as at 30 June 2009 for each year of the historical climate conditions (but excluding water recovered under The Living Murray Initiative); and

(ii) dividing that quantity by all the years of the historical climate conditions; and

(b) the long-term annual average take of water from watercourses under basic rights as at 30 June 2009.

---

*Under Schedule 3 and for most other SDL resource units, the BDL component for take from watercourses under basic rights is listed separately from the BDL component for take accounted for under the relevant Cap and was not estimated at the time the Basin Plan was enacted. For example, New South Wales Murray under Item 15(c) and Victorian Murray under Item 1(b).*
4 BDL MODEL DEVELOPMENT

4.1 Overview

The current BDL estimate for the SA Murray SDL resource unit (SS11) was determined via hydrological modelling over the Basin Plan modelling period (1895–96 to 2008–09) using the Murray Simulation Model9 (MSM) (MDBC 2002a; MDBC 2007; MDBA 2013). Section 4.2 outlines the modelling process and key steps to construct the current BDL model.

The SA Murray SDL resource unit includes the four existing South Australia Cap valleys under Schedule E of the Agreement (refer Section 3.2). The current BDL estimate is the sum of individual diversion limits – BDL components – one for each of the four Cap valleys.

The AOP, LMS and CT CapS were set with an assumption of a 100 per cent allocation against all entitlements issued in those Cap valleys each year. The methods for calculating annual diversion targets each year were also based on this assumption, that is, targets are not reduced when allocations are restricted as a result of South Australia receiving less than its full Entitlement.

To account for periods of restricted water resource availability, assumptions related to allocation priorities, policies and rules were included in MSM. Assumptions about patterns of use were also included, as was an approach to restricting annual diversion targets when full allocations are not available.

Whilst these assumptions were developed for the purposes of determining a BDL, they were also retrospectively applied in the MSM Cap models. That is, the new BDL policies and rules were assumed to have been in place under Cap conditions. As the MSM Cap model provided the foundation for the current BDL model, most changes to the current BDL assumptions also need to be applied to the MSM Cap model. This is described further in Section 4.2.

The review of the assumptions included in the current BDL model has identified several matters that need to be addressed to ensure that the state water management arrangements at 30 June 2009 are reflected, and that the reliability of water rights remains the same as the existing reliability under the Cap.

4.2 BDL Modelling Process and Key Steps

The process undertaken by the MDBA to develop the current BDL model and estimate are summarised below. In order to produce a revised BDL model and estimate, this process needs to be repeated with the set of revised BDL assumptions.

1. Run the MSM Cap model10 from 1891–92 to 2001–02 with scaled monthly demands so that the unrestricted use, and hence the long-term Cap for each Cap valley, was: (1) 50 GL/year for Country Towns; (2) 94.2 GL/year for the LMS; and (3) 449.9 GL/year for the AOP.

In this model run and all subsequent model runs, Metropolitan Adelaide is represented by a fixed monthly demand sequence developed by MDBC (2002b).

9 MSM operates at monthly time step and covers the Murray–Darling River system from Dartmouth Dam to the Barrages, including the Lower Darling from Menindee Lakes. It simulates the various water management, sharing and operating rules across the system as well as the existing spatial and temporal patterns of take.

10 The MSM Cap model developed for the NSW Murray, Victorian Murray and NSW Lower Darling into which the MDBA incorporated the approved Cap models for the AOP, LMS and CT Cap valleys.
2. Extend the MSM Cap model to 1891–92 to 2002–03 and determine an average annual restricted use for each Cap valley (as a result of any years with restricted South Australian Entitlement) over this period. This is the restricted Cap for each Cap valley.

3. Adjust the restricted long-term Caps for the AOP and LMS Cap valleys for permanent inter-state trade, permanent intra-state trade and for the recovery of entitlements under The Living Murray (TLM) Program. This is the adjusted restricted Cap for each Cap valley.

4. Incorporate additional ‘BDL conditions’ (other state policies and assumptions as at 30 June 2009; adjustments for permanent inter-state and intra-state trade, and for TLM recovery) into the MSM Cap model and run from 1891–92 to 2002–03. Scale the demands until the annual average use is equal to the adjusted restricted Cap in each Cap valley.

5. Run scaled BDL conditions in MSM (or Source Murray Model (SMM) – see below) from 1895–96 to 2008–09 to determine the BDL. The model used for this run is then the current BDL model.

In each model run, the key steps for determining a long-term average Cap or BDL component are:

1. Determine the volume of South Australian Entitlement available at the start of each month and distribute in accordance with the water allocation priorities, policies and rules.

2. Determine the monthly use based on available allocation in each Cap valley. The sum of the monthly use for each year represents the annual diversion target for that component.

3. The average annual diversion over the historical period for each Cap valley is then the Cap / BDL component for that valley. The overall Cap / BDL is the sum of the four components.

Since the current BDL model was prepared, there has been significant progress in developing a Source Murray Model (SMM) (MDBA 2015b; MDBA 2015c; MDBA 2019a; MDBA 2019b) as a replacement for MSM. This daily model will ultimately be used to model water management arrangements in all SDL resource units. For the SA Murray SDL resource unit, comparable functions and set-up functionality to MSM are available. The set of revised BDL assumptions can therefore be incorporated into the SMM and used to represent BDL conditions.

However, as noted in Section 4.1, the ‘BDL conditions’ (state policies and assumptions as at 30 June 2009) for allocation priorities, policies and rules, patterns of use and the approach for restricting annual diversion targets were applied in the MSM Cap model. As there is no SMM for Cap conditions, steps 1 to 4 above must again be undertaken using MSM. The assumptions and parameters from the revised MSM Cap model from step 4 can then be incorporated into the SMM.

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11 The period 1891 to 2003 is the revised Cap assessment period, as agreed for the purposes of TLM water recovery (Andy Close, pers. comm., 28 November 2016).

12 Several other changes to the MSM Cap model were also incorporated (Andy Close, pers. comm., May 2017) – the demand models (Cap models) were adjusted for trends to 2000; upstream diversions and tributary flows were adjusted for TLM conditions; and a function to allocate water to TLM accounts and use that allocation at TLM sites was included.
5 WATER ACCESS RIGHTS AND CAP ADJUSTMENTS

5.1 Water Rights – Summary of Issues and Revisions

Issue relates to: Representation of water access rights under Cap and BDL conditions; and the adjustment to the AOP Cap under BDL conditions.

Requirements for water access rights:

- The water access rights accounted for under Cap conditions should be consistent with the definition of each Cap under the Agreement. As the revised Cap assessment period is 1891 to 2003, the assumed volume of water access rights should reflect those held at 30 June 2003.
- The volume of water access rights used to determine a BDL for an SDL resource unit should be those as at 30 June 2009, consistent with the definition of the BDL in Schedule 3 of the Basin Plan.

Changes / updates to:

- Volume of water rights held in the AOP Cap valley under Cap conditions
- Volume of water rights for stock, domestic and industrial purposes under Cap and BDL conditions
- Volume of water rights in the LMS Cap valley under BDL conditions
- Volume of water rights in the AOP Cap valley under BDL conditions
- Maximum Metropolitan Adelaide Entitlement variable under BDL conditions
- AOP Cap adjustment volume under BDL conditions.

5.2 Water Rights – Current Cap and BDL Conditions

The volumes of water access rights applied in the current Cap and BDL model runs are presented in columns 2 and 3 of Table 1 respectively.

### Table 1 Water Access Rights – Current Cap and BDL Conditions

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Water Rights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Cap Conditions (GL)</td>
</tr>
<tr>
<td>All Other Purposes Cap valley¹</td>
<td>485.50</td>
</tr>
<tr>
<td>Lower Murray Swamps Cap valley²</td>
<td>94.20</td>
</tr>
<tr>
<td><strong>Total AOP + LMS</strong></td>
<td><strong>579.70</strong></td>
</tr>
<tr>
<td>Licensed stock, domestic and industrial³</td>
<td>13.40</td>
</tr>
<tr>
<td>Unlicensed stock and domestic</td>
<td>6.60</td>
</tr>
<tr>
<td><strong>Total stock, domestic &amp; industrial</strong></td>
<td><strong>20.00</strong></td>
</tr>
<tr>
<td>Country Towns Cap valley</td>
<td>50.00</td>
</tr>
<tr>
<td>Metropolitan Adelaide Cap valley⁴</td>
<td>180.00</td>
</tr>
</tbody>
</table>

Notes:

1. AOP Cap valley MSM entitlement variable includes entitlements held for irrigation, recreation and environment (classes 3a, 3b, 4 and 7 – as listed in the 2009 River Murray WAP (SA MDB NRMB 2009)) only.
2. LMS Cap valley MSM entitlement variable includes entitlements for irrigation, recreation, environment and land management (classes 3a, 4, 7 and 8) only.
3. Entitlements held for stock, domestic and industrial purposes (classes 1 and 5) are accounted for under the AOP Cap but are specified separately in the MSM parameter file.
4. Metropolitan Adelaide Cap valley entitlement variable in the MSM parameter file represents the maximum annual allocation, not the entitlement actually held.
5.3 Cap Adjustments – AOP and LMS Cap Valleys – Current BDL Conditions

The AOP Cap was initially at 449.9 GL/year, but then needed to take into account permanent inter-state trade, permanent intra-state trade from the LMS Cap valley and recovery for TLM. Table 2 shows the Cap adjustments applied in the current BDL Model.

Table 2 Adjustments to the AOP Cap in the current BDL Model

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Cap Adjustment (GL)</th>
<th>Entitlement Volume (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent inter-state trade</td>
<td>+32.441</td>
<td>+36.045</td>
</tr>
<tr>
<td>Permanent intra-state trade from LMS</td>
<td>+47.200</td>
<td>+47.200</td>
</tr>
<tr>
<td>TLM recovery</td>
<td>-41.529</td>
<td>-43.916</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>+38.112</strong></td>
<td><strong>+39.329</strong></td>
</tr>
</tbody>
</table>

Notes:

1. Permanent inter-state trade – Permanent transfer of entitlements from Victoria and New South Wales before 30 June 2007. These form part of the Class 3a shares listed in the 2009 River Murray WAP (SA MDB NRMB 2009). The overall Cap factor applied to convert the entitlement to a Cap adjustment was around 0.9.

2. Permanent intra-state trade from LMS – MDBA estimate of the permanent transfer of entitlements from LMS Cap valley as at 30 June 2009. The LMS Cap is adjusted downwards by the same amount. The Cap factor applied to convert the entitlement to a Cap adjustment was 1.0. Note – this estimate was based on trade data provided through reporting under Schedule E, which has been reviewed and updated.

3. TLM Recovery – Total acquisition of entitlements for TLM. The factors applied to convert the entitlement volumes to Cap adjustments are a combination of 0.9 and 1.0. Note – the MDBA assumed that all entitlements acquired for TLM were transfer and held in the AOP Cap valley, which was not the case.

5.4 Water Rights – AOP Cap Valley – Revised Cap Conditions

Issue relates to: Representation of AOP Cap valley water access rights under Cap conditions (excluding those for stock, domestic and industrial purposes).

Information for Revision

Table 3 shows the volume of water access rights (excluding those for stock, domestic and industrial purposes) in the AOP and LMS Cap valleys applied in the current Cap model run (column 3), and the actual water rights (column 2) at 30 June 2003, which have now been applied.

These volumes include the transfer of 9.3 GL of highland irrigation entitlements from the LMS to the AOP Cap valley. There are no other transfers of water rights via permanent inter-valley trade and no TLM recovery. Entitlements for stock, domestic and industrial are considered separately in Section 5.5.

Table 3 Water Access Rights – AOP and LMS Cap Valleys – Revised Cap Conditions

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Water Rights¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual (GL)</td>
</tr>
<tr>
<td>All Other Purposes Cap valley²</td>
<td>499.8</td>
</tr>
<tr>
<td>Lower Murray Swamps Cap valley³</td>
<td>94.2</td>
</tr>
</tbody>
</table>

Notes:

1. Entitlements held for stock, domestic and industrial purposes (classes 1 and 5) are accounted for under the AOP Cap but are specified separately in the MSM parameter file.

2. AOP Cap valley MSM entitlement variable includes entitlements held for irrigation, recreation and environment (classes 3a, 3b, 4 and 7 – as listed in the 2009 River Murray WAP (SA MDB NRMB 2009)) only.

3. LMS Cap valley MSM entitlement variable includes entitlements for irrigation, recreation, environment and land management (classes 3a, 4, 7 and 8) only.
Supporting Information

- The total volume of water rights held in the AOP Cap valley under Cap conditions as at 30 June 2003 was 513.7 GL, including entitlements for the historical purposes of irrigation, recreation and the environment (classes 3a, 3b, 4 and 7) and for stock, domestic and industrial (classes 1 and 5).

- The 513.7 GL of entitlements comprises:
  - 489.6 GL of entitlements held at time the AOP Cap was set
  - 9.3 GL of highland entitlements transferred from the LMS
  - 14.8 GL of additional entitlements.

- There were 14.8 GL of additional entitlements issued after the setting of the AOP Cap from the:
  - conversion of groundwater licences in the Angas-Bremer Prescribed Wells Area to the River Murray Prescribed Watercourse. Of the 21 GL of entitlements approved, approximately only 7 GL of entitlements had been issued at the time the Cap was set
  - granting of new stock and domestic entitlements to existing non-licensed stock and/or domestic water users who were not eligible to take under section 124(4) of the NRM Act, and where it could be demonstrated that the water use was occurring at 1 July 2002.

- Excluding entitlements for licensed stock, domestic and industrial (classes 1 and 5) purposes leaves a volume of water rights of 499.8 GL.

Revised Assumption 1

Cap conditions (water rights) – volume of water rights (excluding stock, domestic and industrial) held in the AOP Cap valley is 499.8 GL.

5.5 Water Rights – Stock, Domestic and Industrial – Revised Cap and BDL Conditions

Issue relates to: Representation of AOP Cap valley water access rights for stock, domestic and industrial purposes under Cap and BDL conditions.

Information for Revision

Table 4 shows the volume of water access rights for licensed stock, domestic and industrial (classes 1 and 5) and unlicensed stock and domestic purposes applied in the current Cap and BDL models (column 3), and the actual water rights (column 2) at 30 June 2009, which have now been applied.

There has been no inter-valley trade of stock, domestic or industrial entitlements. Given the small volume of stock and domestic entitlements recovered for TLM – less than 0.02 GL – these are accounted for with other TLM entitlements. The volume of entitlements held for stock, domestic and industrial purposes in the AOP Cap valley is therefore the same under both Cap and BDL conditions.

Table 4 Water Access Rights – Cap and BDL Conditions – Stock, Domestic and Industrial Purposes

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Water Rights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual (GL)</td>
</tr>
<tr>
<td>Licensed stock, domestic and industrial</td>
<td>13.90</td>
</tr>
<tr>
<td>Unlicensed stock and domestic</td>
<td>6.10</td>
</tr>
<tr>
<td>Total stock, domestic &amp; industrial</td>
<td>20.00</td>
</tr>
</tbody>
</table>
Supporting Information

- The total volume of water rights for licensed and unlicensed stock and domestic purposes and industrial purposes is 20 GL.
  - This volume forms part of the 201 GL for critical human water needs (CHWN) determined by South Australia for the 2007–08 water year, and the 204 GL for CHWN determined by the MDBA in 2010.
  - The requirement of 204 GL for CHWN was based primarily on population. The use of this water is via licensed and unlicensed (basic rights) diversions.

- Licensed stock, domestic and industrial rights
  - Entitlements for stock, domestic and industrial (classes 1 and 5) purposes are principally held in the AOP Cap valley (<0.1 GL held in the LMS Cap valley).
  - The volume of class 1 and 5 entitlement shares established under the 2009 River Murray WAP (SA MDB NRMB 2009) was 14.2 GL.
  - A proportion of the class 1 shares established in 2009 was for the granting of new entitlements to existing non-licensed stock and/or domestic water users who were not eligible to take under section 124(4) of the NRM Act, and where it could be demonstrated that the water use was occurring at 1 July 2002.
  - The volume of shares (classes 1 and 5) actually held as at 30 June 2009 was 13.9 GL. The remaining 0.3 GL of class 1 shares were not issued and were removed from the 2017 River Murray WAP (SA MDB NRMB 2017).

- Unlicensed stock and domestic rights (basic rights)
  - Take for stock and domestic purposes is a general right under the NRM Act as outlined in Section 3.3, and a licence is not required.
  - This take is accounted for in the setting of allocation priorities and the sharing of water as a function of the total Entitlement available to South Australia, but use is not accounted for under the AOP Cap (refer Section 3.2.5).
  - The 13.9 GL volume of licensed stock, domestic and industrial take as at 30 June 2009 results in an estimated take for unlicensed stock and domestic of 6.1 GL. This is an improved estimate of the unlicensed component of stock and domestic use at that time.

**Revised Assumption 2**

Cap and BDL conditions (water rights) – volume of water rights for stock, domestic and industrial purposes is as shown in Table 4 (column 2).
5.6 Water Rights – Metropolitan Adelaide – Revised Cap and BDL Conditions

Issue relates to: Maximum Metropolitan Adelaide demand under Cap and BDL conditions.

Information for Revision

The maximum Metropolitan Adelaide demand is 215 GL under Cap and BDL conditions.

Supporting Information

The entitlement held for Metropolitan Adelaide has an average value of 130 GL. Historically, use against this entitlement has been governed by Schedule E of the Agreement (refer Section 3.2.2) and the allocation has been increased above 130 GL when required.

The Metropolitan Adelaide Cap valley entitlement variable in the MSM parameter file represents a maximum allocation, not the entitlement held.

State policies (either now or as at 30 June 2009) have not limited River Murray diversions for Metropolitan Adelaide when other water users have received full allocations to a level less than permitted by the Cap.

Revised Assumption 3

Cap and BDL conditions (water rights) – Metropolitan Adelaide maximum allocation variable is 215 GL, reflecting the maximum demand under BDL conditions.

5.7 Water Rights – AOP and LMS Cap Valleys – Revised BDL Conditions

Issue relates to: Representation of AOP and LMS Cap valley water access rights under BDL conditions (excluding those for stock, domestic and industrial purposes).

Information for Revision

Table 5 shows the volume of water access rights assumed in the current BDL model (column 4) and the actual water rights held as at 30 June 2009 (column 2).

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Actual Volume (GL)</th>
<th>Revised BDL (GL)</th>
<th>Current BDL (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Other Purposes Cap valley¹</td>
<td>572.28</td>
<td>577.36</td>
<td>568.70</td>
</tr>
<tr>
<td>Lower Murray Swamps Cap valley²</td>
<td>57.77</td>
<td>52.69</td>
<td>47.00</td>
</tr>
<tr>
<td>Total AOP + LMS³</td>
<td>630.05</td>
<td>630.05</td>
<td>615.70</td>
</tr>
</tbody>
</table>

Notes:

1. AOP Cap valley MSM entitlement variable includes entitlements held for irrigation, recreation and environment only (classes 3a, 3b, 4 and 7 – as listed in the 2009 River Murray WAP (SA MDB NRMB 2009)).
2. LMS Cap valley MSM entitlement variable includes entitlements for irrigation, recreation and environment only (classes 3a, 4, 7 and 8).
3. Entitlements held for stock, domestic and industrial purposes (classes 1 and 5) are accounted for under the AOP Cap but are specified separately in the MSM parameter file.

The actual water rights held (column 2) takes into account the revised consumptive entitlement volume transferred to the AOP Cap valley via permanent inter-valley trade. Entitlements recovered for TLM are included in the Cap valley that they were recovered from (also reflective of annual Cap accounting).

The current set-up of MSM assumes that all water recovered for TLM in the LMS Cap valley has been traded to the AOP Cap valley. The revised BDL water rights (column 3) in Table 5 also assumes that TLM
entitlements recovered in the LMS Cap valley have been ‘transferred’ to the AOP Cap valley. This approach has been applied for BDL modelling purposes only, so as to avoid significant recoding.

Supporting Information

Lower Murray Swamps Cap Valley

The volume of entitlements held in the LMS Cap valley as at 30 June 2009 was 57.77 GL, which comprised primarily of entitlements for the historical purposes of irrigation, recreation, environment and environmental land management (classes 3a, 4, 7 and 8). This included 5.075 GL for TLM.

The volume of stock, domestic and industrial (classes 1 and 5) entitlements was (and is) negligible (<0.1 GL). Use against these entitlements has historically been accounted for under the AOP Cap

The volume of 57.77 GL was supported by an audit of all trades between the AOP and LMS Cap valleys, which showed that the net permanent consumptive trade from the LMS to the AOP as at 30 June 2009 was 36.43 GL. This revised trade figure was incorporated into the Cap Register in 2015.

The ‘transfer’ of TLM entitlements to the AOP Cap valley for BDL modelling purposes leaves an entitlement volume of 52.69 GL.

Revised Assumption 4
BDL conditions (water rights) – volume of water rights held in the LMS Cap valley is 52.69 GL.

All Other Purposes Cap Valley

The total volume of water rights held in the AOP Cap valley as at 30 June 2009 was 586.2 GL, which comprised:

- entitlements for the historical purposes of irrigation, recreation and environment (classes 3a, 3b, 4 and 7) – including 38.871 GL held for TLM
- licensed stock, domestic and industrial (classes 1 and 5) entitlements – 13.9 GL.

The 586.2 GL of entitlements comprised:

- 489.6 GL of entitlements held at time the AOP Cap was set
- 9.3 GL of highland entitlements transferred from the LMS Cap valley
- 36.05 GL of entitlements permanently transferred from inter-state (Pilot Program)
- 36.43 GL of entitlements permanently transferred from the LMS Cap valley
- 14.8 GL of additional entitlements (from the Angas-Bremer groundwater conversion).

The MSM entitlement variable for the AOP Cap valley excludes those entitlements for licensed stock, domestic and industrial (classes 1 and 5) purposes. Doing this leaves a volume of 572.28 GL. Adjusting for the volume of TLM entitlements ‘transferred’ from the LMS Cap valley (refer above), produces an entitlement volume of 577.36 GL.

Revised Assumption 5
BDL conditions (water rights) – volume of water rights held in the AOP Cap valley is 577.36 GL.
5.8 Cap Adjustments – AOP and LMS Cap Valleys – Revised BDL Conditions

Issue relates to: The change in the volumes of water access rights in the AOP and LMS Cap valleys and consequential updates to the AOP and LMS Cap adjustment volumes.

Information for Revision

Table 6 presents revised Cap adjustments for the AOP Cap valley. The increase for permanent intra-state trade in the AOP Cap valley has a corresponding decrease in the LMS Cap valley.

Table 6 AOP Cap Adjustments – Revised BDL Conditions – AOP Cap Valley

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Cap Adjustment (GL)</th>
<th>Entitlement Volume (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent inter-state trade</td>
<td>+32.441</td>
<td>+36.046</td>
</tr>
<tr>
<td>Permanent intra-state trade from LMS</td>
<td>+41.509</td>
<td>+41.509</td>
</tr>
<tr>
<td>TLM purchase within AOP Cap valley</td>
<td>-41.529</td>
<td>-43.916</td>
</tr>
<tr>
<td>Total</td>
<td>+32.421</td>
<td>+33.639</td>
</tr>
</tbody>
</table>

The AOP Cap adjustment is critical for determining the AOP scaling factor (BDL) (refer Section 7.2). The adjustment for the use of entitlements held for TLM occurs via the determination of this scaling factor.

The value of permanent intra-state trade is the only change in Table 6 from the adjustments shown in Table 2, which is a result of the review and update of trade data and includes the transfer of TLM entitlements for BDL modelling purposes only.

Revised Assumption 6

BDL conditions (Cap adjustment) – updated AOP Cap adjustment of +32.421 GL and LMS Cap adjustment of -41.509 GL.
6 ALLOCATION PRIORITIES, POLICIES AND RULES

Prior to the 2003–04 water year, it was envisaged that South Australia would always receive its full Entitlement under the Agreement. Including a framework for making allocations under low water availability conditions was not considered necessary when the 2002 River Murray WAP (RMW 2002) was prepared.

In response to the unprecedented allocation restrictions in 2006–07, annual drought water allocation frameworks were developed and applied from 2007–08 to 2010–11 and implemented via gazettal. These prioritised the sharing of the Entitlement available to South Australia and included provisions to put aside Entitlement in one year for delivery in the following year.

6.1 Allocation Priorities – Summary of Issues and Revisions

Issue relates to: Representation of allocation priorities and policies.

Requirements for allocation priorities:

- Assumptions for allocation priorities and policies should represent the state water management arrangements in place at 30 June 2009.
- Approach should be consistent with the current Cap on Diversions under Schedule E of the Agreement, and not reduce the rights of existing water entitlements.

Changes / updates required to:

- Allocation priorities for distributing available South Australian Entitlement
- Rules for distributing Entitlement during periods of extremely low water levels in the Lower Lakes.

6.2 Allocation Priorities – Current Cap and BDL Conditions

In developing the current BDL model, updates to MSM were undertaken by the MDBA to reflect the state rules as at 30 June 2009 for distributing and allocating the volume of South Australian Entitlement made available each year under the Agreement – in particular, for prioritising allocations to specific purposes under reduced water availability conditions and to reflect the state requirements for meeting CHWN.

MSM determines the percentage allocation for each purpose of use based on an allocation framework that defines the relationship with total volume allocated to South Australia.

To develop an allocation table to prioritise and share water as a function of the total Entitlement available to South Australia, the MDBA considered sources including:

- state annual water allocation frameworks from 2008–09 and 2009–10
- data on announced irrigation allocation levels versus total water available to South Australia
- correspondence with South Australian officers on potential (and preliminary) future allocation strategies for testing the benefits of water recovery under the Basin Plan.
From this analysis, an allocation table was developed and included in MSM for the purposes of modelling current Cap and BDL conditions. This allocation table is reproduced in Table 7 and was based on the following assumptions (Takken 2009):

1. Any volume up to 348 GL is attributed to losses – defines the nominal loss component from the 696 GL Dilution and Loss Entitlement under the Agreement, which is the first water provided to South Australia. (SA Entitlement = 348 GL)

2. The next 201 GL is allocated to CHWN – provides 150 GL for Metropolitan Adelaide and associated country areas, 31 GL for Country Towns and 20 GL for licensed stock, domestic and industrial purposes, and unlicensed stock and domestic purposes under statutory rights. (SA Entitlement = 549 GL)

3. A 2 per cent allocation is then made to irrigation purposes – this is provided to ensure access for CHWN (stock, domestic or industrial) from irrigation systems. (SA Entitlement = 561.3 GL)

4. Dilution flow is then increased up to 348 GL – represents the nominal dilution component from the 696 GL Dilution and Loss Entitlement. (SA Entitlement = 909.3 GL)

5. Irrigation allocations are then increased up to 50 per cent. (SA Entitlement = 1204.9 GL)

6. Improvements in water availability are then shared so that Country Towns and Metropolitan Adelaide reaches an allocation of 100 per cent when South Australia’s Entitlement reaches 1645 GL. Incrementally, this is about 11 per cent of the improvements between 1204.9 GL and 1645 GL. The remaining improvements have been split equally between irrigation and dilution flow. (Entitlement = 1645 GL)

7. Improvements in water availability are then shared equally between irrigation and dilution flow until dilution flow reaches 182.8 per cent (636.3 GL). This volume represents the dilution component of the Dilution and Loss Entitlement and the unallocated part of South Australia’s Entitlement. (Entitlement = 1830.5 GL)

8. Irrigation allocation increases until 100 per cent irrigation allocation is reached. (Entitlement = 1850 GL)

9. Increases above 1850 GL are attributed to dilution flow – this allows for the delivery of permanent trade, which in MSM is added to the Entitlement calculated under clause 88 of the Agreement.

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13 Despite its inclusion in MSM and in the modelling report that was prepared as a record of the changes made to MSM to determine a BDL for the SA Murray SDL resource unit, it is understood that the 2 per cent allocation from the 696 GL Dilution and Loss Entitlement (Item 3) was removed before the current BDL model was finalised. This change and the reason for the change is not documented.

14 The volume of 201 GL represented the CHWN volume calculated by South Australia during 2006–07 as part of the planning for 2007–08. As part of the Basin Plan development, the MDBA determined that the volume required for CHWN should be 204 GL.

15 Swamp and All Other Purpose ‘Irrigation’ in Table 7 includes all South Australian entitlements in classes 3a, 3b, 4, 7 and 8 as they existed at 30 June 2009. Classes 3a, 3b, 4 and 7 were incorporated into a single Class 3 in the 2017 River Murray WAP (SAMDB NRMB 2017).

16 These allocations are 50 GL for Country Towns and 180 GL for Metropolitan Adelaide. The latter is much greater than the current, nominal allocation of 130 GL and the defined CHWN volume of 150 GL. However, it does not represent the maximum demand that would be permitted to be pumped under Cap and instead represents an artificial upper limit on the pumping requirements.

17 Increases to dilution flow above 348 GL effectively represent the unallocated part of South Australia’s Entitlement.
Table 7 Allocation Table used for current BDL Calculations (from Takken 2009)

<table>
<thead>
<tr>
<th>Full allocations (GL)</th>
<th>Stock &amp; Domestic, Industrial and Riparian (S&amp;D)</th>
<th>All Other Purpose (AOP) irrigation</th>
<th>Swamp irrigation</th>
<th>Country Towns (CT)</th>
<th>Metro Adelaide (MA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.0</td>
<td>563.6</td>
<td>52.2</td>
<td>50.0</td>
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</table>

<table>
<thead>
<tr>
<th>Total SA Allocation (GL)</th>
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<th>348.0</th>
<th>549.0</th>
<th>561.3</th>
<th>696.0</th>
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<th>909.3</th>
<th>1204.9</th>
<th>1645.0</th>
<th>1830.5</th>
<th>1850.0</th>
<th>2000.0</th>
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</thead>
<tbody>
<tr>
<td>% Allocation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation (AOP + Swamp)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
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<td>81.8</td>
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<td>S&amp;D</td>
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<td>Dilution flow</td>
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<td>549.0</td>
<td>561.3</td>
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<td>909.3</td>
<td>1204.9</td>
<td>1645.0</td>
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<td>348.0</td>
<td>348.0</td>
<td>348.0</td>
<td>348.0</td>
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<td>348.0</td>
<td>348.0</td>
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<td>12.3</td>
<td>12.3</td>
<td>12.3</td>
<td>307.9</td>
<td>503.4</td>
<td>596.2</td>
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<tr>
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<td>20.0</td>
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<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
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<tr>
<td>Dilution flow</td>
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<td>0.0</td>
<td>0.0</td>
<td>134.7</td>
<td>335.7</td>
<td>348.0</td>
<td>348.0</td>
<td>543.6</td>
<td>636.3</td>
<td>636.3</td>
<td>786.3</td>
</tr>
</tbody>
</table>

1. The SA allocation values are presented for the total SA allocation at the start of the year. In MSM, the values are recalculated at the start of each month in order to represent the remaining allocation to the end of the year.
6.3 2008–09 River Murray Drought Water Allocation Decision Framework

A water allocation framework for 2008–09 was approved by the South Australian Government in May 2008 for implementation in 2008–09. As this framework provides the basis for many of the updates required to the current BDL model, an overview of the key aspects of the framework and how it was implemented is provided before the detailed descriptions of issues and changes.

The following are excerpts from the material provided to stakeholders, which was also provided to the MDBA in June 2009.

‘The overall objective of the River Murray Drought Water Allocation Decision Framework is:

To optimise the allocation and use of water that becomes available to South Australia (in excess of Critical Human Needs) to support the long-term sustainability and viability of the South Australian community for the greatest net benefit of the whole community.

Achieving this objective will involve complex and potentially conflicting decisions and associated trade-offs between different uses (e.g. environmental uses, irrigation, urban supplies, stock and domestic supplies, tourism and recreation). To assist this process, the framework includes three key principles and several more specific criteria (refer Appendix D.1). It also identifies the critical assets and activities that rely on the River Murray and the costs, benefits, opportunities and risks of allocating water to any of these potential uses and assets.

Importantly, the framework sets out an adaptive decision-making process for each month, following receipt of the Murray–Darling Basin Commission’s water resources assessment of the water available for sharing between New South Wales, Victoria and South Australia (refer Appendix D.2).

Through a series of decisions under this approach, the preferred application or use of any particular improvement in the water available to South Australia can be determined in a consistent, transparent and justifiable manner. Each decision point narrows down the preferred alternative use or uses to which the water could be allocated.’

An analysis of water availability scenarios from a multi-history assessment was undertaken at the time to provide indicative projections on the timing of allocation improvements. The following is an excerpt of the material provided to stakeholders (also provided to the MDBA in June 2009).

‘The basic assumptions used in the analysis are:

- allocation to irrigation licences is the first priority in June, July and August 2008;
- from September onwards, if the CHN reserve for 2009–10 is less than the target end of month volume, all improvement is directed to the reserve;
- after August, any improvement in excess of the target volume for the CHN reserve will be available to irrigation licences if the licence allocation is < 25 per cent;
- if the licence allocation is > 25 per cent, a portion of the improvement available to licences will be available for critical environmental needs up to 10 gigalitres; and
- no allocation will be made to irrigation licences after March 2009. Instead any improvement after this time will be allocated to refilling the Lower Lakes.’

Key points to note with respect to the 2008–09 allocation framework:

- CHWN (then referred to as critical human needs) were the highest priority following the Dilution and Loss Entitlement, but the final volume provided from the River Murray was subject to the consideration of other water sources. This meant that the volume taken for CHWN could be
reduced if other sources were available, with the difference provided for other consumptive purposes.

- The framework included rules for putting aside a CHWN Reserve for the following year. However, this was not put aside before some irrigation allocations were made.
  - Irrigation allocations received all improvements in the first three months.
  - Improvements from September onwards were put aside for a CHWN Reserve, up to a defined monthly maximum volume.
  - Monthly targets for the CHWN Reserve were defined from September 2008 to May 2009, with any remaining improvements going to increase irrigation allocations.

- The assignment of water for critical environmental needs was included because a significant number of wetlands along the River Murray had been shut for a number of years. While this allocation was included in the 2008–09 policy, it was explicitly linked to that situation. This is supported by the fact the allocation was not made under the 2007–08 allocation framework.

- The allocation projections assumed that the majority of all improvements above requirements for CHWN would be provided to increase irrigation allocations. This was also consistent with the 2007–08 framework.

- The policy not to allocate to irrigation licences after March 2009 was included because in May 2008 the water level in Lake Alexandrina was at -0.5 mAHD and was projected to fall to below -1.0 mAHD by the end of 2008–09. That is, this rule was included because water levels in the Lower Lakes were projected to approach critical levels (which are outside the thresholds contemplated under implementation of the Basin Plan).

6.4 Allocation Priorities – Revised Cap and BDL Conditions

Issue relates to: Representation of the South Australian water management arrangements as at 30 June 2009 with respect to allocation priorities.

Information for Revision

The allocation priorities for distributing the Entitlement available to South Australia under the Agreement, consistent with state water management policies at 30 June 2009, are as follows:

- Dilution and Loss Entitlement is prioritised above all other purposes.
- If the water available to South Australia is less than 897 GL, then a 2 per cent allocation is made from the Dilution and Loss Entitlement.
- CHWN of 201 GL is provided following dilution and loss.
- Any allocation provided from the Dilution and Loss Entitlement is repaid from the first available Entitlement after CHWN.
- Irrigation allocations have priority after CHWN.
- Allocations for Country Towns should increase once parity for irrigation allocations has been reached, not earlier.
- Allocations for Metropolitan Adelaide may increase above 150 GL once allocations for irrigation and Country Towns have reached 100 per cent, not earlier. The maximum allocation should reflect the maximum demand in the BDL annual demand sequence.
Unallocated Entitlement is provided once allocations for all water users reach 100 per cent. Supporting information for these priorities is outlined below. A revised allocation table is presented in Section 6.5 and Table 8.

Supporting Information

Dilution and Loss

The 696 GL Dilution and Loss Entitlement under clause 88(b) of the Agreement is the first water provided to South Australia.

Under the current BDL allocation framework (Section 6.2), the first 348 GL of water available is attributed to losses. This is followed by CHWN and 348 GL to dilution purposes. This does not represent South Australian policy at 30 June 2009.

- Providing water for CHWN from the 696 GL Dilution and Loss Entitlement reflects the situation that occurred in 2007–08. A special arrangement was required due to the unprecedented low water availability – only 487 GL was available to South Australia at the start of 2007–08.
- During 2007–08, it was shown that 896 GL was required to deliver the then requirement of 201 GL for CHWN to Wellington whilst maintaining a salinity of less than 1400 EC at Murray Bridge (Sharma and Heneker 2007).
- Since 2008–09, the 696 GL Dilution and Loss Entitlement has been viewed as a minimum flow requirement and has formed an essential part of all annual allocation frameworks. It has also now been explicitly preserved under the 2017 River Murray WAP (SA MDB NRMB 2017).

The only exception to the above policy position on the use of the Dilution and Loss Entitlement is when there is not enough water available to provide a 2 per cent allocation.

- An initial opening allocation of at least 2 per cent for irrigation was made on 1 July during each year of the Millennium Drought, including in 2007–08 and 2008–09, irrespective of the total volume available to South Australia.
- This is a small but critical allocation to ensure the delivery of CHWN that are supplied through irrigation infrastructure. Without this allocation, CHWN cannot be delivered in all cases.
- This allocation should be provided and the requirement that it be paid back before any increase in irrigation allocations ensures the protection of the Dilution and Loss Entitlement.
- The inclusion of clause 88A of the Agreement during the negotiations on Schedule H ensured that this policy could continue without special arrangement, particularly as the inclusion of the 225 GL conveyance reserve would further delay increases in water availability during dry years.

Revised Assumption 7

BDL conditions (allocation priorities):

- First 348 GL is provided for loss purposes followed by 335.4 GL for dilution.
- Initial allocation provision of 2 per cent (12.6 GL) for irrigation purposes is provided from the 696 GL Dilution and Loss Entitlement.
- Initial allocation provision is ‘repaid’ after the provision of water for CHWN.
**Critical Human Water Needs**

CHWN are the highest priority water use under section 86A(1)(a) of the *Water Act 2007* (Cth) and clause 135(10)(a) of the Agreement, which has also been reflected in South Australia’s water allocation policies since 2007–08. Once CHWN are provided, increases in available Entitlement can be provided to other purposes. This is primarily for irrigation but also for recreation, land management and environmental purposes, as well as increases to urban water supply above CHWN levels.

The CHWN volume of 201 GL/year from the River Murray represented the CHWN requirements estimated by South Australia in 2006, explicitly for use in planning for the extreme water shortage of 2007–08. The shortcomings of this estimate were identified at the time, particularly the underestimation of regional water requirements. It was intended that the volume would be revised.

The Water Act came into place in 2007, with section 86B(1)(a) requiring the Basin Plan to include a statement of the amount of water to meet CHWN. The MDBA undertook an assessment of the CHWN requirements for this purpose, which commenced before 30 June 2009. Given this process, South Australian officers worked with the MDBA with their assessment of a CHWN volume, rather than proceed with an independent revision. The intention was to adopt the revised volume once the Basin Plan was agreed, as this would represent the best understanding of the CHWN requirements at 30 June 2009.

In July 2010, the MDBA finalised their assessment and determined a CHWN requirement of 204 GL/year from the South Australian Murray. This adequately addressed issues with the original estimate, and as this was an improved estimate of the CHWN volume, it was assumed at the time that the new information would subsequently be reflected in the BDL and SDL.

The updated CHWN volume was included in the 2013–14 South Australian Allocation Framework, the first full water year after the Basin Plan was agreed. This increased the previously assumed CHWN requirement for Country Towns by the additional 3 GL, to 34 GL. This assignment is supported by the calculations undertaken by the MDBA, which showed additional volumes were required for CHWN in rural areas.

Whilst the CHWN volume of 204 GL provides a better estimate of the CHWN requirement at 30 June 2009, it has been determined that state policy did not explicitly reflect the 204 GL estimate at that time.

**Country Towns**

The CHWN volume of 31 GL for Country Towns represents a 62 per cent allocation.

The 2008–09 allocation framework was not explicit about the timing for increases in the allocation for Country Towns. However, it was acknowledged that only providing CHWN places significant restrictions on rural South Australian communities who have no other sources of water. The 31 GL volume is also well below the annual average use.

In the context of increasing allocations above CHWN, the 2008–09 framework lists country town reticulated supplies as a critical asset (Appendix D.1) and assesses the ‘costs of not allocating water to other priority uses’ in the decision sequence (Appendix D.2).

Whilst on a 50 per cent allocation, the costs to irrigators from increasing allocations to urban domestic and industrial supplies would be considered unreasonable under the 2008–09 framework. An increase in allocation for Country Towns would be unlikely until irrigation allocations were at least comparable.

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**Revised Assumption 8**

**BDL conditions (allocation priorities)** – once the irrigation allocation reaches 62 per cent, pro-rata increases are made to Country Towns and irrigation allocations.
Metropolitan Adelaide

The CHWN volume of 150 GL for Metropolitan Adelaide represents an allocation of 115 per cent of the nominal licence volume and well above the long-term average use of around 100 GL. However, it does not represent the maximum demand under very dry conditions in the Mount Lofty Ranges.

The 2008–09 allocation framework was not explicit about the timing for increases in the allocation for Metropolitan Adelaide. However, as for Country Towns, the 2008–09 framework lists urban reticulated supplies as a critical asset (Appendix D.1) and assesses the ‘costs of not allocating water to other priority uses’ in the decision sequence (Appendix D.2).

The 150 GL CHWN volume provides sufficient water to meet 100 per cent of demands in Metropolitan Adelaide in all but around 15 per cent of the driest years. Given this, an expectation of an increase in allocation while other water users are restricted would not be considered reasonable. In line with the 2008–09 allocation framework, the costs to irrigators and rural water users would be too high.

Revised Assumption 9
BDL conditions (allocation priorities) – Metropolitan Adelaide allocation is increased to the maximum demand (if required) once allocations for Country Towns and irrigation reach 100 per cent.

Irrigation

Takken (2009) describes the process for the development of the allocation framework. This included an analysis of the announced percentage allocation for irrigation as a function of the total water available for diversions from the period from July 2001 to August 2009. The results of this analysis can be seen in Figure 2 of Takken (2009).

While the actual allocations in 2007–08 and 2008–09 were considered when defining the framework, it does not reflect how allocations would have been made if water availability had increased in those years.

- Should water availability have increased further in 2008–09, the majority of the improvements would have been directed to increasing irrigation allocations (refer Section 6.3). This was also consistent with the allocation framework in 2007–08.
- While water availability improvements in 2008–09 also went to a CHWN Reserve for the following year, this provision does not need to be incorporated into the allocation table itself. It is instead covered as a separate rule for distributing the Entitlement available to South Australia (refer Sections 6.6 and 7.2.2).
- The inclusion of a provision in the 2008–09 allocation framework to provide up to 10 GL for critical environmental needs was not included in the current BDL model. This provision was explicitly linked to wetland closures at the time, and the onset of a third year of drought. It was not state policy to provide this volume in this manner under normal conditions and water levels.18

Revised Assumption 10
BDL conditions (allocation priorities) – once the initial 2 per cent (12.6 GL) allocation from the Dilution and Loss Entitlement is repaid, increase the allocation for irrigation purposes to 62 per cent, then pro rata with the allocation to Country Towns.

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18 The operation of wetlands along the River Murray is not explicitly modelled in MSM so it would also be difficult to incorporate a rule that only provides this allocation at that time.
Unallocated Entitlement

Once irrigation allocations reach 50 per cent, the current BDL allocation framework assigns a proportion of water availability improvements to dilution, which represents the unallocated part of South Australia’s Entitlement. It is understood that this is based on:

- the analysis of irrigation allocations by Takken (2009)
- the policy to not provide increased allocations to irrigation licences after March 2009, but instead to provide these improvements to refilling the Lower Lakes (refer Section 6.3)
- scenarios provided by South Australian officers to test the effect of different rules on lake levels during dry periods.

The analysis of irrigation allocations is presented above and the context of the policy to not increase irrigation allocations after March 2009 is outlined in Section 6.3.

The range of scenarios provided by South Australian officers were not official state policy positions but were provided to test broad scale water recovery and climate scenarios only.

The 2009–10 allocation framework did not represent state water management policies as at 30 June 2009, nor should it have been regarded as ongoing state water management policy to be incorporated into a BDL model, or that it would apply in every year. The fourth year of severely restricted water availability was about to commence in 2009–10. With water availability in 2008–09 only allowing irrigation allocations to increase to 18 per cent, a policy to direct Entitlement to the Lower Lakes was made solely for the following reasons:

- The water level in Lake Alexandrina had fallen below -1.0 mAHD and was at risk of falling below -1.5 mAHD (a critical level for acidification) during the next 12 months.
- A water level of -1.5 mAHD in Lake Alexandrina may have:
  - resulted in a massive acidification event
  - required the barrages to be opened, causing irreversible ecological damage
  - necessitated major infrastructure works at Wellington to construct a weir to safeguard water supply for Metropolitan Adelaide and some country areas.
- The water level in Lake Albert was being maintained at -0.75 mAHD by a bund across the lake entrance at Narrung combined with the pumping of significant volumes of water.
- The Goolwa Channel had been disconnected from Lake Alexandrina by a regulator at Clayton and was being maintained at 0.0 mAHD only via the pumping of significant volumes of water.

The decision to leave improvements in water availability unallocated was explicitly linked to the unprecedentedly low levels in the Lower Lakes at that time, which are outside the ranges contemplated under the Basin Plan. It was not state policy to put in place these rules when water levels in the Lower Lakes were within the normal operating levels and, as such, these rules should not be expected to apply in a BDL model under all conditions or in all years.

Revised Assumption 11

BDL conditions (allocation priorities) – the unallocated part of South Australia’s Entitlement is provided once all water users reach a 100 per cent allocation.
6.5 Allocation Table – Revised Cap and BDL Conditions

An allocation table that better reflects the South Australian allocation framework and priorities as at 30 June 2009 is presented in Table 8. Consistent with the table used in the current BDL model, this prioritises and shares water as a function of the total Entitlement available to South Australia under the Agreement.

1. Any volume up to 348 GL is attributed to losses – defines a nominal loss component from the 696 GL Dilution and Loss Entitlement, which is the first water provided to South Australia. (SA Entitlement = 348 GL)

2. Dilution flow of 335.4 GL – represents the majority of the dilution component of the 696 GL Dilution and Loss Entitlement. This provides approximately 950 ML/day into the Lower Lakes. (SA Entitlement = 683.4 GL)

3. Two per cent allocation to irrigation purposes 19 – this is provided to ensure access for CHWN (stock, domestic or industrial) from irrigation systems. (SA Entitlement = 696.0 GL)

4. The next 201 GL is allocated to CHWN – providing 150 GL for Metropolitan Adelaide and associated country areas, 31 GL for Country Towns and 20 GL for licensed stock, domestic and industrial purposes and unlicensed stock and domestic purposes under statutory rights. (SA Entitlement = 897.0 GL)

5. Dilution flow is increased up to 348 GL – represents the full nominal dilution component from the 696 GL Dilution and Loss Entitlement. This provides approximately 950 ML/day into the Lower Lakes. (SA Entitlement = 909.6 GL)

6. Irrigation allocation is then increased to 62 per cent. (SA Entitlement = 1287.6 GL)

7. Irrigation and Country Towns allocations then increase pro rata until both reach 100 per cent. (SA Entitlement = 1546.0 GL)

8. Improvements are then provided to Metropolitan Adelaide up to the maximum demand of 215 GL (if required). (Entitlement = 1611 GL)

9. Further improvements remain unallocated. (Entitlement = 1850.0 GL)

10. Increases above 1850 GL remain unallocated – this allows for the delivery of permanent trade, which in MSM is added to the Entitlement calculated under clause 88 of the Agreement.

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19 Swamp and All Other Purpose ‘Irrigation’ in Table 8 includes all South Australian entitlements in classes 3a, 3b, 4, 7 and 8, as listed in the 2009 River Murray WAP (SAMDB NRMB 2009).
Table 8 Revised Allocation Table – Reflecting South Australian Policies as at 30 June 2009

Full allocation (GL) when SA Entitlement is 1850 GL

<table>
<thead>
<tr>
<th>GL</th>
<th>Dilution and Loss Entitlement (D&amp;L) (includes provision for Class 9)</th>
<th>Licensed stock, domestic and industrial; Unlicensed stock and domestic (Classes 1 and 5 = 13.9 GL; Unlicensed = 6.1 GL)</th>
<th>Classes 3a, 3b, 4 and 7 in the All Other Purposes Cap valley</th>
<th>Classes 3a, 4, 7 and 8 in the Lower Murray Swamps Cap valley</th>
<th>Country Towns (Class 2)</th>
<th>Metro Adelaide (Class 6)¹</th>
<th>Unallocated (remains in-river)</th>
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<tr>
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<td>52.69</td>
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</tr>
</tbody>
</table>

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<th>683.4</th>
<th>696.0</th>
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Allocation (GL)

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<td>239.0</td>
<td>389.0</td>
<td></td>
</tr>
</tbody>
</table>

1. Metropolitan Adelaide maximum volume of 215 GL represents the maximum demand included in the BDL model – it is not a ‘100 per cent allocation’ against the volume held for Metropolitan Adelaide on a water access entitlement.

2. Increases above 1850 GL allow for the delivery of permanent trade, which in MSM is added to the Entitlement calculated under clause 88 of the Agreement.
6.6 Allocation Policies – Metropolitan Adelaide Allocation Adjustment

Issue relates to: Maintaining CHWN allocation of 150 GL to Metropolitan Adelaide when the water is not required and other allocations are restricted.

Information for Revision

An analysis of the monthly and annual Metropolitan Adelaide baseline demands was undertaken to determine whether there was a simple relationship that could be used to estimate the total end-of-year requirements and reduce the volume ‘reserved’ for Metropolitan Adelaide once it was no longer required. This reduction would only occur while irrigation allocations are less than 100 per cent and any reduced allocation would be assigned in accordance with the revised allocation table in Section 6.5.

The relationship below projects the maximum annual diversion based on the total diversion to the end of each month – from August to March. The CHWN volume is set at 150 GL at the start of the water year and then revised at the end of each month. The revised allocation is based on the minimum percentage of the annual demand pumped to the end of each month, which is dependent on a final demand of between 75 to 100 GL or greater than 100 GL. The full analysis and results are presented in Appendix E.

Projected annual maximum = minimum \([\text{Annual}_{100} (m), \text{Annual}_{75} (m), \text{MAR} (m-1), 150]\)

where:

- \(\text{Annual}_{100} (m) = \text{maximum} [\text{EndMonthDiv} (m) / \text{100min} (m), 100]\)
  where:
  - \(\text{EndMonthDiv} (m) = \text{total diversion to the end of month} \ m.\)
  - \(\text{100min} (m) = \text{minimum} \% \text{of the annual total diverted by the end of month} \ m, \text{when more than 100 GL will be diverted for the year. This determines a maximum annual total of 100 GL if the first term equates to less than 100 GL. These are shown in Table 9.}\)

- \(\text{Annual}_{75} (m) = \text{maximum} [\text{EndMonthDiv} (m) / \text{75min} (m), 75]\)
  where:
  - \(\text{75min} (m) = \text{minimum} \% \text{of the annual total diverted by the end of month} \ m, \text{when between 75 and 100 GL will be diverted for the year. This determines a maximum annual total of 75 GL if the first term equates to less than 75 GL. These are shown in Table 9.}\)

- \(\text{MAR} (m-1) = \text{reserve at the end of the previous month. The minimum percentages ensure that the reserved volume in any month is greater than the annual total. However, the variability above the minimum percentage may result in an unnecessary increase from a previous month.}\)

- \(150 = \text{limit on the reserve calculation to 150 GL.}\)

- \(m = \text{the month of the year (August to March).}\)
Table 9 Minimum Percentage of Annual Total Diverted by end of each Month

<table>
<thead>
<tr>
<th>Month (m)</th>
<th>% Diverted by End Month</th>
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<tbody>
<tr>
<td></td>
<td>75min (m)</td>
</tr>
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<td>August</td>
<td>8</td>
</tr>
<tr>
<td>September</td>
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<td>January</td>
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</tr>
<tr>
<td>February</td>
<td>58</td>
</tr>
<tr>
<td>March</td>
<td>65</td>
</tr>
</tbody>
</table>

Supporting Information

The overall objective of the 2008–09 allocation framework was to optimise the allocation and use of water that became available to South Australia in excess of CHWN (refer Section 6.3). The final CHWN volume required from the River Murray was subject to the availability of other water sources and could be reduced if other sources were available.

Runoff captured in the Mount Lofty Ranges storages is the most significant alternative source of water for Metropolitan Adelaide. In some years, it may provide 85 per cent of the annual demand and is the preferred source in all years. As May to November are the major inflow months, it is generally predictable by November as to whether above or below average volumes will need to be pumped from the River Murray.

From 2006–07 to 2008–09, the full 150 GL demand for CHWN was required for Metropolitan Adelaide due to extremely low rainfall and runoff in the Mount Lofty Ranges. However, the policy was still to consider alternative sources of water. This policy was only able to actually be applied in 2009–10, when a reduction to the volume permitted to be taken by Metropolitan Adelaide was applied.

Maintaining or increasing the CHWN allocation of 150 GL to Metropolitan Adelaide when the water is not required and while irrigation allocations are less than 100 per cent is not consistent with the 2008–09 policy. It can significantly affect irrigation allocations in years of restricted Entitlement.

Revised Assumption 12
Cap and BDL conditions (Metropolitan Adelaide allocation adjustment)

- Projected maximum annual diversion for Metropolitan Adelaide (based on the total diversion to the end of each month from August to March) is calculated.
- The CHWN allocation is reduced accordingly (if irrigation allocations less than 100 per cent) and re-assigned in accordance with revised allocation framework (Table 8).
6.7 Allocation Policies – Critical Human Water Needs Reserve

6.7.1 CHWN Reserve – Current Cap and BDL Conditions

The importance of ensuring water was available for CHWN became clear in 2006–07 when inflows to River Murray storages were lower than had ever occurred before. This unprecedented low water availability saw only 487 GL available to South Australia at the start of 2007–08 and South Australia’s CHWN was put at risk. As a result, South Australia’s policy from that point onwards was to ensure that the full volume of CHWN was available at the start of each water year.

A CHWN Reserve was implemented in MSM as follows (Takken 2009):

- Monthly targets from the South Australian 2009–10 allocation framework were used to accumulate a CHWN target of 201 GL. The targets were implemented as a fraction of the total CHWN Reserve to be held by the end of the month, as shown in Table 10.

- Entitlement was set aside if the minimum reserve (under clause 103 of the Agreement) was smaller than 201 GL, and only to increase the minimum reserve up to 201 GL.

<table>
<thead>
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<th>Monthly Fraction</th>
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<tr>
<td>May</td>
<td>1.000</td>
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</table>

- The Entitlement volume allocated to the CHWN Reserve in a given month was the minimum of:
  - the monthly CHWN Reserve target;
  - the difference between current minimum reserve and the CHWN target of 201 GL; and
  - improvements from the current month, assuming that 897 GL has already been allocated (i.e. this is the minimum allocation before Entitlement is put into the minimum reserve).

The minimum reserve calculation also includes any part of the annual Entitlement determined to be undeliverable in the current water year due to the special accounting provisions under clause 128(2) of the Agreement. This determination required assumptions for the delivery distribution of South Australia’s Entitlement during restricted periods. These assumptions were in the form of monthly flow patterns as outlined in Takken (2009) and discussed further in Section 7.2.2. With full Entitlement from the start of a water year, the pattern would follow that outlined under clause 88 of the Agreement.
6.7.2 CHWN Reserve – Revised Cap and BDL Conditions

Issue relates to: Implementation of the South Australian CHWN Reserve policy.

Information for Revision

The modelling approach in the current BDL model does not allow the policy to be implemented in all years and if applied would inappropriately affect the reliability of water rights. In particular, it does not allow CHWN to be available at the start of 2007–08, which leads to zero irrigation allocations in both 2007–08 and 2008–09 – a direct detrimental effect on reliability and a material reduction in the long-term annual average use permitted under the AOP and LMS Caps. (This modelling approach under the current BDL model is also inconsistent with the arrangements agreed under the 3 July 2008 Intergovernmental Agreement on Murray-Darling Basin Reform, which expressly contemplated South Australia building critical human water needs reserves during Tier 1 water sharing.)

There are two viable options for overcoming the impact of the current modelling approach:

1. Use the South Australian Storage Right under clause 91 and Schedule G of the Agreement as the best available surrogate for implementation of the 2008–09 CHWN policy. This will ensure the outcomes of the South Australian policy as at 30 June 2009 are realised in the model. The approach of holding back Entitlement in one year for use in a subsequent year(s) during the Millennium Drought is the same as how the Storage Right operates.

2. Turn off the CHWN Reserve provisions in the BDL model. This would allow all Entitlement in excess of CHWN to be provided for allocation to irrigation. The resulting irrigation allocations are the same as if the CHWN Reserve was in place at the start of the restricted Entitlement years.

Whilst Schedule G was not approved until 2011, the rights of South Australia to store water in the upstream storages were clearly established as of 30 June 2009, as were the requirements to provide for its own CHWN.

Despite this, the option to turn off the CHWN Reverse provisions in the revised BDL model has been adopted. This is on the basis that there is no material impact to irrigation allocations versus the Storage Right option.

Supporting Information

Drought Approach

Since 2007–08, South Australian Government policy has been to ensure that the full volume of CHWN is available at the start of each water year when Entitlement is restricted.

The actual framework for implementation of the CHWN Reserve varied from year to year. In 2008–09 and 2009–10, CHWN Reserve targets for each month were defined at the start of the water year to achieve the 201 GL target by the end of the year. These targets were based on several factors including forecast improvements in water availability and a multi-history assessment of likely increases to South Australia’s Entitlement over the coming year.

Current BDL Approach

In the current BDL model, the CHWN Reserve of 201 GL is accumulated for the following year using a series of monthly targets that were used to accumulate the reserve in 2009–10. There are several issues with this approach.

- The 2009–10 monthly targets specify that water is to be aside from October. Applying this approach over the Basin Plan modelling period means that no CHWN Reserve is available at the
start of 2007–08, as there were no improvements in Entitlement availability after September in that year.

- While the use of monthly targets is consistent with the allocation frameworks from 2007–08 to 2009–10, the actual targets used in 2009–10 were specific to that year. These were based on projected Entitlement availability, projected water availability in the Mount Lofty Ranges and volumes put aside in 2007–08 for use in 2009–10. Increases in water availability and a reduction in diversions from the River Murray meant that less than 150 GL for Metropolitan Adelaide’s CHWN would be required (only 57 GL was pumped).

- There is a similar issue if the monthly targets from 2008–09 are used. As outlined in Section 6.3, the 2008–09 allocation framework also directed all Entitlement improvements to irrigators until September.

**Storage Right Approach**

Clause 91 of the Agreement was enacted in 2008. Rules for giving effect to, and accounting for, South Australia’s storage rights under clause 91 were not approved until Schedule G was agreed and enacted in September 2011. Despite this, formal arrangements relating to the access and use of South Australia’s Storage Right were in effect from 3 July 2008.

Clause 91(1) of the Agreement, as at 30 June 2009, provided the ability for South Australia to store any part of its entitlement under clause 88 for the purposes of meeting CHWN. Clause 91(3) then stated that ‘During the period before a Schedule is made under Subdivision F of Division 1 of this Part, the Authority is to account for water stored pursuant to this clause, as far as possible, consistently with Subdivisions D and E of this Division’.

Most significantly, the 3 July 2008 Intergovernmental Agreement on Murray–Darling Basin Reform clearly states the policy position of the Basin jurisdictions that:

- South Australia will be provided with storage capacity in the headwater storages in New South Wales and Victoria (that may include Hume and Dartmouth storages) to store sufficient water to meet its critical needs (clause 7.7).

- In the period following the commencement of the new arrangements and up until the Basin Plan is made, due in 2011, the principles and arrangements established under Part 7 would be applied through the cooperative endeavours of Basin Governments through the Ministerial Council and Basin Officials Committee (clause 7.20) – including access to headwater storages as per clause 7.7.

The Storage Right under clause 91 and Schedule G of the Agreement operates to allow the delivery of Entitlement to be deferred in one year, for use in the next or future years. This is the only approach that could be used to model the strategies used by South Australia to secure CHWN reserves.

The rules for the operation of the Storage Right could be set to ensure that at least 201 GL for CHWN is available at the start of a year of restricted Entitlement. The volume held in the Storage Right would then be used to underpin CHWN until sufficient Entitlement in that year is available to be allocated via the revised BDL allocation framework in Table 8. Using this framework would ensure that the Storage Right was not used to increase the reliability of irrigation allocations relative to 30 June 2009 conditions.

**Revised Assumption 13**

*Cap and BDL conditions (CHWN Reserve) – turn off the CHWN Reserve provisions.*
6.8 Allocation Rules – Water Level Dependent Priorities

6.8.1 Allocation Rules – Current Cap and BDL Conditions – Water Level Dependent Priorities

Other allocation rules were coded into MSM by the MDBA to manage the distribution of South Australia’s available Entitlement and incorporate drought policies (Takken 2009), as follows:

1. The sharing of water between irrigation and dilution flow (unallocated Entitlement) takes into account the water levels in the Lower Lakes. This reflected consideration being given to changing allocation priorities in 2010–11, given water levels in the Lower Lakes at that time.

Once the irrigation allocation reaches 50 per cent, the relative allocation to irrigation and dilution flow is adjusted as follows:

- If lake levels are in the normal operating ranges of 0.75 to 0.35 mAHa, then the distribution under step 6 above remains 50 per cent to irrigation, 50 per cent to dilution flow.
- If lake levels are below 0.35 mAHa, then the distribution is revised to 25 per cent to irrigation, 75 per cent to dilution flow.

2. In 2009–10, a decision was made not to make additional allocations after March 2010. This was reflected in the model by including parameters that allowed allocations to not be increased after a certain month, if the water level in the Lower Lakes is below a certain threshold value.

6.8.2 Allocation Rules – Revised Cap and BDL Conditions – Water level Dependent Priorities

Issue relates to: Broad application of rules for the priority distribution of the Entitlement available to South Australia during periods of extremely low water levels in the Lower Lakes.

Information for Revision

Changes in the priority distribution of South Australian Entitlement were only considered and implemented in the third and fourth years of the Millennium drought, when water levels in the Lower Lakes were at critical levels and the region was facing irreversible ecological damage.

The changes related to:

- providing a proportion of Entitlement improvements to the Lower Lakes before allocations reached 100 per cent in the 2009–10 water year
- not increasing irrigation allocations after March 2009 during the 2008–09 water year.

These rules have been removed as they were not designed to apply in ‘normal circumstances’ or in all years, are not consistent with state policy as at 30 June 2009 and unnecessarily penalise irrigation allocations. They could, however, be applied when the water level in the Lower Lakes is below -1.0 mAHa. However, given that the Lower Lakes do not fall to this level under the historical conditions from 1895 to 2009, the inclusion of these rules, or otherwise, does not affect the results.

Supporting Information

During development of the current BDL model, South Australian officers put forward 2009–10 scenarios to test the 2009–10 approach. These scenarios were solely to test alternative rules and determine the benefits (or otherwise), not for the rules to be permanently included in the baseline model. However, the rules were ‘fixed’ in the model in December 2009, before the results could be sufficiently reviewed.

Section 6.4 described the basis for sharing resource improvements between irrigation and dilution; the approach was only considered and implemented due to the dire situation in the Lower Lakes in the fourth
year of the Millennium Drought. It was not state policy as at 30 June 2009 to apply this approach under normal conditions.

Section 6.3 outlined the decision not to increase irrigation allocations after March 2009, which was a result of the significantly reduced water levels in the Lower Lakes and the projection of further substantial falls in the following water year. It was not state policy as at 30 June 2009 to not increase irrigation allocations after March in all water years.

Revised Assumption 14
Cap and BDL conditions (allocation rules) – remove rules that share water resource availability improvements between irrigation and dilution (unallocated Entitlement) based on water levels in the Lower Lakes; and remove the restriction to increasing irrigation allocations after March.
7 CALCULATION OF ANNUAL WATER USE

The annual diversion targets calculated by the South Australian Cap models and methods represent the maximum water use permitted under the Cap in each Cap valley. The current BDL model was used to determine the 114-year time series of annual diversion targets from which the long-term average annual use was calculated. The sum of the modelled long-term annual average use from each of the four BDL components is then the BDL estimate.

The term ‘annual demand’ is often used to refer to the requirements for water, such as crop requirements or urban needs. In areas where allocations vary significantly from year to year, the ‘annual water use’ may be different from the annual demand if insufficient allocations are available.

During the setting of the LMS, AOP and Country Towns Caps it was assumed that every year a 100 per cent allocation would be received against all entitlements issued in Cap valley and all demands would be met (refer Section 4.1). For Metropolitan Adelaide, it was assumed that the required demand, within the limits of the Cap, would be available.

These assumptions reflect the historically reliable nature of South Australia’s Entitlement under the Agreement and, consequently, the types of irrigated agriculture (predominately permanent horticulture) at the time. In this context, the annual ‘water use’ is equivalent to the annual ‘demand’. That is, if a 100 per cent allocation is made in a given year, then annual use should equal the annual demand determined by the Cap models and methods. Any modelled reduction in annual use from the Cap demand is a reduction to the volume permitted to be taken under the Cap.

Given the significant allocation restriction in 2006–07, an approach was required to determine a restricted annual diversion target when full Entitlement was not available to South Australia at the start of the water year. The IAG for Cap Implementation put options to Ministerial Council but these were not agreed. Instead, it was agreed that the then MDBC would work with South Australia to develop a method (refer Appendix F). However, there has been no formal agreement for any approach for restricting annual diversion targets, including for the approach used in the current BDL model.

In the following sections, equations are used to document the assumptions and processes used to determine the annual water use for each BDL component (including restrictions to annual diversion targets). As these processes and equations are not documented elsewhere, the actual variable names used have been defined for the purpose of this report.

7.1 Annual Water Use – Summary of Issues and Revisions

Issue relates to: Calculation of annual water use in each Cap valley.

Requirements for calculating annual water use:

- Average annual water use must be within the Cap for each Cap valley.
- Annual water use should be the maximum permitted within each Cap valley so that each legislated Cap is maintained at the appropriate level.
- The reliability of entitlement holders should not be unnecessarily reduced as a result of the assumptions used to calculate water use during restricted periods.
Changes / updates required to:

- Methods for restricting annual water use when 100 per cent allocations are not available
- Include water use for unlicensed stock and domestic purposes (basic rights).²⁰

7.2 Water Use – AOP Cap Valley – Current Cap and BDL Conditions

The BDL component for the AOP Cap valley is the average annual use of allocations made against the entitlements held in this valley as at 30 June 2009, over the 114-year modelling period. The entitlements held include those permanently traded from other Cap valleys (inter-state and intra-state) but do not account for any temporary allocation trade. Use against entitlements acquired for TLM is removed.

Each year, the annual use – the Annual AOP Use – was calculated as:

\[
\text{Annual AOP Use} = \sum \text{Mthly AOP Use} (m) \quad (\text{where } m = \text{July to June})
\]

In each year, the monthly use for the AOP Cap valley was calculated as:

\[
\text{Mthly AOP Use} (m) = \text{minimum} [\text{Max Mthly AOP Use} (m), \text{Mthly AOP Cap Use} (m)]
\]

where:

- \(\text{Max Mthly AOP Use} (m) = \text{AOP allocation remaining} \times \text{Mthly irrigation factor} (m)\)
  
  where:
  
  - \(\text{AOP allocation remaining} = \text{Annual AOP allocation volume minus use for the year to date.}\)
  - \(\text{Mthly irrigation factor} (m) = \text{Monthly pattern of irrigation use, defined as the monthly fraction of the total annual allocation remaining to be used in each month (Takken 2009).}\)

The \(\text{Max Mthly AOP Use} (m)\) is an upper bound or limit on the monthly use based on the available allocation remaining to be delivered. In years where a 100 per cent allocation is not provided, this is a restricted use. This parameter and equation were the mechanism applied by the MDBA to restrict the annual diversion targets under the Cap and BDL conditions in MSM.

- \(\text{Mthly AOP Cap Use} (m) = \text{Mthly AOP Model Demand} (m) \times \text{AOP scaling factor}\)
  
  where:
  
  - \(\text{Mthly AOP Model Demand} = \text{monthly demand from the AOP Cap model (refer Appendix B).}\)
  - \(\text{AOP scaling factor} = \text{scaling factor to ensure the long-term annual use from the AOP Cap model is equal to the agreed AOP Cap; and then to take into account adjustments to the AOP Cap as a result of permanent inter-state trade, permanent intra-state trade from the LMS Cap valley and recovery for TLM under BDL conditions.}\)

The \(\text{Mthly AOP Cap Use}\) represents the unrestricted monthly use. The sum of these unrestricted monthly volumes over the year is equal to the full annual diversion target that would normally be calculated at the end of the year.

- \(m = \text{the month of the year.}\)

²⁰ Noting that a corresponding adjustment to the BDL estimate will only be made when corresponding revisions are made to the Basin Plan.
Given the above, the *Annual AOP Use* will be equal to the maximum annual diversion target under Cap in years of full allocation made at the start of the water year. However, this may be restricted during periods when full allocations are not made, or are not made at the start of the water year.

7.2.1 Restricted AOP Annual Diversion Targets

If the *Max Mthly AOP Use* is less than the *Mthly AOP Cap Use* in any month, the difference is referred to as an AOP shortfall.

If a shortfall occurs in any month, then the *Annual AOP Use* for that year will be less than the full annual diversion target under Cap for that year. These shortfalls may occur under a number of circumstances with differing materiality. A shortfall does not mean that the volume permitted to be taken will be truly restricted – it may be possible to take it later.

The magnitude and materiality of shortfalls depends on the opening and final annual allocation volumes, the timing of allocation increases and the assumed sequence of monthly irrigation delivery factors.

If the final annual allocation volume is less than the full annual diversion target:

- shortfalls will have occurred in some or all months
- the *Annual AOP Use* may equal the annual allocation volume and hence the volume permitted to be taken is not really ‘restricted’, but only if the *Max Mthly AOP Use* is less than the *Mthly AOP Cap Use* in all months. This may occur if opening allocations are low and remain low
- the *Annual AOP Use* may be less than the annual allocation volume – if the *Max Mthly AOP Use* is less than the *Mthly AOP Cap Use* in some months and greater in others. This is likely when opening allocations are low for the first few months and shortfalls occur, but then allocations increase quickly and significantly. The *Mthly AOP Cap Use* parameter may then control diversions.

The *Annual AOP Use* may be restricted to less than the full annual diversion target, despite full allocations being made available by the end of the year. This would occur if low opening allocations restrict the *Max Mthly AOP Use* below the *Mthly AOP Cap Use* for one or more months.

The monthly irrigation factors control the calculation of the *Max Mthly AOP Use* for each month and hence, how much of the available (and remaining allocation) is assumed to be delivered (and taken) in each month. The derivation of these factors is discussed below.

7.2.2 Monthly AOP Irrigation Delivery Factors

A series of factors were derived to implement a better distribution for the monthly delivery of South Australian Entitlement for irrigation during restricted years. The factors derived by Takken (2009) are included in Table 11 and were used for determining demands in both the AOP and LMS Cap valleys. The parameter *Mthly irrigation factor (m)* is represented by the data in column 3 – ‘monthly fraction of remaining allocation’.

The factors allow the delivery of irrigation allocations under increasing water availability, while ensuring that there is water available in the account throughout the year to meet likely demands, that is, the account does not run out of water (Andy Close, *pers. comm.*, 18 October 2016). With increasing water availability, these factors will also contribute to limiting the Entitlement that can be delivered during a period of special accounting as per clause 128(2) of the Agreement.

Takken (2009) states that historical data on monthly diversion patterns from 1995 to 2008 were analysed to derive the irrigation distribution factors. An average pattern over these years was then used, excluding the 2005–06 water year when there were exceptionally high diversions in January 2006.
Table 11  Monthly Irrigation Distribution Patterns (from Takken 2009)

<table>
<thead>
<tr>
<th>Month</th>
<th>Monthly Fraction of Annual Allocation</th>
<th>Monthly Fraction of Remaining Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>0.024</td>
<td>0.024</td>
</tr>
<tr>
<td>July</td>
<td>0.019</td>
<td>0.020</td>
</tr>
<tr>
<td>August</td>
<td>0.036</td>
<td>0.038</td>
</tr>
<tr>
<td>September</td>
<td>0.056</td>
<td>0.060</td>
</tr>
<tr>
<td>October</td>
<td>0.086</td>
<td>0.100</td>
</tr>
<tr>
<td>November</td>
<td>0.105</td>
<td>0.135</td>
</tr>
<tr>
<td>December</td>
<td>0.145</td>
<td>0.215</td>
</tr>
<tr>
<td>January</td>
<td>0.170</td>
<td>0.321</td>
</tr>
<tr>
<td>February</td>
<td>0.135</td>
<td>0.378</td>
</tr>
<tr>
<td>March</td>
<td>0.110</td>
<td>0.494</td>
</tr>
<tr>
<td>April</td>
<td>0.069</td>
<td>0.609</td>
</tr>
<tr>
<td>May</td>
<td>0.044</td>
<td>1.000</td>
</tr>
</tbody>
</table>

The data used to derive the factors in Table 11 was supplied from the MDBA (MDBA, pers. comm., 24 November 2016). This data was itself derived from monthly pumping data for the Central Irrigation Trust (CIT) irrigation districts, supplied through annual water use reporting under Schedule E. The monthly proportional use from the metered data was then applied across all water use data (MDBA, pers. comm., 30 November 2016; Andy Close, pers. comm., 29 November 2016).

The historical monthly use data that was used to derive the regression equations for the AOP Cap model was from selected CIT pumps only (refer Appendix B). The development of these factors has therefore also assumed that the intra-annual water use by crops supplied through CIT pumps is representative of all irrigation use across the AOP and LMS Cap valleys.

7.2.3  AOP Scaling Factors

The monthly water use generated by the approved AOP Cap model (refer Section 3.2.5; Appendix B) results in an annual average use of 367.463 GL/year over the period from 1891–92 to 2001–02. The monthly use is then scaled to ensure the appropriate long-term average use is modelled. Initially this was the AOP Cap of 449.9 GL/year, but permanent inter-state and intra-state trade (from the LMS Cap valley) and recovery for TLM subsequently needed to be taken into account.

The AOP scaling factor is used to adjust the monthly demand (Mthly AOP Model Demand) from the regression model. In developing the current BDL model, two AOP scaling factors were determined:

- **AOP scaling factor (Cap)** – the factor required to scale the monthly demands to ensure that the unrestricted annual use in the MSM Cap model over the period from 1891–92 to 2001–02 was equal to the unrestricted AOP Cap of 449.9 GL/year.
  
  o The theoretical AOP scaling factor (Cap) from the accredited AOP spreadsheet model is \( \frac{449.9}{367.463} \) – equal to 1.22434. The actual factor used was determined by trial and error to be 1.229 (Jong Lee, pers. comm., 2 June 2017).
  
  o The higher AOP scaling factor (Cap) is partly required because of data errors in the MSM climate file containing the monthly rainfall data at Berri, which is used to determine the Mthly AOP Model Demand. This is discussed further in Section 8.1, together with the required data updates.
Another contribution to the difference is the initialisation of some of the data used in the regression equations (Andy Close, pers. comm., 13 February 2018). As a result, the annual diversion target for the first year (1891–92) in MSM is different (almost 1 GL higher) to the value in the accredited spreadsheet model. This leads to all other years being scaled down to ensure the appropriate long-term average use is maintained.

A restricted AOP Cap is calculated in this MSM Cap model run by using the allocation priorities and rules under current Cap and BDL conditions (refer relevant part of Sections 0 to 6.8) and the approach for restricting annual diversion targets above.

As part of this review, the climate data errors were corrected and the Cap model re-run from 1891–92 to 2001–02. The revised AOP scaling factor (Cap) was calculated to be 1.22429.21

The restricted AOP Cap determined during development of the current BDL model was not readily available. However, using the recalculated AOP scaling factor (Cap) of 1.22429 and re-running the MSM Cap model, the restricted AOP Cap was determined to be 447.53 GL/year over 1891–92 to 2001–02, and 447.80 GL/year over 1891–92 to 2002–03.22 This provides an indicative estimate of the value determined by the MDBA at the time.

- **AOP scaling factor (BDL)** – the factor required to scale the monthly demands to ensure that the long-term annual average use in the MSM Cap model is equal to the adjusted restricted AOP Cap, when run over the period 1891–92 to 2002–03.

  - The adjusted restricted AOP Cap is equal to the restricted AOP Cap plus net permanent trade into the AOP Cap valley minus TLM recovery.

The adjustments applied in the current BDL model for permanent inter-state trade, permanent intra-state trade from the LMS Cap valley and for the recovery of entitlements for TLM were shown in Table 2. By applying these adjustments:

- the adjusted restricted AOP Cap would have been in the order of 480.22 GL/year (based on the indicative restricted AOP Cap of 447.80 GL/year above).

- the AOP scaling factor (BDL) was calculated as 1.3285 (Jong Lee, pers. comm., 2 June 2017). This factor was then used in the current BDL model run from 1895–96 to 2008–09.

In MSM, the scaling of the *Mthly AOP Model Demand* is a two-step process. The output from the regression equations is first scaled to ‘current conditions’ to account for trends in average annual use to a specified year. The AOP scaling factor is then used to scale use to the required long-term average value.

The scaling is process differs slightly between Cap and BDL model runs, as follows:

- Cap model runs – use is normally adjusted for trend to 1994. However, the regression equations in the AOP Cap model reflect use at 1994 levels of development so no actual adjustment is required.

- BDL model runs – use is adjusted for trend to 2000. As a result, the AOP scaling factor required in MSM for the current BDL only scales the year 2000 use to the required long-term average value.

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21 Refer results of Run #2061 in Section 9.2.3.

22 Refer results of Runs #2061 and #2062 in Section 9.2.3.
This means that the scaling factor used in MSM will be different to the factor required to calculate the same use directly from the regression equations.

7.3 Water Use – AOP Cap Valley – Revised Cap and BDL Conditions

**Issue relates to:** Determination of AOP annual diversion targets when allocations are restricted.

**Information for Revision**

The restriction of AOP annual diversion targets, using a ‘monthly assessment’ of allocation volumes and assumed use, unnecessarily reduces the long-term average use, and hence BDL component, relative to the existing AOP Cap.

The AOP Cap was explicitly set at an annual timescale as a long-term annual average value over the period 1891 to 2002 (refer Section 3.2.5), based on the assumption that a 100 per cent allocation would be received each year. It was not set at a specific level of water resource development.

The AOP Cap model was developed to allow for the agreed Cap to be climate adjusted, not to limit use at a monthly timescale. Therefore, the method applied to restrict an annual diversion target in a year of reduced allocation should only be applied at the end of the water year. It should not impose a monthly restriction based on assumptions about water users’ decisions, business models, risk profiles and sources of water.

If allocations are made available to water users in a given water year, it is reasonable to assume that these allocations can and will be used, subject to the upper limit imposed by the AOP Cap model.

In order to ensure that both the AOP Cap and the reliability of entitlements are not unnecessarily reduced, the Annual AOP Use should be equal to the lesser of the Annual AOP Cap Use and the AOP allocation volume. In a given year, this is as follows:

\[
\text{Annual AOP Use} = \text{minimum } [\text{Annual AOP Cap Use}, \text{AOP Allocation Vol}]
\]

where:

\[
\text{Annual AOP Cap Use} = \sum \text{Mthly AOP Cap Use (m)} \quad (\text{where } m = \text{July to June})
\]
\[
\text{AOP Allocation Vol} = \text{volume allocated against entitlements held in the AOP Cap valley}
\]

By allowing the Annual AOP Use to equal the AOP Allocation Vol when allocations are restricted, the approach allows private carryover to be managed via a system of debits and credits. That is, any underuse relative to the Annual AOP Use will register as a credit; the use of this water subsequently made available as private carryover will register as a debit. This approach is logical given that private carryover is not provided every year and that, given the large amount of permanent horticulture, a high proportion of the total volume available when allocations are 100 per cent is consistently used.

The approach above has been implemented in MSM through a ‘use catch-up’, which allows shortfalls to be taken in subsequent months, if the allocation permits. It is only required for BDL conditions, as there are no years with restricted allocations in the Cap period from 1891 to 2003.

**Supporting Information**

The current BDL model does not calculate use in the AOP Cap valley in a way that reflects the level of use that is permitted by the existing Cap on Diversions under Schedule E of the Agreement. This is principally due to the method applied to restrict annual diversion targets in years of reduced allocation.

It is reasonable to assume that if a 100 per cent allocation is made in any year, then full use under the Cap would result. That is, the annual diversion target would not be reduced. The ‘monthly assessment’ method to restrict annual diversion targets has effectively resulted in a monthly compliance regime, rather than
the annual compliance regime that is the basis of the Cap. The approach was not documented in the information and reports on the setting of the BDL, and the process to develop the method was inconsistent with the decision by Ministerial Council in May 2008.

For each month, the restricted use is the lesser of the unrestricted *Mthly AOP Cap Use* and the estimated use of the available allocation (refer Section 7.2). The estimated use of the remaining available allocation is based explicitly on the sequence of *Mthly irrigation factors* (refer Table 11).

If the estimated use of the remaining available allocation is less than the *Mthly AOP Cap Use*, the associated ‘shortfall’ volume may be lost and not able to be subsequently taken. Restrictions may occur despite full allocations being made available during the year.

The *Mthly irrigation factors* and *Mthly AOP Cap Use* are the key variables controlling the restricted use for irrigation:

- Takken (2009) states that historical data on monthly diversion patterns from 1995 to 2008 were analysed to derive the *Mthly irrigation factors*, with an averaged pattern over these years used to define the factors.
- However, monthly diversions for the majority of water users across the AOP Cap valley were only recorded from 2007–08 to 2010–11.

The irrigation factors may be acceptable to compare scenarios as part of a large-scale assessment under restricted water availability conditions. They allow the model to manage delivery of the Entitlement available to South Australia, without ‘running out of water’. However, they are not appropriate for calculating absolute values for intra-annual irrigation use, to which take is then explicitly limited. Critical issues and considerations are discussed below.

- If high allocations are not available in the early months of a year, then the approach assumes that irrigators would have made a decision on water use (e.g. not planted crops) and so increases in allocations would not necessarily be taken. To account for this assumption, the annual diversion target is not necessarily adjusted to appropriately account for the increased allocation – effectively, all or part of the increase is not allowed to be taken.

- It is argued that if the aim is for watering to match the plant use, then once a shortfall has occurred there would be limited capacity to catch up. This has a number of critical assumptions:
  - Water users make their decisions on annual water use in the first month (or first few months) of the water year.
  - The distribution of *Mthly AOP Cap Use* is representative for all crop types.
  - *Mthly AOP Cap Use* in a given year follows the pattern of *Mthly irrigation factors*.

- Water Use Decisions:
  - Water users do not make an ultimate decision about their water use until well into the water year, even those with permanent horticulture. Those growing annual crops may also not need to make a decision until a number of months into the year.
  - Decisions will be based on each individual’s business model and risk profile, availability of other sources of water (e.g. carryover) and/or resources to purchase annual allocations to maintain normal levels of water use, with an expectation that their entitlement allocation will increase. None of these factors forms part of the current BDL model.
It is not reasonable to remove the ability for irrigators to flexibly manage the water available to them and limit the volume that can be taken based on the level of allocation in the early months.

- **Crop Types and Demands:**
  - The data used to derive the Mthly AOP Cap Use was from selected CIT pumps only, which represented a limited selection of crops and permanent horticulture (refer Section 3.2.5). It was not necessarily representative of all crop types or intra-annual watering patterns.
  - Crops may have changed since the AOP Cap was set – but the AOP Cap does not require the crops that were in place under 1993–94 conditions to be maintained, just that the total long-term average water use does not increase.
  - There is potential for Mthly AOP Cap Use in a given month to be less than the restricted use using the Mthly irrigation factors. This applies additional restrictions to what the Cap intended.
  - The Mthly irrigation factors were derived using the data used for Mthly AOP Cap Use, combined with some more recent annually recorded CIT pumping data (inter-annually distributed using the original data).
  - As such, the use of these factors also assumes that the average monthly use follows the same pattern as the historical diversions. This is not necessarily the case, nor is it required to be if an assessment is carried out at an annual time scale.

- **Distribution of Mthly AOP Cap Use versus Mthly irrigation factors:**
  - The Mthly irrigation factors do not allow the intra-annual climate variability to control the intra-annual use under restricted circumstances (noting the above issues with the Mthly AOP Cap Use).
  - The factors assume that the monthly distribution of the Mthly AOP Cap Use in each year will not be significantly different from the average monthly distribution.
  - The Mthly irrigation factors may therefore unreasonably limit use in some months. There is the potential to restrict use in hotter and drier than average months but subsequently ‘tie up’ use in cooler than average months.

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**Revised Assumption 15**

Cap and BDL conditions (AOP water use) – Annual AOP Use is equal to the lesser of the maximum annual water use permitted under the AOP Cap model and the AOP allocation volume.
7.4 Water Use – LMS Cap Valley – Current Cap and BDL Conditions

The BDL component for the LMS Cap valley is the average annual use of allocations made against the entitlements held in this valley as at 30 June 2009, over the 114-year modelling period. The volume of entitlements held was adjusted for permanent trade to the AOP Cap valley, which was assumed to include all entitlements recovered for TLM.

Each year, the annual use – the Annual LMS Use – was calculated as:

\[
\text{Annual LMS Use} = \sum \text{Mthly LMS Use} (m) \quad (where \ m = \text{July to June})
\]

Consistent with the derivation of the LMS Cap (refer Section 3.2.3), it is assumed 100 per cent of the available allocation will be used, that is, the annual use is not adjusted for the prevailing climate.

In each year, the monthly use for the LMS valley was calculated as follows:

\[
\text{Mthly LMS Use} (m) = \text{minimum} \left[ \text{Max Mthly LMS Use} (m), \text{Mthly LMS Cap Use} (m) \right]
\]

where:

- Max Mthly LMS Use (m) = LMS allocation remaining * Mthly irrigation factor (m)
  where:
  - LMS allocation remaining = Annual LMS allocation volume minus use for the year to date.
  - Mthly irrigation factor (m) = Monthly pattern of irrigation use, defined as the monthly fraction of the total annual allocation remaining to be used in each month (Takken 2009). These factors are shown in Table 11 (column 3) and are the same factors used for the AOP Cap valley.

The Max Mthly LMS Use (m) is an upper bound or limit on the monthly use based on the available allocation remaining to be delivered. In years where a 100 per cent allocation is not provided, this is a restricted use. This parameter and equation were the mechanism applied by the MDBA to restrict the annual diversion targets under the Cap and BDL conditions in MSM.

- Mthly LMS Cap Use (m)
  \[
  = \text{LMS Entitlement volume} \times \text{Mthly irrigation factor A} (m) \times \text{LMS scaling factor}
  \]
  where:
  - LMS Entitlement volume = volume of entitlements held in the LMS Cap valley.
  - Mthly irrigation factor A (m) = Monthly pattern of irrigation use, defined as the monthly fraction of the total annual allocation taken in each month (Takken 2009). These factors are shown in Table 11 (column 2).
  - LMS scaling factor = 1.0

The Mthly LMS Cap Use represents the unrestricted use. As the annual use is not adjusted for the prevailing climate, this is a fixed maximum monthly use pattern.

- \( m \) = the month of the year.

Given the above, the Annual LMS Use will only be equal to the LMS Entitlement volume – the unrestricted LMS Cap – in years when full allocation is made at the start of the water year.
7.4.1 Restricted LMS Annual Diversion Targets

If the Max Mthly LMS Use is less than the Mthly LMS Cap Use in any month, the difference is referred to as an LMS shortfall.

If a shortfall occurs in any month, then the Annual LMS Use will be less than the LMS Cap for that year. As with AOP use, LMS shortfalls also occur in a number of circumstances with differing materiality, but when a shortfall does occur in this Cap valley, the volume permitted to be taken will likely be restricted.

The magnitude and materiality of shortfalls depends on the opening and final annual allocation volumes, the timing of allocation increases and the assumed sequence of monthly irrigation use factors:

- If 100 per cent allocation is not received at the start of the year, then the Annual LMS Use will be less than the full annual diversion target, irrespective of whether a 100 per cent allocation is reached.\(^{23}\)
- If allocations increase quickly to a level less than 100 per cent (and do not increase to 100 per cent), then it is possible that the Annual LMS Use will equal the volume allocated.
- If allocations increase slowly over the year, then the Annual LMS Use will likely be restricted.

7.4.2 Monthly LMS Irrigation Delivery Factors

The monthly irrigation factors control the calculation of both the Max Mthly LMS Use and the Mthly LMS Cap Use for each month. Hence, they also control the pattern of the monthly use under Cap and how much of the available (and remaining allocation) is assumed to be used in each month. The derivation of these factors was discussed in Section 7.2.2, noting that no data on intra-annual water use from the LMS was likely to have been included.

7.4.3 LMS Scaling Factors

The LMS scaling factor is used to adjust the monthly use (Mthly LMS Cap Use) to ensure the appropriate long-term annual average use is reproduced. Two LMS scaling factors were determined.

- LMS scaling factor (Cap) – the factor required to ensure that the unrestricted use in the MSM Cap model over the period from 1891–92 to 2001–02 was equal to the unrestricted LMS Cap of 94.2 GL/year.
  - The LMS scaling factor (Cap) is equal to 1.0 because the entitlement volume controls the maximum Annual LMS Use.
  - This MSM Cap model run also determined a restricted LMS Cap as it applied the allocation priorities and rules presented in Section 6.2, together with the approach outlined above for restricting annual diversion target restrictions.
  - The restricted LMS Cap determined during development of the current BDL model was not readily available. However, by re-running the MSM Cap model, the restricted LMS Cap was determined to be 93.30 GL/year over 1891–92 to 2001–02, and 93.31 GL/year over 1891–92 to 2002–03.\(^{24}\) This provides an indicative estimate of the value determined by the MDBA at the time.

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\(^{23}\) This differs from the AOP Cap valley because the AOP Cap is less than the entitlements issued.

\(^{24}\) Refer results of Runs #2061 and #2062 in Section 9.2.3.
• **LMS scaling factor (BDL)** – the factor required to scale the monthly use to ensure that the long-term annual average use in the MSM Cap model is equal to the *adjusted restricted LMS Cap*.
  
  o The *LMS Entitlement volume* was adjusted for permanent trade into the AOP Cap valley. TLM recovery was assumed to be part of the volume of permanent trade to the AOP Cap valley (refer Table 2).
  
  o The *adjusted restricted LMS Cap* was then equal to the *restricted LMS Cap* over the period from 1891–92 to 2002–03, adjusted only for any restrictions in the Cap model run.
  
  o Despite the small restriction under the Cap run, a *LMS scaling factor* of 1.0 was applied.
  
  o The published breakdown of the current BDL does not separate the AOP and LMS components (MDBA 2011) (refer Section 9.4) to see how the restriction to the LMS Cap translated into the current BDL.
  
  o However, it is understood that the *AOP scaling factor (BDL)* was actually determined to ensure that the sum of the *adjusted restricted AOP Cap* and the *adjusted restricted LMS Cap* was equal to the appropriate value. Therefore, the LMS Cap restriction was effectively applied in the AOP Cap valley.

### 7.5 Water Use – LMS Cap Valley – Revised Cap and BDL Conditions

**Issue relates to:** Determination of the LMS annual diversion targets when allocations are restricted.

**Information for Revision:**

The restriction of LMS annual diversion targets, using a ‘monthly assessment’ of allocation volumes and assumed use, unnecessarily reduces the long-term average use, and hence BDL component, relative to the existing LMS Cap.

The LMS Cap is a purely annual Cap with no regression model (or otherwise) to generate monthly demands (refer Section 3.2.3). It was set as a non-climate adjusted annual value equal to the volume of entitlements issued. This was due to an absence of metered water use data and because the entitlements issued were based on an estimate of historical use.

The method applied to restrict an annual diversion target in a year of reduced allocations should only be applied at the end of the water year. It should not impose a monthly restriction based on assumptions about water users’ decisions, business models, risk profiles and sources of water.

If allocations are made available to water users in a given water year, it is reasonable to assume that these allocations can and will be used.

In order to ensure that both the LMS Cap and the reliability of entitlements are not unnecessarily reduced, the *Annual LMS Use* should be equal to the lesser of the *LMS Cap Use* and the LMS allocation volume. This has been implemented in MSM through a ‘use catch-up’, which allows shortfalls to be taken in subsequent months, if the allocation permits.

**Supporting Information**

The current BDL model does not calculate use in the LMS Cap valley in a way that reflects the level of use that is permitted by the existing Cap on Diversions under Schedule E of the Agreement. This is principally due to the method applied to restrict annual diversion targets in years of reduced allocations.

It is reasonable to assume that if a 100 per cent allocation is made in any year, then full use under the Cap would result. That is, the annual diversion target would not be reduced. The ‘monthly assessment’ method to restrict annual diversion targets has effectively resulted in a monthly compliance regime, rather than
the annual compliance regime that is the basis of the Cap. The approach was not documented in the information and reports on the setting of the BDL, and the process to develop the method was inconsistent with the decision by Ministerial Council in May 2008.

For each month, the restricted use is the lesser of the unrestricted *Mthly LMS Cap Use* and the estimated use of the available allocation (refer Section 7.3). The estimated use of the remaining available allocation is based explicitly on the *Mthly irrigation factors* – the same sequence of average monthly irrigation delivery factors (refer Table 11) used for restricting AOP Cap valley use.

All issues with the use of the *Mthly irrigation factors* described under Section 7.3 apply to their use in restricting the annual diversion target in the LMS Cap valley. However, there are also other issues associated with using the factors and the method that has been applied in the current BDL model.

By generating the *Mthly LMS Cap Use* sequence by multiplying the entitlements held in the Cap Valley by the *Mthly irrigation factors*, it has been assumed that the monthly water use in the LMS Cap valley is the same every year and follows a pattern of average monthly water use in the AOP Cap valley. However, it is unreasonable to assume that the average pattern of water use for the predominately permanent horticulture in the upper River Murray in South Australia would apply exactly to different land uses, such as dairy farming in the Lower River Murray.

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### Revised Assumption 16

**Cap and BDL conditions (LMS water use)** – *Annual LMS Use* is equal to the lesser of the maximum annual water use permitted under the LMS Cap (*Annual LMS Cap Use*) and the LMS allocation volume.

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### 7.6 Water Use – Country Towns Cap Valley – Current Cap and BDL Conditions

The BDL component for the Country Towns Cap valley is the average annual use of allocations made against the single entitlement held in this valley over the 114-year modelling period. There has been no permanent trade in or out of this Cap valley, nor any recovery for TLM.

Each year, the annual use – the *Annual CT Use* – was calculated as:

\[
Annual CT Use = \sum Mthly CT Use (m) \quad \text{(where m = July to June)}
\]

In each year, the monthly use for the CT valley was calculated as follows:

\[
Mthly CT Use (m) = \text{minimum} \left[ \text{Max Mthly CT Use} (m), \text{Mthly CT Cap Use} (m) \right]
\]

where:

- **Max Mthly CT Use (m) = CT allocation remaining * Mthly CT factor (m)**

where:

- **CT allocation remaining** = Annual CT allocation volume minus use for the year to date.
- **Mthly CT factor (m)** = Monthly pattern of use of CT allocations, defined as the monthly fraction of the total annual allocation remaining to be used in each month (Takken 2009).

The *Max Mthly CT Use (m)* is an upper bound or limit on the monthly use based on the available allocation remaining to be delivered. In years where a 100 per cent allocation is not provided, this is a restricted use. This parameter and question were the mechanism applied by the MDBA to restrict the annual diversion targets under the Cap and BDL conditions in MSM.
7.6.1 Restricted Country Towns Annual Diversion Targets

If the Max Mthly CT Use is less than the Mthly CT Cap Use in any month, the difference is referred to as a CT shortfall.

If a shortfall occurs in any month, then the Annual CT Use will be less than the full annual diversion target for that year. As with AOP and LMS use, CT shortfalls may not necessarily result in the volume taken to be less than the allocation.

Whether a shortfall occurs depends primarily on the timing of allocation increases. In years where the CT allocation is only initially restricted, shortfalls would be less likely. This is because the minimum allocation in the current BDL model is the CHWN volume of 31 GL.

The monthly CT delivery factors control the calculation of the Max Mthly CT Use for each month and, hence, how much of the available (and remaining) allocation is assumed to be delivered (and used) in each month.

7.6.2 Monthly CT Delivery Factors

A series of factors were developed to implement a better distribution for the monthly delivery of South Australian Entitlement for Country Towns during restricted years. The factors derived by Takken (2009) are included in Table 12 and were used for determining use in CT Cap valley. The parameter Mthly CT factor (m) is represented by the data in column 3 – ‘monthly fraction of remaining allocation’.

Takken (2009) states that historical data on monthly diversion patterns from 1995 to 2008 were analysed to derive the CT distribution factors. An average pattern over these years was then used, excluding the 2005–06 water year when there were exceptionally high diversions in January 2006.

---

25 A current conditions model run describes a model scenario where all parameters are set to reflect the rules in place at the time the model run is undertaken.
Table 12 Monthly Country Towns Distribution Patterns (from Takken 2009)

<table>
<thead>
<tr>
<th>Month</th>
<th>Monthly Fraction of Annual Allocation</th>
<th>Monthly Fraction of Remaining Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>0.056</td>
<td>0.056</td>
</tr>
<tr>
<td>July</td>
<td>0.056</td>
<td>0.060</td>
</tr>
<tr>
<td>August</td>
<td>0.058</td>
<td>0.066</td>
</tr>
<tr>
<td>September</td>
<td>0.066</td>
<td>0.080</td>
</tr>
<tr>
<td>October</td>
<td>0.083</td>
<td>0.109</td>
</tr>
<tr>
<td>November</td>
<td>0.091</td>
<td>0.133</td>
</tr>
<tr>
<td>December</td>
<td>0.109</td>
<td>0.186</td>
</tr>
<tr>
<td>January</td>
<td>0.120</td>
<td>0.250</td>
</tr>
<tr>
<td>February</td>
<td>0.105</td>
<td>0.292</td>
</tr>
<tr>
<td>March</td>
<td>0.103</td>
<td>0.403</td>
</tr>
<tr>
<td>April</td>
<td>0.083</td>
<td>0.544</td>
</tr>
<tr>
<td>May</td>
<td>0.069</td>
<td>1.000</td>
</tr>
</tbody>
</table>

7.6.3 CT Scaling Factors

The climate-dependent regression model used by the MDBA to represent annual diversion targets under the CT Cap was scaled using a **CT Scaling Factor** of 1.32652. This produced a **restricted CT Cap** of 49.03 GL/year.

The regression model factor was derived by the MDBA when a benchmark model for assessing TLM water recovery was being developed (Andy Close, *pers. comm.*, 22 May 2017), to provide an alternative representation of CT use under Cap conditions.

The scaling factor itself was derived by trial and error. The factor was increased until further changes did not have a significant impact on the long-term average use. It was subsequently used for Basin Plan modelling.

7.7 Water Use – Country Towns Cap Valley – Revised Cap and BDL Conditions

**Issue relates to:** The CT annual diversion target is not equal to the CT allocation.

**Information for Revision**

The CT Cap is an annual Cap that is equal to the single entitlement held in the CT Cap valley. There is no agreed or accredited regression model (or otherwise) to generate monthly demands (refer Section 3.2.4).

The parameters for a demand model to ensure the **Annual CT Use** always equals the allocation for the year were developed for use in a revised BDL model as follows:

- **Constant Mthly CT Cap Demands** based on the **Mthly CT factors** were developed, which equalled the CT Cap of 50 GL over the year.
- These constant **Mthly CT Cap Demands** were used for each month except June, when a 50 GL demand was specified to use any remaining allocation.
- To ensure a more even recovery in use after a year in which low allocations were announced early in the season, these demands were all subsequently scaled up by a factor of 1.2. This process ensures that diversions always equal the annual allocation.
Supporting Information

The current BDL model does not calculate use in the CT Cap valley in a way that reflects the level of use that is permitted by the existing Cap on Diversions under Schedule E of the Agreement. This is due to the use of a climate-adjusted model for determining annual diversion targets, and to the method applied to restrict those targets in years of reduced allocations.

Under the CT Cap, it is expected that the volume permitted to be taken will be equal to the allocation. Using a climate-adjusted model with a scaling factor to represent the Mthly CT Cap Use had led to:

- **Annual CT Use** being less than the allocation in a number of years because:
  - the demand was less than 50 GL in some wetter years
  - occasionally it was not possible for the CT use to catch up if the allocation increased after low allocations early in the season.

- **Annual CT Use** being greater than the water allocated in some years and being truncated to the allocated volume.

So, while CT Scaling Factor was increased until the long-term average annual use did not change significantly, the actual use in some years was reduced.

The Mthly CT factors (refer Table 12) are also used to restrict the Max Mthly CT Use if allocations are restricted. These factors have a similar effect to the Mthly irrigation factors if either (a) allocations are lower at the start of the season, or (b) the Mthly CT Cap Use does not follow the ‘average’ pattern of the factors.

As the highest demands in the CT Cap valley occur over summer, and the nature of the demand is not related to annual crop or water use decisions, it is not reasonable to restrict the demand based on allocations early in the year.

Revised Assumption 17

Cap and BDL conditions (CT water use) – Annual CT Use is equal to the CT allocation volume.

7.8 Water Use – Metropolitan Adelaide Cap Valley – Current Cap and BDL Conditions

The BDL component for the Metropolitan Adelaide Cap valley is the average annual use of allocations made against the single entitlement held in this valley over the 114-year modelling period. The entitlement currently held has a nominal value of 130 GL. As use against the entitlement is governed by Schedule E of the Agreement (refer Section 3.2.2), the allocation may be increased above 130 GL if required. As trade from this Cap valley is not permitted, any allocation not required remains in-river.

When setting the current BDL, the MDBA determined that the form of the Metropolitan Adelaide Cap was not appropriate for defining a BDL. Instead, an estimate of the diversions under Cap conditions and historical diversion information was used (MDBA 2011). The approach is described below.

Each year, the annual use – the Annual MA Use – was calculated as:

\[
\text{Annual MA Use} = \sum \text{Mthly MA Use (m)} \quad \text{(where m = July to June)}
\]

In each year, the monthly use for Metropolitan Adelaide were calculated as follows:

\[
\text{Mthly MA Use (m) = minimum [Max Mthly AOP Use (m), Mthly MA Cap Demand (m)]}
\]
where:

- **Max Mthly MA Use (m)** = MA allocation remaining * Mthly MA factor (m)

where:

- **MA allocation remaining** = Annual Metropolitan Adelaide allocation volume minus use for the year to date.
- **Mthly MA factor (m)** = Monthly pattern of use of Metropolitan Adelaide allocations, which is defined as the monthly fraction of the total annual allocation remaining to be used in each month (Takken 2009).

The **Max Mthly MA Use (m)** is an upper bound or limit on the monthly use that will occur based on the available allocation remaining to be delivered. In years where a 100 per cent allocation is not provided, this is a restricted use. This parameter and equation are the mechanism applied by the MDBA to restrict the annual diversion targets under Cap and BDL conditions in MSM.

- **Mthly AOP Cap Demand (m)** = monthly Metropolitan Adelaide demands assumed by the MDBA to represent use under Cap and baseline conditions. These were based on the work of MDBC (2002b), where a monthly sequence of River Murray extraction estimates for Metropolitan Adelaide over the period 1891 to 2001 and under 2001 levels of development were derived. When the BDL was calculated, the dataset was extended to 2009 with observed diversion data. Further details can be found in Appendix E.

- **m** = the month of the year.

### 7.8.1 Restricted Metropolitan Adelaide Annual Diversion Targets

If the **Max Mthly MA Use** is less than the **Mthly MA Cap Demand** in any month, the difference is referred to as an **MA shortfall**. If a shortfall occurs in any month, then the **Annual MA Use** for that year will be less than the full annual use for that year.

In reality, restrictions to River Murray diversions for Metropolitan Adelaide do not occur very often, as the majority of the annual demand is available at the start of the year through the CHWN provisions. As a result, the magnitude of these shortfalls is primarily dependent on the assumed sequence of monthly Metropolitan Adelaide delivery factors.

### 7.8.2 Monthly Metropolitan Adelaide Delivery Factors

A series of factors were developed to implement a better distribution for the monthly delivery of South Australian Entitlement for Metropolitan Adelaide during restricted years. The factors derived by Takken (2009) are included in Table 13 and were used for determining use in Metropolitan Adelaide Cap valley. The parameter **Mthly MA factor (m)** is represented by the data in column 3 – ‘monthly fraction of remaining allocation’.

Takken (2009) states that an analysis of historical extraction data showed that the pattern varied significantly from year to year. As such, the pattern used was the average of the 10 driest years. Given the high variability in intra-annual pumping, the use of an average delivery distribution for Metropolitan Adelaide causes restrictions to the volume pumped in a number of years. The higher the variation in the intra-annual distribution of **Mthly MA factor** and **Mthly MA Cap Demand** in a given year, the more likely that diversions will be restricted. It is also more likely to occur in years with high demands (greater than 150 GL/year), or when the annual demand is close to the allocation volume.
Table 13 Monthly Metropolitan Adelaide Distribution Patterns (from Takken 2009)

<table>
<thead>
<tr>
<th>Month</th>
<th>Monthly Fraction of Annual Allocation</th>
<th>Monthly Fraction of Remaining Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>0.049</td>
<td>0.049</td>
</tr>
<tr>
<td>July</td>
<td>0.054</td>
<td>0.057</td>
</tr>
<tr>
<td>August</td>
<td>0.074</td>
<td>0.082</td>
</tr>
<tr>
<td>September</td>
<td>0.096</td>
<td>0.116</td>
</tr>
<tr>
<td>October</td>
<td>0.108</td>
<td>0.149</td>
</tr>
<tr>
<td>November</td>
<td>0.103</td>
<td>0.166</td>
</tr>
<tr>
<td>December</td>
<td>0.111</td>
<td>0.216</td>
</tr>
<tr>
<td>January</td>
<td>0.106</td>
<td>0.261</td>
</tr>
<tr>
<td>February</td>
<td>0.091</td>
<td>0.305</td>
</tr>
<tr>
<td>March</td>
<td>0.084</td>
<td>0.405</td>
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<tr>
<td>April</td>
<td>0.065</td>
<td>0.524</td>
</tr>
<tr>
<td>May</td>
<td>0.059</td>
<td>1.000</td>
</tr>
</tbody>
</table>

7.9 Water Use – Metropolitan Adelaide Cap Valley – Revised Cap and BDL Conditions

Issue relates to: Determination of Metropolitan Adelaide annual diversion targets.

Information for Revision

The sequence of unrestricted **Mthly MA Cap Demands** represents the monthly diversions required from the River Murray to meet Metropolitan Adelaide demands, given the prevailing reservoir catchment inflows and infrastructure operating rules and restrictions (refer Appendix E). In years when the Metropolitan Adelaide allocation is restricted to the CHWN volume of 150 GL at the start of the year, the **Mthly MA Cap Demands** already incorporate the restricted allocation and no further restrictions are required.

The limitation in modelling the CHWN Reserve (refer Section 6.7.2) in the current BDL model restricts the allocation to Metropolitan Adelaide below 150 GL at the start of 2007–08 and 2008–09. This issue is corrected by turning off the CHWN Reserve provisions as outlined in Section 6.7.2. Combined with an increase in maximum allocation to 215 GL, it is not necessary to apply further restrictions.

Removing the additional restrictions applied in the current BDL model has been implemented via a ‘use catch-up’ function, similar to the AOP, LMS and CT Cap valleys. This approach reduced the required code updates in MSM.

Despite the catch-up function, the sequence of monthly Metropolitan Adelaide in Table 13 was found to be unnecessarily restricting diversions during certain months, particularly early in the water year. Updating the factors to the pattern shown in Table 14 overcame this issue and reduced the occurrences of having to catch-up pumping.
Table 14 Revised Monthly Metropolitan Adelaide Distribution Pattern

<table>
<thead>
<tr>
<th>Month</th>
<th>Monthly Fraction of Remaining Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>0.270</td>
</tr>
<tr>
<td>August</td>
<td>0.340</td>
</tr>
<tr>
<td>September</td>
<td>0.310</td>
</tr>
<tr>
<td>October</td>
<td>0.220</td>
</tr>
<tr>
<td>November</td>
<td>0.281</td>
</tr>
<tr>
<td>December</td>
<td>0.356</td>
</tr>
<tr>
<td>January</td>
<td>0.390</td>
</tr>
<tr>
<td>February</td>
<td>0.570</td>
</tr>
<tr>
<td>March</td>
<td>0.838</td>
</tr>
<tr>
<td>April</td>
<td>0.700</td>
</tr>
<tr>
<td>May</td>
<td>0.700</td>
</tr>
<tr>
<td>June</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Supporting Information

The current BDL model restricts diversions in the Metropolitan Adelaide Cap valley by limiting the maximum permissible allocation to 180 GL (refer Table 7) and then applying additional restrictions to the annual diversion target.

An increase to the maximum allocation to 215 GL was outlined in Section 5.6. This section deals with the additional restrictions applied to the annual diversion target.

Restrictions to the annual diversion targets in the Metropolitan Adelaide Cap valley have been implemented in the current BDL model by calculating restricted monthly demands. For each month, the restricted use is the lesser of the Mthly MA Cap Demand and the estimated use of the available allocation (refer Section 7.8). The latter is based explicitly on the Mthly MA factors (refer Table 13). This has a number of effects:

- In some months, the Mthly MA factors restrict the annual diversion target where no restriction was necessary, that is, the allocation volume was sufficient to meet the full annual demand. This occurs when the highly variable intra-annual demand pattern for Metropolitan Adelaide diversions doesn’t follow the averaged pattern of the driest 10 recorded years.

- The higher the variation in the intra-annual distribution between the Mthly MA factors and Mthly MA Cap Demand in a given year, the more likely that diversions will be restricted. It is also more likely to occur in years with high demands (greater than 150 GL/year), or when the annual demand is close to the allocation volume.

The Entitlement available to South Australia, and hence the allocation available to Metropolitan Adelaide, is sufficient to cover the full annual demand in each year from 1895–96 to 2008–09. If there was a future scenario where the full volume of CHWN was not available at the start of a year, there would still be no need to place additional diversion restrictions based on an average demand profile.

This is because the 150 GL allocation for CHWN for Metropolitan Adelaide is much greater than the long-term average use of 100 GL and provides sufficient water to meet the annual demand in 85 per cent of all years.

There is also limited risk in supplying the full Mthly MA Cap Demand from the start of the year. There is considerable capacity in the Mount Lofty Ranges storages to meet demand and the consequences of only
being able to divert small volumes of water late in the season would be small enough to reduce the need to ration pumping.

A ‘use catch-up’ similar to the AOP, LMS and CT Cap valleys is implemented in the revised BDL model to reduce the additional code changes and updates required in MSM. An alternative approach for modelling Metropolitan Adelaide demands would be to use the Mthly MA Cap Demand sequence as a series of monthly orders (similar to the approach used in the Millennium Drought).

Revised Assumption 18
Cap and BDL conditions (Metropolitan Adelaide water use):
- Annual MA Use is equal to the Annual MA Cap Demand, if the allocation permits.
- Revised monthly distribution pattern.

7.10 Water Use – Basic Rights – Current Cap and BDL Conditions

In the current BDL model, the use of water for unlicensed stock and domestic purposes under basic rights is taken into account when setting the allocation priorities (refer Section 5.5), but the use itself is not included in the current BDL estimate.

7.11 Water Use – Basic Rights – Revised Cap and BDL Conditions

Issue relates to: Unlicensed stock and domestic use (basic rights) in the BDL estimate.

Information for Revision:

The use of water for basic rights (unlicensed stock and domestic use) is added to the allocation for the AOP Cap valley in the current BDL model, but the use itself is not added to the current BDL estimate.

The 6.1 GL annual use for basic rights is required to be separated from the AOP allocation and should be explicitly calculated in the revised BDL model. The 6.1 GL forms part of the CHWN requirements from the River Murray and will be used each year.

Supporting Information

The AOP Cap does not include unlicensed stock and domestic diversions (basic rights) that occur as a result of the statutory rights under section 124(4) of the NRM Act. Section 3.3 identified this omission from the current BDL description and Section 5.5 outlined the annual use of 6.1 GL, which forms part of South Australia’s CHWN requirement of 204 GL.

Revised Assumption 19
Cap and BDL conditions (basic rights) – separate 6.1 GL use for basic rights from AOP allocation and calculate explicitly as a fixed annual use.
8 BDL MODEL – OTHER UPDATES

8.1 Climate Data

Issue relates to: Data issue with monthly rainfall data at Berri in the MSM climate file.

Information for Revision

An update to the MDBA database and MSM climate file fixed a data error affecting the AOP scaling factor.

Berri monthly rainfall data changes, as per Bureau of Meteorology, are:

- December 1995: reduce 35.3 mm to 3.2 mm
- January 1968: increase 0 mm to 25.7 mm
- September 1995: reduce 21 mm to 19.2 mm.

The updated data input file should be used when re-modelling the current BDL conditions, as well as to develop the revised BDL model, because it relates to fixing an error in MSM rather than to the revision of BDL assumptions.

Supporting Information

A data issue with the monthly rainfall data at Berri in the MSM climate file was outlined in Section 7.2. The data is used to determine the Mthly AOP Model Demand and hence affects the AOP scaling factor (Cap). In detail:

- The rainfall data value for December 1995 was entered as 32.5 mm, compared to the value in the accredited AOP spreadsheet model of 2.8 mm. A check was made with the Bureau of Meteorology (BOM) dataset, which showed a value of 3.2 mm.

- The December climate is critical for the magnitude of the annual diversion target generated by the AOP Cap model each year. A high rainfall total in December, particularly one that is significantly above average, appreciably reduces the final target. This occurred for 1995–96.

- For the AOP scaling factor (Cap) to scale the unrestricted use to 449.9 G/year, a higher factor was needed to increase the annual diversion targets in other years to compensate.

- A full comparison of the monthly rainfall data for Berri in the MSM climate file and the BOM dataset was undertaken. Two other months were found to be materially different – January 1968 (0 mm instead of 25.7 mm) and September 1995 (21 mm instead of 19.2 mm) – although these did not have the same effect on the Mthly AOP Model Demands and the AOP scaling factor (Cap).

- It was also found that there had been a number of updates to the BOM data since the AOP accredited spreadsheet model had been developed. The majority of these data updates were included in the MSM climate file. The accredited spreadsheet model was also updated.

Revised Assumption 20

Cap and BDL conditions (data correction) – updated Berri monthly rainfall data in MDBA database, as outlined above.
# REVISED BDL MODEL AND ESTIMATE

## 9.1 Overview

The process to prepare the current BDL model was outlined in Section 4.2, which involved a number of MSM runs under both Cap and BDL conditions. As outlined in Section 4.1, the pre-existing Cap conditions in the MSM Cap model were also updated with the BDL assumptions for allocation priorities, policies and rules, patterns of use and restrictions to annual diversion targets when allocations are not available in full.

To prepare a revised BDL model therefore required a revised Cap model to be produced, and a sequence of Cap and BDL model runs to be undertaken, as follows:

1. Update the current MSM Cap model with ‘revised Cap conditions’ as outlined in Sections 4 to 0 to produce a revised MSM Cap model. Run model from 1891–92 to 2001–02 with appropriately scaled monthly Cap demands to confirm the *unrestricted use*, and hence the long-term *unrestricted Cap*, for each Cap valley under Schedule E.\(^26\)

2. Extend the revised MSM Cap model to 1891–92 to 2002–03 and determine the average annual *restricted use*, and hence the *restricted Cap*, for each Cap valley over this period (as a result of restricted South Australian Entitlement in some years).

3. Adjust the *restricted AOP Cap* and *restricted LMS Cap* for the revised net volume of permanent inter-state trade, permanent intra-state trade and for the recovery of entitlements under TLM. This produces the *adjusted restricted Cap* for each Cap valley.

4. Update the revised MSM Cap model with ‘revised BDL conditions’ as outlined in Sections 4 to 0 to produce a revised MSM BDL model. Run the model from 1891–92 to 2002–03, scaling the monthly demands until the annual average use is equal to the *adjusted restricted Cap* in each Cap valley.

5. Incorporate the revised BDL assumptions and parameters into the SMM model and run from 1895–96 to 2008–09 to determine the revised BDL. The model used for this run is then the revised BDL model.

The following sections outline how the revised BDL assumptions were incorporated into the MSM and SMM to produce the revised BDL model and estimate.

## 9.2 Updates to MSM FORTRAN Code, Parameter Files and Input Data

### 9.2.1 Basis for the Revised BDL Model – MSM Version #873

The starting point for the revised BDL model was the ‘trunk’ version #873 of MSM, as stored by the MDBA in its TortoiseSVN version control system. This was created on 27 September 2016.

The ‘trunk’ version is the mainstream version of MSM that is maintained by the MDBA. Version #873 builds on version #764, which is the version accredited as the current Cap model (MDBA 2013). The ‘trunk’ model differs from the numerous ‘branch’ versions of MSM, which have split from the ‘trunk’ model during the development of the Basin Plan. The ‘branch’ versions of the model were used for Basin Plan modelling and were developed further for SDL adjustment mechanism determination.

Compared with the ‘branch’ version of MSM used for the development of the Basin Plan, the ‘trunk’ version has been subject to recalibration and includes the fixing of a number of ‘bugs’ uncovered as part of the process of transitioning from MSM to SOURCE IMS. The differences between the MSM version used

---

\(^{26}\) 50 GL/year for the CT Cap valley, 94.2 GL/year for the LMS Cap valley and 449.9 GL/year for the AOP Cap valley.
to create the current BDL model and MSM version #873 include the following (Andy Close, pers. comm., May 2017):

- Changes to the basis of the South Australian allocation of the nominal dilution component of the 696 GL Dilution and Loss Entitlement, from allocating for the rest of the year to allocating for the whole year. This was updated by the MDBA post calculation of the current BDL as it was determined to better reflect how allocations for this purpose were made in years when water availability increased later in the year.
- Corrections to TLM accounting for Koondrook and the Mid Murray storage.
- Corrections to TLM accounting in Hattah Lakes.
- Corrections to bugs in water allocation algorithms, which were detected when implementing Source Murray Model (SMM).
- Additional code to implement changes to the Snowy Water Licence.

MSM version #873 as the latest, most correct version of the model was used because a number of coding ‘bugs’ in the version of MSM used for the current BDL model have been resolved. Updating the current BDL model for these errors is consistent with the MDBA’s position statement (MDBA 2015a), which supports updating BDLs where there is evidence of an improvement to the current methods.

9.2.2 Incorporation of Revised Cap and BDL Conditions in MSM

South Australia’s proposed revisions to the current Cap and BDL assumptions were detailed in Sections 4 to 0. These were incorporated into MSM via a combination of algorithm updates in the FORTRAN code of MSM version #873, and changes to MSM parameter and climate data input files. The code changes were merged into the MSM trunk through the TortoiseSVN version control system in various stages, including Version #896 (22 December 2016) and Version 924 (12 May 2017).

Each revision, and the process (MSM FORTRAN code, MSM parameter file or MSM input data file) by which the revision has been made, is summarised below. All changes were made to both the current Cap and BDL models, unless indicated otherwise.

1. Water access rights (Revised Assumptions 1 to 5)
   – changes to MSM parameter file.

   The volume of water access rights applicable under Cap conditions has been updated for the AOP Cap valley (Table 3), stock, domestic and industrial purposes (Table 4) and Metropolitan Adelaide (Section 5.6).

   The volume of water access rights applicable under BDL conditions has been updated for the AOP and LMS Cap valleys (Table 5), stock, domestic and industrial purposes (Table 4) and Metropolitan Adelaide (Section 5.6).

2. Cap Adjustment (Revised Assumption 6)
   – change to MSM parameter file.

   The updated AOP Cap adjustment volume was used to determine the AOP scaling factor (BDL), which was then included in the MSM parameter file.
3. Allocation priorities (Revised Assumptions 7 to 11)
   – changes to MSM parameter file.
   The MSM allocation table for the priority distribution of South Australian Entitlement was updated in line with Table 8.

4. Metropolitan Adelaide allocation adjustment (Revised Assumption 12)
   – change to MSM parameter file and MSM FORTRAN code.
   Method outlined in Section 6.6 and Appendix E was incorporated to project the maximum annual diversion for Metropolitan Adelaide based on the total diversion to the end of each month (August to March).
   Allocation to Metropolitan Adelaide reduced accordingly (when applicable) and any reduction assigned in accordance with the revised allocation framework in Table 8.

5. CHWN reserve (Revised Assumption 13)
   – change to MSM parameter file.
   CHWN Reserve parameters turned off.

6. Allocation rules related to water levels (Revised Assumption 14)
   – change to MSM parameter file.
   Turned off the rule that shares water resource availability improvements between irrigation and unallocated Entitlement based on water levels in the Lower Lakes.
   Turned off the rule that restricted further increases to irrigation allocations after March.

7. Calculation of water use (Revised Assumptions 15 to 18)
   – changes to MSM parameter file and MSM FORTRAN code.
   Methods for calculating annual water use for the AOP (Section 7.3), LMS (Section 7.5), Country Towns (Section 7.7) and Metropolitan Adelaide (Section 7.9) Cap valleys were revised:
   - For the CT Cap valley, the method for determining the unrestricted annual demands was revised to ensure that the volume allocated is able to be taken in any year by replacing the climate adjusted model with constant monthly demands that equalled the CT Cap of 50 GL over the year.
   - Option for ‘use catch-ups’ was included for all Cap valleys to allow shortfalls to be taken in subsequent months, if the allocation permits. The annual use is then equal to the lesser of the unrestricted annual diversion target and the allocated volume.
   - For the Metropolitan Adelaide Cap valley, the monthly distribution pattern was revised.

8. Calculation of demands under basic rights (Revised Assumption 19)
   – changes to MSM FORTRAN code.
   The annual use for basic rights (unlicensed stock and domestic purposes) was separated from the AOP Cap allocation and explicitly calculated as a fixed annual use.
9. Climate data correction (Revised Assumption 20)
   – change to MSM data input file.

   Corrections to Berri rainfall data in the MSM climate data file (1412-msm-monthly.csv).

9.2.3 Incorporation of Revised BDL Conditions in the SMM

The revised assumptions listed in Section 9.2.2 for BDL conditions were also incorporated by the MDBA into a Source BDL model. In most cases, the code or parameter settings were simply directly converted from one model to the other.

One exception is the AOP scaling factor (BDL). As the SMM does not scale the regression demands twice (refer Section 7.2.3), an equivalent factor was determined using the accredited AOP Cap model.

Full details of the SMM and its setup can be found in MDBA (2019a, 2019b).

The Source BDL model was run and a revised BDL estimate was calculated. The details of the Source BDL model used to produce the revised BDL estimate are as follows:

- Source: 4.8.0.b.8359
- MDBA Plugins: MDBA Formal Release v957
- Source Project File: V967River Murray Model 4.8.0.rsproj
- BDL Input Set: BDL

The Source BDL model run was completed using the following:

- Dell Latitude 7480 with Intel Core i7-6600U CPU @ 2.60GHz and 16 GB RAM
- Microsoft Windows 10 Enterprise 10.0.17134 Build 17134
- .Net Framework 4.7.03056

9.3 Revised BDL Model – Model Runs

The sequence of model runs outlined in Section 9.1 was undertaken to produce revised Cap and BDL models. This sequence was also used to re-model the current BDL conditions with the updated version of MSM. This allowed the changes to the current BDL to be attributed to MSM updates or revised BDL assumptions.

A total of four model runs were completed.

Table 15 outlines each model run, the model used, the conditions (Cap or BDL) that were used, the period the model was run over, the assumptions applied and additional descriptive information. Table 16 presents the results from the model runs.

There remains a modelling issue in the Source BDL model that relates to the calculation of water use if the river stops flowing. Even if the river does stop flowing, there remains a significant body of water from which water users can pump. The issue in the model is that when the flow stops, diversions also cease because it is assumed that there is no water available to pump.

Over the historical climate sequence, this issue only occurs for short periods in 2007-08 and 2008-09, with an expected impact on the revised BDL estimate of approximately 0.02 GL. Although this long-term average impact is small, the potential for underestimating use in any individual year is much greater. As a result, this may negatively affect annual permitted take calculations. Future improvements to the Source
model should ensure that pumping can still occur when the flow ceases (where there is still access to water) to eliminate this avoidable underestimation of annual water use.

### 9.4 Revised BDL Estimate

A revised BDL of 681.056 GL has been determined for the four South Australian Cap valleys under Schedule E.

The increase to the BDL from the current estimate of 665 GL can be attributed to the following:

- 5.4 GL – updates to the trunk version of MSM to fix coding bugs
- 7.5 GL – revised BDL assumptions
- 3.1 GL – model improvements in the representation of SA Entitlement in the Source BDL model.

If the full volume of South Australian Entitlement was available in each year of the historical climate sequence, and 100 per cent allocations were possible, the BDL estimate would be in the order of 686 GL.

A revision to the BDL estimate to account for 6.062 GL of take under basic rights as of 30 June 2009 is subject to future Basin Plan amendments.
Table 15  BDL Model Runs Undertaken to Develop the Revised BDL Model

<table>
<thead>
<tr>
<th>Model</th>
<th>ID</th>
<th>Conditions</th>
<th>Period</th>
<th>Assumptions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSM</td>
<td>2061</td>
<td>Cap</td>
<td>1891–2002</td>
<td>MDBA Cap</td>
<td>• Cap conditions run to determine the AOP scaling factor (Cap) of 1.22429 that is required to ensure an unrestricted use of 449.9 GL/year.</td>
</tr>
</tbody>
</table>
| MSM   | 2089| Cap        | 1891–2003| Revised Cap | • Cap conditions run to determine the revised restricted AOP + LMS Cap over the revised Cap assessment period.  
• Uses AOP scaling factor (Cap) from run #2061. |
| MSM   | 2091| BDL        | 1891–2003| Revised BDL | • BDL conditions over the revised Cap period to determine the AOP scaling factor (BDL) required to ensure that the average demands are equal to the adjusted restricted AOP Cap.  
• The adjusted restricted Cap is equal to the restricted Cap from run #2089 plus net permanent trade at 30 June 2009 minus TLM water recovery. |
| SMM   |     | BDL        | 1895–2009| Revised BDL | • Revised BDL model run with all revised BDL conditions.  
• Uses AOP scaling factor (BDL) of 1.31252 as SMM scales directly from the regression equations to BDL conditions. This scaling factor ensures the correct adjusted restricted AOP Cap over the period 1891–2003. |

Table 16  BDL Model MSM Run Results – Runs Undertaken to Develop the Revised BDL Model.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AOP Use (GL/year)</td>
<td>450.14</td>
<td>482.55</td>
<td>478.552</td>
</tr>
<tr>
<td>AOP Scaling Factor</td>
<td>1.22429</td>
<td>1.22071</td>
<td>1.31252</td>
</tr>
<tr>
<td>LMS Use (GL/year)</td>
<td>94.19</td>
<td>52.69</td>
<td>52.180</td>
</tr>
<tr>
<td>CT Use (GL/year)</td>
<td>50.00</td>
<td>50.00</td>
<td>49.759</td>
</tr>
<tr>
<td>Metro Adelaide Use (GL/year)</td>
<td>99.69</td>
<td>99.72</td>
<td>100.595</td>
</tr>
</tbody>
</table>

Notes:
1. The AOP Cap was set at 449.9 GL/year over the period 1891 to 2002. The restricted AOP Demand over the revised Cap period of 1891 to 2003 may be different than the original value as a result of the change in time period.
10 REFERENCES


*Water Act 2007* (Cth), including Schedule 1 (*Murray–Darling Basin Agreement 2008*).
APPENDIX A  BACKGROUND TO BASIN PLAN BDL ESTIMATES

An SDL is the long-term average volume of water that may be sustainably extracted from an SDL resource unit. The Basin Plan BDLs provide the reference points from which SDLs are calculated, as follows:

\[
SDL = BDL - \text{local reduction amount} - \text{shared reduction amount} + \text{SDL adjustment.}
\]

In some SDL resource units, the local and / or shared reduction amounts may be zero. The SDL adjustment may also be zero.

The methods used to determine the BDLs considered several elements, including (MDBA 2010):

- Current limits on take defined by existing water resource plans or current water management arrangements
- All existing water access rights including water access entitlements and stock, domestic and riparian domestic rights
- The current use of existing water access rights
- All known forms of take that may not be currently covered by water access rights
- Climate characteristics.

The Basin Plan separates the BDL for each surface water SDL resource unit into two components, namely watercourse diversions and interception. Watercourse diversions reflect direct extraction from regulated or unregulated watercourses or rivers. Interception includes volumetric estimates for take under basic rights\textsuperscript{27}, take by runoff dams and net take by commercial plantations.

The BDL estimate must reflect the water management arrangements in place as at 30 June 2009 and includes both watercourse diversions and interception. Therefore, it may be different from other long-term diversion limits such as the Cap on Diversions under Schedule E of the Agreement, water allocation plan limits or other figures associated with a given area.

Hydrological modelling was the primary tool used to determine the BDL in each SDL resource unit (MDBA 2010), including the SA Murray. Hydrological models were used to represent the various water management, sharing and operating rules, the infrastructure and other relevant physical characteristics, and the existing spatial and temporal patterns of take. Many of these models were also used to establish existing limits under water allocation plans and similar instruments. Where forms of surface water take were not explicitly represented in a hydrologic model, the BDL was generally defined by the current level of take, which was quantified by the most appropriate method using the elements identified above.

Where possible, climatic information (rainfall, evaporation) over the 114-year period from July 1895 to June 2009 was used in the hydrological models. This is referred to as the Basin Plan modelling period. The BDL was then the annual average modelled use or ‘demand’ over this 114-year sequence. The use of this 114-year sequence with updated water management rules and patterns of take resulted in differences between the BDL and other existing long-term diversion limits, particularly where the latter were determined over a different time period.

\textsuperscript{27} Under section 1.07 of the Basin Plan, basic rights means any of the following: (a) a right under state water management law to take water for domestic or stock purposes; (b) a harvestable right under the Water Management Act 2000 of New South Wales; (c) a native title right.
The water recovered for The Living Murray and Water for Rivers programs was removed from the calculation of the BDL (MDBA 2010). This means that the BDL is the baseline diversion limit for all of the remaining consumptive entitlements.

Environmental entitlements that have been secured or made available to the Australian Government under the Water for the Future program have not been removed. The consumptive use of these entitlements before 30 June 2009 is included in the BDL and will contribute to meeting the required water recovery targets (where applicable) to meet the SDLs.
The AOP Cap model is described in Prasad and Foreman (2004). Key details are as follows:

- It is a regression model developed using historical monthly demands (1983–84 to 1999–00) and climate data, in particular, monthly rainfall data from Berri and monthly temperature data from Loxton.
- The historical monthly demands (diversion data) were available from selected Central Irrigation Trust (CIT) pumps only. This data was used to derive a monthly diversion pattern, which was then applied to the remaining diversion data that was collected on an annual basis.
- It was assumed that the intra–annual water use by crops supplied through CIT pumps (predominately permanent horticulture) was representative of all irrigation use across the AOP Cap valley.
- The model produces a monthly demand sequence, which is then summed to produce an annual demand based on 1993–94 level of development. The average of the annual demands from the AOP Cap model over the period from 1891–92 to 2001–02 was 367.463 GL/year.
- Annual demands from the AOP Cap model were then scaled by \(\frac{440.6}{367.463}\) (equal to 1.19903). This ensured that the average of the annual demands over the period from 1891–92 to 2001–02 was increased to the agreed long-term Cap of 440.6 GL/year. The scaling factor is referred to as the AOP scaling factor. The scaled annual demands are then the annual diversion targets that are used for Cap compliance.
- The annual use produced by the scaled AOP model are also referred to as ‘unrestricted use’, and the annual Cap of 440.6 GL/year as the unrestricted AOP Cap. This is because the modelled annual use has assumed that full allocations are available to all consumptive users and no allocation restrictions (due to reduced water availability) have been required.

The transfer of 9.3 GL of highland irrigation entitlements from the LMS Cap valley in March 2008 increased the AOP Cap to an average of 449.9 GL/year. Key details of resulting changes are as follows:

- The LMS Cap and annual diversion targets were reduced by 9.3 GL/year because of the transfer of entitlements, as this Cap is not climate adjusted and the volume of entitlements held in the LMS Cap valley equals the LMS Cap.
- In the AOP Cap valley, there was not a fixed 9.3 GL increase to the annual diversion target. Instead, the annual diversion targets generated by the AOP Cap model were scaled to ensure that the average demand over the period 1891–92 to 2001–02 was equal to 449.9 GL/year. The fixed annual Cap for the transferred entitlements essentially became climate adjusted.
- The AOP scaling factor was then increased to \(\frac{449.9}{367.463}\) (equal to 1.22434).

The Murray Simulation Model (MSM) is the Cap model used for the three upstream designated Cap valleys, namely the NSW Murray, Victorian Murray and NSW Lower Darling (Prasad and Foreman 2004).

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28 The period for AOP Cap was set based on a recommendation of the Independent Auditor in the Audit Report for the Lachlan Cap Model, the first Cap model approved by the MDBC under Schedule E (then Schedule F).
The MDBA undertook a recalibration of MSM in 2006 (MDBC 2007) and incorporated the accredited AOP Cap model equations (a spreadsheet model at that time). The increase in the long-term AOP Cap from the permanent trade of:

- inter-state entitlements before 30 June 2007 (32.44 GL/year)
- intra-state entitlements from the LMS Cap valley (3.81 GL/year to end of 2001–02; 36.43 GL/year to end of 2008–09).

The long-term Cap for the AOP Cap valley was adjusted by these trades. Another revision to the AOP scaling factor was required to ensure the modelled long-term average diversion was equal to the revised long-term Cap.

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29 Despite the incorporation of the AOP Cap model into MSM, annual Cap compliance under Schedule E of the Agreement has continued to use the accredited spreadsheet model.
APPENDIX C  REVIEW OF BASIC RIGHTS AND THE ALL OTHER PURPOSES CAP

Take for basic rights (unlicensed stock and domestic) in South Australia does not form part of, and is not accounted for under, the Cap on Diversions under Schedule E of the Agreement.

This section outlines supporting evidence for a change to the Basin Plan to explicitly and separately include basic rights in a revised BDL description for the SA Murray SDL resource unit. Following this, an explicit increase to the BDL estimate for this form of take can be made.

C.1 SCHEDULE E – COMPONENTS, DEFINITIONS AND REQUIREMENTS

This section outlines the components, definitions and requirements of Schedule E, with reference to the AOP Cap and basic rights.

The purposes of Schedule E are defined under clause 1, which are to:

(a) establish long-term caps on the volume of surface water used for consumptive purposes in river valleys within the Murray–Darling Basin;

(b) to set out action to be taken by the Ministerial Council, the Authority and State Contracting Governments to quantify and comply with annual diversion targets; and

(c) to prescribe arrangements for monitoring and reporting upon action taken by State Contracting Governments to comply with annual diversion targets.

Under clause 2(1), a river valley means a river valley within the Murray–Darling Basin referred to in sub-clause 3(2).

(a) Sub-clause 3(2) states that, subject to any amendment to the description by Ministerial Council, the river valleys listed in Appendix 2 are river valleys for the purposes of this Schedule.

(b) Appendix 2 defines four river valleys for South Australia:

1. The pumps on the Murray within South Australia used to supply Metropolitan Adelaide and associated country areas;

2. Lower Murray Swamps irrigation;

3. Country Towns water use; and

4. Water use for All Other Purposes from the Murray within South Australia.

The first three Caps cover water diversions via specific infrastructure, for specific purposes and/or for specific geographical areas. The fourth river valley, commonly referred to as the All Other Purposes (AOP) Cap valley, is therefore defined explicitly as ‘Water use for All Other Purposes from the Murray within South Australia’. If take by basic rights was accounted for under Schedule E, it would be accounted for under this Cap.

Clause 4 defines the Diversion Formula Register to calculate diversions in a river valley. Under clause 4(1), the Authority must:

(a) determine a formula for calculating diversions within each river valley for the purposes of this Schedule; and

(b) maintain a Diversion Formula Register which records each formula determined under paragraph (a) and the river valley to which the formula relates.
The first Diversion Formula Register was approved by Murray–Darling Basin Commission (MDBC) Meeting 93 (MDBC 2007) – a protocol established under paragraph 4(1)(b) to Schedule F (now Schedule E) of the Agreement. Version 6 was approved by MDBA decision D18/19277 (MDBA 2018).

The quantitative formula for ‘Water use for All Other Purposes from the Murray within South Australia’ is consistently listed in each version of the Diversion Formula Register as:

\[
\text{Total Diversions} = \text{The sum of all licensed diversions} \ (\text{Pumped Irrigation diversions (metered)} + \text{Pumped Irrigation diversions (unmetered)} + \text{Recreation & Environmental diversions} + \text{Industrial diversions} + \text{Stock & Domestic licensed diversions}) \text{ from the River Murray Prescribed Water Course in South Australia (including water transported by SA Water on behalf of other licensees via the Metro-Adelaide system or Country Town pipelines), obtained from the Database system of the responsible state agency.} \]  

where:

\[
\text{Stock & Domestic licensed diversions} = \text{The sum of all metered and unmetered (assumed to be equivalent to total allocation) Stock & Domestic licensed diversions not including those which are conjunctive with irrigation licences from the River Murray Prescribed Water Course, obtained from the Database system of the responsible state agency.} \]  

Under clause 4(2) the Authority or States, as may be appropriate, must use the formula entered in the Diversion Formula Register with respect to a river valley for the purpose of:

(a) developing or approving any analytical model under clause 11;

(b) making any calculation under clause 12;

(c) preparing any report required under clause 13; and

(d) maintaining the Cap Register.

Clause 11 specifies the requirements for developing analytical models for determining annual diversion targets:

- Under clause 11(3), the Government of South Australia must develop analytical models for determining the annual diversion target for diversions in paragraphs 7(1)(a) and (d).

- Under clause 7(1)(d), the Government of South Australia must ensure that diversions from the River Murray within South Australia for ‘all other purposes’ do not exceed a long-term average annual diversion of 449.9 GL.

- The analytical model developed under clause 11(4)(a) must simulate the long-term diversion cap in the relevant designated river valley.

- The model developed to generate annual diversion targets with a long-term average limit of 449.9 GL for the ‘all other purposes’ river valley must therefore use the relevant formula in the Diversion Formula Register.

Clause 12 specifies the requirements for calculating annual diversion targets:

- Using the analytical models developed and approved under clause 11, clause 12(1)(b) requires that the Government of South Australia must, for each designated river valley within the territory of that State, calculate the annual diversion target for that year.
• This means that an annual diversion target must be determined for the ‘Water use for All Other Purposes from the Murray within South Australia’ river valley.

• MDBC Meeting 82 approved the South Australian ‘All other Uses’ model under clause 9(4)(c) of Schedule F for determining annual diversion targets for South Australia’s ‘All other Uses’ designated Cap valley (MDBC 2004b). This model is still used for the determination of annual diversion targets and is the basis of the development of the Basin Plan BDL.

• The approved model is defined Prasad and Foreman (2004). This report:
  o states that it ‘...documents the Cap model for the “All Other Uses of Water from the River Murray” Designated River Valley’; and
  o defines the components of this river valley in accordance with the formulae outlined in the current Diversion Formula Register for the ‘Water use for All Other Purposes from the Murray within South Australia’ river valley.

Clause 13 specifies the requirements for monitoring and reporting:

• In accordance with clause 13(1), the Government of South Australia must, for each water year and in relation to each designated river valley specified in Appendix 2, monitor and report to the Authority on:
  (a) diversions made within and to;
  (b) water entitlements, announced allocations of water and declarations which permit the use of unregulated flows of water within; and
  (c) trading of water entitlements within, to or from, the territory of that State in that water year.

• In accordance with clause 13(2)(a), the Government of South Australia must, for each water year and in relation to each designated river valley, monitor and report to the Authority upon the compliance by that State with each relevant annual diversion target calculated under this Schedule for that water year.

• For each water year since 2003–04, South Australia has determined the annual diversion target for the AOP Cap valley in accordance with the model developed by Prasad and Foreman (2004) and approved by MDBC Meeting 82 in 2004 – as required under clause 12(1)(b). Prior to this, the annual diversion target was assumed equal to the long-term average Cap.

• For most water years, South Australia has reported the annual actual use in accordance with the formula defined for the ‘Water use for All Other Purposes from the Murray within South Australia’ river valley in the Diversion Formula Register – as required under clause 13(1)(a). An exception was in 2008–09 when a volume of take for unlicensed stock and domestic was reported in error by South Australia and not in accordance with this clause.

• The construct and purpose of Schedule E defines explicit links to establish long-term Caps, to quantify and comply with annual diversion targets and prescribe arrangements for monitoring and reporting. Based on the assessment above, unlicensed stock and domestic take is explicitly excluded from the accounting and compliance of diversions under the AOP Cap.

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30 The corresponding clause under Schedule E is clause 11(4)(c).
31 The document Register of Diversion Definitions in the Murray–Darling Basin, Technical Report 2000/2 was the precursor to the official Diversion Formula Register. In this document, the relevant formula was listed as ‘All Other Uses of Water from the River Murray’, again with no reference to unlicensed stock and domestic take.
C.2 DEVELOPMENT OF THE ALL OTHER PURPOSES CAP

During the development of the All Other Purposes Cap, no reference was made to unlicensed stock and domestic use or use under basic rights or riparian rights, as highlighted in the reports and references below.


To support a decision on whether to cap diversions, the MDBC coordinated the collection of data on water diversions throughout the Basin, which was presented to Ministerial Council. This report:

- assessed the current and potential water use under several scenarios related to the partial or full use of existing water entitlements and in consideration of water allocation procedures
- included South Australian annual water use volumes for each scenario, with data aggregated to ‘Private Pumped Diversion’, ‘Government Pumped Diversion’ and ‘Reclaimed Swamps’ categories.


The available data for the ‘Pumped Irrigation’ category specifies allocations and diversions for Stock and Domestic, Industrial, Recreation and Environment, Private Irrigation (metered and unmetered), Government Irrigation (metered) and Government extras (domestic, industrial, vegetables and losses).

Total allocation and use for irrigation was by far the largest volume.

For stock and domestic allocations, 100 per cent use of the allocated volume was assumed. The volume of licensed entitlements at the time was around 3.5 GL.

Setting the Cap (MDBMC 1996a)

The report was prepared by the Independent Audit Group (IAG) for Cap Implementation, which was set up in 1996 to review progress towards implementation of an operational Cap and to consider ways to resolve inconsistencies and equity issues in water use.

The report includes each state’s proposed approach for implementing the Cap and presents recommendations to solve equity issues between states.

Key text:

- Page XI – ‘The South Australian Government proposed, on the basis of existing property rights, to include an estimated 69 GL per annum of allocated but unutilised irrigation water within the South Australian cap.’ [emphasis added]
- Page XI – ‘The IAG considered that the 69 GL per year should be included in the cap in recognition of South Australia’s conservative water management practices.’
- Page XII – IAG Recommendation 13 – ‘the 69 GL per year increase in diversions expected from the uptake of water allocated for irrigation and previously not used, be included in the Cap.’
- Page XII – IAG Recommendation 12 – ‘the proposal to allocate an additional 50 GL per year for economic use not be approved…’
- Page 15 – ‘The IAG is of the view that the Cap for SA should permit increased utilisation of existing statutory entitlements for irrigation diversions. That is, SA should be permitted to divert up to a maximum of 570 GL for irrigation in any year, provided long term average utilisation of entitlements do not exceed 90 percent. This is calculated to be equivalent to an increase of 69 GL per year in irrigation diversions compared with 1993/94 levels of development.’
• Page 15 – ‘In coming to this view, the IAG took into account the following special circumstances: the projected increase in diversions of 69 GL represents a 90 percent utilisation of existing rights and will be taken up through pre-existing allocated statutory rights.’ [third dot point]

• Page 56 – The hierarchy of water rights within South Australia, except for SA Water supplies to Adelaide and Country Towns, is explicitly defined relative to licences and allocations for various purposes.

MDB Ministerial Council Meeting 20 (MDBMC 1996b)

• Agenda Item 7 – Water Audit – Implementation of the Diversion Cap. Ministers discussed and agreed (under paragraph 49(h)) to the release of the IAG’s ‘Setting the Cap’ report to the public for information.

• Paragraph 45 – ‘New South Wales advised that it was opposed to both 69 GL and 50 GL allocations to South Australia. In order to resolve both issues at this meeting, however, if South Australia was prepared to accept the IAG’s recommendations on both issues, then New South Wales reluctantly would agree to do so also. South Australia advised that it would accept this compromise.’

• Paragraph 49 – Council (c) ‘agreed to the recommendations in the IAG report, with the exception of recommendations 5, 18, 32 and 37...’.

Schedule F development

• Schedule F was developed over several years and included several trial periods before it was officially included in the Agreement in 2000. It became Schedule E in 2008.
  o Over its development, there was a significant amount of rewording and rearranging of the South Australian river valleys and those used in reference to the long-term Caps. The version of Schedule F proposed at each of the meetings below shows this evolution.
  o Ministerial Council 24 (March 1998) – the Council adopted Schedule F (Cap on Diversions) for trial implementation during the 1998–99 season. Clause 6 outlined the long-term diversion Cap for South Australia, which comprised four individual limits. This included, under clause 6(1)(c): a long-term average annual diversion of 440.6 GL for irrigation, being 90 percent of the total allocation of 489.6 GL made by South Australia for irrigation from the River Murray within South Australia in areas other than reclaimed swamps. Note that the river valley under Appendix 2 was simply Murray within South Australia. This geographical naming is consistent with other states where the river valleys are almost purely river names.
  o Ministerial Council 27 (October 1999) – in this version, it was proposed to combine three of the four caps. A Cap for Metropolitan Adelaide remained separate, but the second South Australian Cap was defined under clause 6(1)(b) as: for all remaining uses do not exceed a long-term annual diversion of 574 GL. The previously single river valley in Appendix 2 was split into one for Metropolitan Adelaide and another for ‘All other portions of the Murray within South Australia’. These changes show that the term ‘all other uses’ was one of simplicity to express the part of the South Australian Cap that excluded Metropolitan Adelaide. It was not a change to alter the composition of diversion types that were to be accounted for under the South Australian Cap.
  o Ministerial Council 29 (August 2000) – proposed the ‘combined’ Cap valley from Ministerial Council 27, but South Australia proposed that four Caps be defined. Whilst South Australia proposed that the fourth component under clause 6(1)(d) be referred to as ‘Highland
Irrigation and other minor pumped diversions’, Council agreed to continue with ‘all other purposes’, again likely for simplicity.

C.3 PRINCIPLES OF THE CAP IN RELATION TO WATER RIGHTS

Accounting for additional water rights under the same long-term volumetric limit would result in a corresponding reduction to the reliability of the existing entitlements accounted for under that limit. The principles of the Cap do not support the inclusion and accounting of additional forms of take under the same volumetric limit, as highlighted in the reports identified below.

The Cap: Providing security for water users and sustainable rivers (MDBC 2004a)

An information brochure prepared by then MDBC on the implementation of the Cap, which states that: ‘The Cap itself does not attempt to reduce Basin diversions, it merely prevents them from increasing.’

Therefore, if new forms of take or water rights were added under an existing Cap and the Cap limit was not increased, then the Cap would be reducing Basin diversions and would not provide security for water users.

Setting the Cap (MDBMC 1996a)

This report states that for South Australia: ‘...the Cap for SA should permit the increased utilisation of existing statutory entitlements for irrigation diversions...’and ‘...provided that the long-term average utilisation of entitlements do not exceed 90 percent’.

If new forms of take or water rights are added under the existing volumetric Cap limit without increasing that limit, then the long-term average utilisation of entitlements would be reduced below 90 per cent and continue to be reduced with every additional volume of take incorporated.

If a government decides to add in new water rights of the type that are already accounted for and limited under the Cap, then an increase to the Cap cannot be expected.

When entitlements from inter-state have been traded into South Australia, the Cap was increased. In the same way, allocations traded from inter-state increase the Cap each year. (Refer Schedule D Appendix 3 for protocols for adjusting the Caps for trade.)


Information Box 2 (p 26) states that ‘...Cap promotes the sustainable use of the Basin’s resources by: ...preserving the existing security of supply to water users within river valleys...’

Adding additional forms of take to an already determined volumetric Cap and not increasing that Cap is incompatible with this statement.

The Cap is the volume that would have been diverted under 1993–94 levels of development. If another form of take is to be included, then the volume for that form of take would be determined under 1993–94 levels of development and added to the Cap. Then, both the new and existing take is monitored and reported against the new Cap. There is evidence of this process when the 2012 Basin Plan BDL estimates were determined (MDBA 2011).

Comparison of watercourse diversion estimates in the proposed Basin Plan with other published estimates (MDBA 2011)

The report states (p 8) that ‘...to account for total diversions from the catchments, estimates of interceptions in various catchments and unregulated licensed diversions which are not in the model are added to the modelled diversion estimates.’
The BDL model developed by the MDBA included the allowance for unlicensed stock and domestic in the allocation framework, but actual use for these water rights was not determined in the model.

In the determination of BDLs for the Basin Plan, long-term average limits for new forms of take that were not previously accounted for or reported on were determined and added into existing estimates under the Cap.

If the new forms of take were supposed to be added to the existing volumetric Caps without increasing the Cap limit, then these other forms of take would not have been specified separately and separate limits determined, which were added to the BDL.

C.4 REFERENCES


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32 The additional estimates generally relate to basic rights, farm dams and commercial forestry.
APPENDIX D  2008–09 RIVER MURRAY DROUGHT ALLOCATION FRAMEWORK

D.1  2008–09 RIVER MURRAY DROUGHT ALLOCATION DECISION FRAMEWORK

Objective

To optimise the allocation and use of water that becomes available to South Australia (in excess of Critical Human Needs) to support the long-term sustainability and viability of the South Australian community for the greatest net benefit of the whole community.

Key Principles

- Decisions should primarily reflect the most beneficial application of water at the time of the decision but take account of other relevant factors;
- Decisions should recognise the imperative for sustainable environmental outcomes to enable the future sustainable consumptive use of these resources; and
- Decisions should be based on the best available information at the time and should, where possible, be based on quantitative data.

Specific Criteria

- Decisions should not jeopardise future recovery options;
- Decisions should recognise triggers or thresholds for potentially long-term or irreversible damage;
- Decisions should take account of the risk of long-term or irreversible damage or loss if allocations are not made;
- Decisions should take account of previous allocations to the various assets or activities made during the water year;
- Decisions should build on previous investments in water allocations;
- Decisions should recognise the significance of the potential use of market mechanisms and water trade between informed participants to optimise the use of allocations; and
- Decisions should take into account the availability of alternative water sources or potential actions that could achieve the same desired outcome (e.g. carry-over or unregulated flows).

Critical Assets and Activities

- barrage releases
- fishing industry
- floodplain asset watering
- industrial supplies
- irrigation and other commercial consumptive uses
- Lower Lakes – management of acid sulfate soils
- Lower Lakes refill
- private stock and domestic supplies
- recreation and tourism
- salt transport
- urban, country town and rural reticulated supplies
- wetland watering
D.2 2008-09 RIVER MURRAY DROUGHT WATER ALLOCATION DECISION SEQUENCE

**STEP 1**
Questions
- What are the characteristics of the water?

Relevant Factors
- Regulated flow
- Unregulated Flow
- Timing
- Volume and duration

Outputs
- Description of water available and restrictions on its use

**STEP 2**
Questions
- What assets or activities water could be put to?

Relevant Factors
- Water level
- Flow rates
- Quality
- Condition of assets

Outputs
- List of assets or actions the available water could be put to under the prevailing circumstances

**STEP 3**
Questions
- What are the priority uses for the water?

Relevant Factors
- Benefits of allocating the water to priority uses
- Costs of not allocating water to other priority uses

Outputs
- Priority assets or actions for the water at the time of the decision

**STEP 4**
Questions
- Will the preferred application(s) affect other actions? Can the same outcome be achieved through other means?

Relevant Factors
- Potential adverse impacts
- Potential alternative actions to achieve same outcomes
- Affect future actions

Outputs
- Recommended allocation of water
APPENDIX E  REVIEW OF METROPOLITAN ADELAIDE REQUIREMENTS

E.1  SUMMARY

A review of the assumptions for the volume reserved for Metropolitan Adelaide for CHWN as the water year progresses was undertaken. Proposed changes are in the form of rules that redistribute part of Metropolitan Adelaide’s critical human water needs (CHWN) reserve when it is not required in a given year. These rules are necessary to replicate the policy settings in place as at 30 June 2009 and should be applied in a revised BDL model.

E.2  BACKGROUND

CHWN are the highest priority water use under section 86A(1)(a) of the Water Act 2007 (Cth) (the Act) and clause 135(10)(a) of the Agreement. CHWN requirements for Metropolitan Adelaide constitute almost 75 per cent of the total CHWN requirements from the River Murray in South Australia. As such, urban water security is a key criterion in allocation decisions.

Metropolitan Adelaide has an established CHWN requirement of 150 GL. It is considered to be the minimum amount of water required to meet core human consumptions requirements, in line with the definition of CHWN under section 86A(2) of the Act. This does not mean that 150 GL is required each year and the full volume could not be taken each year or South Australia would be in breach of the Cap. The volume actually diverted in a given year depends on inflows and storage levels in the Mount Lofty Ranges (MLR) reservoirs, with a higher requirement in dry years in the MLR compared to wet years.

The allocation assumptions for Metropolitan Adelaide, and in particular, the volume reserved for the CHWN component, can impact on the water available for other purposes. This in turn affects the BDL. Since 2007–08, a volume of 150 GL has been reserved at the start of each water year for CHWN for Metropolitan Adelaide.

In 2009–10, the reserved volume was reduced part-way through the year when it was determined through consultation between the then Department for Water, Land and Biodiversity Conservation and SA Water that the full 150 GL would not be required. The volume not required was then allocated for other purposes. A reduction and redistribution was also considered in 2008–09 but was not possible given the dry conditions in the MLR. Based on this, a redistribution policy is considered to be in place as at 30 June 2009 and consistent with the Basin Plan and MDBA Position Statement 3D on BDL changes.

The reserved volume of 150 GL is reflected in the allocation framework in the current BDL model. However, the model maintains this reserve throughout the year, irrespective of the volume actually diverted. This is because the Metropolitan Adelaide diversions are included as a fixed monthly time series, with no link to the actual conditions in the MLR that would enable an adjustment to the reserve. Any part of the reserve not diverted remains in-river.

E.3  ANALYSIS OF METROPOLITAN ADELAIDE RIVER MURRAY DIVERSIONS

There are likely to be a number of options for updating the current BDL model to allow the reserved volume of 150 GL to be reduced over the year if conditions in the MLR mean that the full volume is not required. The most complex would be to include a sub-model representing the relationship between MLR inflows, Metropolitan Adelaide demands, rules for water supply operations and the required River Murray diversions. However, a simple relationship was investigated first.

The majority of inflows to the MLR reservoirs occur in winter and spring. Although the highest demands in Metropolitan Adelaide (and demand variability) occur over summer, it is likely that the River Murray
requirements would be known with some confidence following the main MLR inflow season in winter and spring.

This section first reviews the calculation of the River Murray diversions to meet Metropolitan Adelaide’s demand in the current BDL model. The relationship between monthly and annual diversions is then evaluated.

### E.3.1 Method for Calculating River Murray Diversions

The MDBA used the work of MDBC (2002) to determine a sequence of River Murray diversions to meet Metropolitan Adelaide’s demands under baseline conditions. MDBC (2002) developed monthly River Murray diversion estimates for the period 1891 to 2001, based on 2001 ‘level of development’ conditions, and taking into account climatic variations during that period. When the BDL was determined, the dataset was extended to 2009 with observed diversion data.

The work was contracted by the then Murray–Darling Basin Commission (MDBC) in order to revise, update and extend input data sets associated with SA Water’s monthly extractions from the River Murray. MDBA (2011) stated that at the time the BDL estimate was required, the data from this study provided the best available representation of the long-term annual average take, which was also within the requirements of the current Cap on Diversions under Schedule E.

MDBC (2002) collated and reviewed available data associated with reservoir catchment yields in the MLR, water supply system demands in Metropolitan Adelaide, rainfall, temperature and monthly pumping capacities and costs. Varying lengths of data was available for each of these variables and a number of different techniques were used to extend each time series. Monthly estimates of Metropolitan Adelaide water supply system demand and reservoir catchment inflows were produced, which covered the period from 1891 to 2001 and assumed 2001 levels of development.

The Headworks Optimisation Model – Adelaide (HOMA) was then used to determine the monthly River Murray pumping requirements. This model uses a mathematical optimisation technique to determine optimal monthly pumping and transfer schedules for the bulk water headworks system while satisfying the system operating rules, constraints and attributes. The operating rules include reservoir reserve storage holding levels, inflow forecast datasets and demand forecast sets while the system constraints and attributes include reservoir capacities and pumping station, pipeline and dissipater restrictions.

The annual average diversion from the River Murray for Metropolitan Adelaide determined by MDBC (2002) was 100 GL, with the annual diversions varying from around 35 GL to over 200 GL as shown in Figure E1. This range is a result of the high variability in the volume and timing of inflows to the Mount Lofty Ranges reservoirs and of water supply demands for Adelaide, particularly over the summer months.

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33 As identified in Section 5, the Metropolitan Adelaide BDL component was not determined directly from the work of MDBC (2002). The average diversion in MDBC (2002) was higher than the 99.59 GL volume in the BDL model. The difference is due to the maximum diversion of 180 GL permitted in the BDL model. This difference was not obvious in relevant Basin Plan documentation due to the effect of rounding. It has not been state government policy to limit River Murray diversions for Metropolitan Adelaide when other water users received full allocations. This BDL model assumption is addressed in Section 5.6.
E.3.2 Relationship between Monthly and Annual River Murray Diversions

An analysis of the monthly and annual Metropolitan Adelaide baseline diversions was undertaken to assess whether there is a simple relationship that could be used to estimate the total end of year requirements.

Figures E2 to E4 show the percentage of the annual volume diverted for Metropolitan Adelaide at the end of the month indicated, against the annual totals (for the 114 years in the BDL model run). For example, Figure E2(a) shows the percentages of the annual totals that are diverted by the end of August, against those annual totals.

There is significant variability in the annual volume diverted for Metropolitan Adelaide. The variability in the volume diverted by the end of the month is higher earlier in the water year but decreases as the year progresses.

This indicates that as the water year progresses we can estimate with increasing confidence what the total annual volume required from the River Murray for Metropolitan Adelaide will be. The minimum percentage diverted by the end of each month provides a conservative indicator that can be used to estimate the maximum annual volume required in the given water year.

Key observations from the data analysis are that:

- If a volume greater than 100 GL is diverted by the end of the year, then the minimum percentage of the annual total diverted by the end of each month increases through the water year. The minimum percentages for each month are also indicated by a horizontal dashed line in each panel of Figures E2 to E4.

- A similar relationship is evident for an annual total between 75 and 100 GL.

- The monthly minimum percentage diverted for an annual total of 100 GL or greater is higher than for 75 to 100 GL, but both are much higher than the minimum percentage for lower annual totals.
Given the operating rules for Metropolitan Adelaide’s bulk water headworks system, the results in Figures E2 to E4 are consistent with our understanding of how the system is managed because:

- If MLR storages are low early in the season and dry conditions are forecast, higher volumes will need to be diverted early to ensure that, given the system’s pumping constraints, sufficient water is available in storage should dry conditions continue.

- If higher volumes are diverted early and conditions remain dry in the MLR, then the final annual total will continue to increase due to the demand in Metropolitan Adelaide over summer. Lower summer demands mean that the volumes diverted before summer may represent a higher proportion of the annual total than if summer demands are higher.

- If early diversions occur but subsequently conditions in the MLR become wetter, then the volume diverted early in the water year may be a larger percentage of a small annual total.

- If storages have reasonable reserves at the start of the water year and then MLR catchment inflows also occur early in the season, then the early diversions and the annual totals will be lower.

Table E1 shows the minimum percentage of the annual totals diverted by the end of each month for August to March.

**Table E1 Minimum Percentage of Annual Total Diverted by end of each Month**

<table>
<thead>
<tr>
<th>Month</th>
<th>% Diverted by End Month</th>
<th>Annual Total 75 to 100 GL</th>
<th>Annual Total &gt; 100 GL</th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td>8</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>15</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>23</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>28</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>December</td>
<td>39</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>58</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>65</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>
Figure E2 Percentage annual volume diverted by end month (a) August (b) September (c) October
Figure E3  Percentage annual volume diverted by end month (a) November (b) December (c) January
E.4 PROPOSED CHANGE TO RESERVED ALLOCATION METHOD

The aim of the analysis in Section E.3 was to identify whether a simple relationship could be identified between the cumulative volume diverted for Metropolitan Adelaide at the end of each month and the volume diverted for the full water year. The analysis showed that:

- The minimum percentage of the annual diversion pumped by the end of each month could be used to conservatively project the maximum annual total.
- A simple relationship could be developed to project the maximum annual diversion based on the total diversion to the end of each month from August to March.

The implications of this are that:

- The reserved volume for Metropolitan Adelaide could be adjusted intra-annually to allow any volume not required for that year to be redistributed to other consumptive purposes.
The earlier in the year that a redistribution can occur, the better it is for irrigators and other water users to plan for the year.

This section identifies a simple method that could be included in the BDL model. This would be used to adjust the reserved volume for Metropolitan Adelaide in a given year, should the full volume not be required.

This proposal relates to the initial 150 GL reserved allocation for Metropolitan Adelaide only. If more than 150 GL is required in a given year, this would still be provided following allocations to other water users. As such, an upper limit of 150 GL on the reserve remains.

It is proposed to include a method in the BDL model that includes the following:

1. At the end of each month from August to March, the maximum annual diversion is projected based on the cumulative volume diverted to that point and the minimum threshold percentage diversions (as per Table E1) identified in the modelled baseline diversion data from MDBC (2002).

2. It is initially assumed that the total annual diversion for Metropolitan Adelaide will be between 75 and 100 GL, with the projected maximum annual diversion equal to the cumulative diversion to date divided by the minimum percentage diverted by the end of that month (as per column 2 of Table E1). If a value less than 75 GL is determined, a value of 75 GL is adopted.

3. It is then assumed that total annual diversion will be greater than 100 GL, with the projected maximum annual diversion equal to the cumulative diversion to date divided by the minimum percentage diverted by the end of that month (as per column 3 of Table E1). If a value less than 100 GL is determined, a value of 100 GL is adopted.

4. The minimum of the values calculated in (2) and (3), and the maximum Metropolitan Adelaide CHWN volume of 150 GL then becomes the maximum annual diversion at that point in time.

This method assumes that projected maximum annual diversion for Metropolitan Adelaide is at least 75 GL.

This method could be implemented through a two-step calculation process, as described below.

1. The projected maximum annual total under each of the >100 GL and 75 to 100 GL scenarios are calculated as:

   \[
   \text{Annual}_{100}(m) = \max \{ \text{EndMonthDiv} (m) / 100 \text{min} (m), 100 \} \\
   \text{Annual}_{75}(m) = \max \{ \text{EndMonthDiv} (m) / 75 \text{min} (m), 75 \}
   \]

   where:

   \begin{itemize}
   \item \( m \) is the month (August to March).
   \item \( \text{EndMonthDiv} (m) \) = total diversion to the end of month \( m \).
   \item \( 100 \text{min} (m) \) = minimum % of the annual total diverted by the end of month \( m \), when more than 100 GL will be diverted for the year. This determines a maximum annual total of 100 GL if the first term equates to less than 100 GL.
   \item \( 75 \text{min} (m) \) = minimum % of the annual total diverted by the end of month \( m \), when between 75 and 100 GL will be diverted for the year. This determines a maximum annual total of 75 GL if the first term equates to less than 75 GL.
   \end{itemize}
2. In line with the CHWN policy in place as at 30 June 2009, the Metropolitan Adelaide Reserve (MAR) is then:
   - set at 150 GL at the start of the water year; and
   - revised at the end of month $m$ (August to March) as the minimum of:
     - $Annual_{100} (m)$
     - $Annual_{75} (m)$
     - 150
     - $MAR (m-1)$

where:
   - $MAR (m-1)$ = reserve at the end of the previous month. The minimum percentages ensure that the reserved volume in any month is greater than the annual total. However, the variability above the minimum percentage may result in an unnecessary increase from a previous month.
   - 150 = limit on the reserve calculation to 150 GL.

E.5 REFERENCES

APPENDIX F    RESTRICTIONS TO ANNUAL DIVERSION TARGETS

The percentage allocation made by the South Australian Government in any given year (and conversely the level of allocation restriction applied) depends on two key factors:

1. the volume of water available for distribution, that is, the volume of South Australian Entitlement provided under the Agreement; and

2. the order and priority for the distribution of water available to the differing uses such as critical human water needs, irrigation, environment (licensed and non-licensed) and recreation.

In response to the significant allocation restriction that occurred for the first time in South Australia in 2006–07, the Independent Audit Group (IAG) for Cap Implementation recommended to Ministerial Council that percentage allocation restrictions be applied to the annual diversion targets to prevent unrealistic Cap credits being generated. The recommendations and final Ministerial Council decisions are presented below.

In years of restricted allocations, entitlement holders will use a much higher proportion of the water available to them. As entitlement holders used around 80 per cent of the entitlements held at the time the AOP Cap was set, it is realistic to assume that they would use 100 per cent of the water available to them if allocations are less than 80 per cent. Hence, a percentage allocation restriction approach was not supported by South Australia as a permanent solution.

South Australia proposed alternative recommendations to the IAG, which were agreed by the Ministerial Council. The recommendations were that all Cap models should incorporate mechanisms to account for reduced water availability, but the final methods needed to be developed by the then Murray–Darling Basin Commission (MDBC) in conjunction with the relevant states. The agreed methods would then be applied to the relevant annual diversion targets for inclusion in the Cap register.

From 2006–07 to 2009–10, the MDBA reduced annual diversion targets for the AOP and LMS Cap valleys in the Cap Register in accordance with the level of restriction placed on allocations made in those valleys (before adjustment for trade and environmental water use)34. While South Australia has accepted this interim approach for the preparation of the annual water use reports to date, there has been no formal agreement for this approach, or any other, for reducing annual diversion targets. The MDBA applied its own approach during the development of the current BDL.

MDBC (2011) states, in a report describing the calculation of the current BDL in the Basin Plan, that:

The administration of the diversion by South Australia so as to remain within the Cap is carried out based on climate adjusted annual diversion targets with an allowance for imposition of restrictions. The allowance for the imposition of restrictions was recommended by the IAG in 2007–08 and for the last two years this has been included in the calculations of annual diversion targets.

This suggests that the method of reducing the annual diversion targets in accordance with the allocation percentage restriction has been used in the BDL model. However, examination of the current BDL model and advice received (Andy Close, pers. comm., 18 October 2016) indicated that a different approach was implemented during the calculation of the monthly allocation demands in each Cap valley.

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34 Note that no reduction was made in 2010–11 despite a 67% allocation, as the issuing of carryover resulted in a total allocation volume equivalent to a 100 per cent allocation.
Independent Audit Group Recommendations and Ministerial Council Decision

In 2006–07, the IAG of Cap Implementation raised restrictions as an emerging problem with the Cap modelling undertaken in South Australia. It was recommended that:

- All Cap models used to calculate annual diversion targets should incorporate mechanisms to account for water restrictions.
- An allowance be included in the calculation of annual diversion targets for the Metropolitan Adelaide, Country Towns, the Lower Murray Swamps and the All Other Purposes Cap valleys for the imposition of water restrictions.
- The adjustment should be incorporated in the models that calculate the Cap targets since this would be consistent with the practice used in the other States.
- An adjustment be made in 2006–07 by multiplying the annual diversion target by the final announced allocation of 60 per cent, to ensure equality between the restriction-adjusted Cap estimates prepared for valleys in other States and those applying in South Australia.

The recommendations in IAG (2008) were presented to Ministerial Council for agreement in May 2008. South Australia disputed the recommendation [1(c)(iii)] to reduce the 2006–07 AOP and LMS Cap targets by 60 per cent and instead proposed the following additional recommendations that were subsequently agreed by the Council:

- Recommendation (d) – Agreed to the intent of the IAG recommendations that for reasons for equity and consistency, all Cap models should incorporate mechanisms to account for reduced water availability and generate consequent adjustment to Cap targets to prevent unrealistic Cap credits being generated;
- Recommendation (e) – Agreed that the Commission in conjunction with the relevant States be required to develop methods to incorporate mechanisms to account for reduced water availability by October 2008 in time for inclusion in the Annual IAG Cap report and presentation to Ministerial Council in November 2008; and
- Recommendation (f) – Agreed that SA make adjustments to the 2006–07 Cap targets for its designated Cap valleys through application of the mechanism developed under (e).

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