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MURRAY–DARLING BASIN AUTHORITY

Assessment of State water resource model – Wimmera–Mallee

Informing preparation of advice on Water Resource Plan accreditation

Wimmera REALM model

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Acknowledgement of the Traditional Owners of the Murray–Darling Basin
The Murray−Darling Basin Authority pays respect to the Traditional Owners and their Nations of the Murray−Darling Basin. We acknowledge their deep cultural, social, environmental, spiritual and economic connection to their lands and waters.

The guidance and support received from the Murray Lower Darling Rivers Indigenous Nations, the Northern Basin Aboriginal Nations and our many Traditional Owner friends and colleagues is very much valued and appreciated.

Aboriginal people should be aware that this publication may contain images, names or quotations of deceased persons.

Contents

Summary

This report forms the basis of internal advice from the 'Basin Plan Modelling' team to the 'Sustainable Diversion Limit Implementation' team on the suitability of Victoria's REALM models – in this case for the Wimmera – to be incorporated into its Water Resource Plan in accordance with the Basin Plan sections 10.10, 10.12 and 10.49.

The assessment is commensurate with the risks associated with the proposed method for determining permitted take, as outlined in the MDBA's regulatory approach policy.

This report outlines the reviewer(s) assessment against the MDBA's positions statement 3C, regarding methods for determining permitted take, published on the MDBA's website. Note that the position statements are guidelines, not agreed to by State jurisdictions, that are used to formulate the MDBA's views in a transparent manner.

Wimmera WRP Model – Assessment against Position Statement 3C criteria

The assessment findings against the position statement 3C guidance notes are as follows:

Documentation and model overview – (goes to BP 10.10)

The Wimmera model is documented to a high standard. The interpretation of BDL and SDL are clear and appropriate as outlined in DEWLP (2018). The reports describing the model development and application are comprehensive and provide significant detail about the data informing the model, the spatial coverage (maps) and its conceptualisation in the model (node-link), the calibration, and model runs required. The objectives are considered in the scenario report, and the SDL is appropriately interpreted in the model runs. The forms of take – surface water diversions only – and all classes of water right are adequately outlined in the scenario report. The WRP model provides for a practical method to determine permitted take each year.

Overall, strong evidence is presented to support the view that this WRP model is fit for purpose and is an improvement on historical versions.

Data analysis – (goes to 10.49)

Standard practice methods have been used to compile climate data for input into the model using SILO or stations in the valley. Demands are extended typically using an approach outlined in a manual prepared by GHD in 2012, and is well documented. Some residual risk exists because actual demand data has not been analysed, however this risk is very low because full utilisation is employed and actual diversions are considerably less than assumed in the model – a conservative assumption commonly used to generate diversion limits.

Overall, the evidence presented in the reports supports the view that the input data used is fit for purpose.

Model structure – (goes to BP 10.10 and 10.12)

The WRP model and associated model documentation describes the system adequately, and the reported system components are represented in the model, primarily entitlements with associated conditions and catchment features such as tributaries. All of the primary features are appropriately represented including water entitlements, allocations and carryover of unused allocation. Groundwater interaction is not considered in the model. Water held by CEWH is represented, and use of environmental water is set to full use of entitlement by delivering water to key locations. Consumptive demands are set at full entitlement, so any actual growth in use cannot exceed the entitlement limits. Therefore the model addresses the 10.12 provisions.

The model results are presented for the historical 1895–2009 period consistent with the Basin Plan, and the diversion limit meets the SDL – demonstrating against 10.10(4).

Calibration, validation and testing – (goes to 10.49)

DEWLP has not provided any new information about calibration or validation of the model to indicate predictive performance. This is a clear deficiency in the reporting. Historical information about the calibration and validation of the model over 2008 and 2009 for Cap compliance is still the current best available information to describe the predictive performance of the model.

It is noted that calibration/validation against current conditions is difficult given the limited data available for the post-pipeline system, however there are reasonable avenues available for verifying the performance of the model that have not been explored. No new calibration has been done since the last calibration over 2008 and 2009. Overall, the previous calibration is considered reasonable, given it recently received CAP accreditation (in 2013) and the model has not changed significantly since.

It is recommended that an updated calibration and validation be carried out as part of building the new Source model for the Wimmera system.

Prediction – (goes to 10.49)

The revised BDL estimate has been compared with the Basin Plan estimate in the scenario report. The differences in the BDL are minor, indicating that the changes have not had a material impact. Basic diversions information is provided in the scenario report (DEWLP 2018) outlining the model run comparisons, which is sufficient. The WRP model demonstrates that the WRP is compliant with the SDL.

The water balance demonstrates that the changes to the models, since Cap accreditation, are very minor. Therefore the predictive performance as described in the Cap accreditation is still relevant and is adequate. However the predictive performance of the model may become more uncertain over time, as new system operating rules are applied in the post-irrigation Wimmera system.

Sensitivity and uncertainty analysis – (goes to 10.49)

Lack of sensitivity and uncertainty analysis is a deficiency in the DEWLP (2018) reporting. The potential limitations and uncertainties in the model are documented in the Cap audit report and these are still relevant. DEWLP (2018) recommend increasing the compliance trigger under Basin Plan 6.12 to 35%, but no evidence is provided to support this, and this is outside the scope of the model review.

Model improvements (identified) – (goes to 10.49)

DEWLP have not indicated any model improvements, identify the next stage of development is to move to the Source platform. It is recommended that DEWLP address limitations of the current calibration and predictive performance of the model, identified in all previous assessments, as part of the transition to the new Source model.

Quality assurance – (goes to 10.49)

The model version and associated detail is reported in the scenario report DEWLP (2018). The model and model runs were submitted to the BP modelling team for review. DEWLP provided the BP modelling team with the system files for the updated BDL and WRP models, in which the key features of the system are represented as per DEWLPs documentation provided.

The numbers reported by DEWLP were replicated adequately by the BP modelling team.

Determination of Actual Take (goes to 10.15) – if relevant

Not applicable

1. Background

1.1 This assessment – terms of reference

This report outlines a technical assessment, of State water resource planning models, carried out to demonstrate that a model is fit to be used as a method to determine permitted take (for any nominated form of take). Each analysis informs a response to the criteria outlined in the MDB Authority's 'Position Statement 3C: Method for determining take'.

This assessment report represents the Basin Plan modelling team's best advice on whether State models – brought forward to satisfy requirements of Water Resource Plans – and associated reporting, adequately complies with Basin Plan requirements.

The information in this report can be used to inform the development of advice to the Minister on whether to accredit a Water Resource Plan submitted by a State for accreditation.

1.2 Context

Water resource modelling is used by States to consider the effects of climate, resource availability, complex system operations, and other factors, when making water resource management decisions, such as setting diversion targets. Water resource models are also used by States to develop and administer their water sharing arrangements.

In 1995 the Murray–Darling Basin (MDB) Ministerial Council agreed to cap water diversion from the Basin at 1993/94 levels. As part of the implementation of the 'Cap', numerous water resource models were developed to set Cap targets across the MDB.

Many of these models were submitted for approval by the Authority under 'Schedule E' of the Murray Darling Basin Agreement. Subsequently, versions of these models were also used to formulate estimates of take under the Baseline Diversion Limit (BDL) outlined in the Basin Plan. It stands to reason that these models, or new versions of them, will be used to inform the development of Water Resource Plans under the Basin Plan.

Chapter 10 of the Basin Plan sets out requirements that a Water Resource Plan (WRP) must comply with, in order for it to be accredited or adopted under Division 2 of Part 2 of the Act. States must bring forward a 'method' to determine the maximum quantity of water permitted to be taken for consumptive use each year, which may include modelling.

A WRP must be based on the best available information (section 10.49(1) of Basin Plan, MDBA 2012). It must also identify and describe the significant sources of information on which the WRP is based (section 10.49(2) of BP, MDBA 2012).

1.3 MDBA Position Statement 3C and Regulatory Approach

Position Statement 3C

On 27 July 2015, the Water Resource Plan Steering Committee approved the MDBA's policy approach, Position Statement (PS) 3C, to assessing whether models brought forward by States, to determine permitted or actual take, comply with the Basin Plan requirements.

The position statement outlines a list of criteria to explain the supporting evidence sought to evaluate whether a model brought forward by a State meets Basin Plan requirements.

Regulatory approach policy

Consistent with the MDBA's obligations under Section 58 of the Water Act, the MDBA exercises its monitoring and compliance functions and powers consistently with, and in a manner that gives effect to, the water resource plans. Additionally, the MDBA will do so in accordance with a number of principles published on its website (as at 29 August 2017):

https://www.mdba.gov.au/publications/policies-guidelines/water-resource-plans-what-they-are-how-they-are-developed

A key principle in that policy[1], with respect to this assessment, is the 'adoption of a risk-based approach to water resource plan compliance'. This principle states that the MDBA 'will apply greater scrutiny to some obligations than others, depending on the likelihood and consequence of the risks to Basin Plan outcomes or risks identified in a particular water resource plan area'. Under a risk-based approach, we will also seek to verify that obligations with the most significant implications for outcomes in a water resource plan area have been fulfilled more rigorously than obligations with less implications for outcomes.

Position Statement 3C assessments will be interpreted in accordance with this regulatory approach, meaning assessment rigour will be proportional to the risks.

1.4 Modelling and terminology

When the term 'modelling' is used, this is often in reference to the various model 'runs' or 'scenarios' (referring to the same thing). Model runs – or scenarios – are a combination of computer software files that describe the system and assumptions about the system behaviour. The runs can be varied depending on the assumptions being applied. The basic files used in a model are the system file, demand file, and climate file.

The terms 'model' and 'models' can often be used interchangeably to describe the system scenarios (models) between which are minor differences but are in effect one 'model'.

[1] MDBA (2015a)

Common terminology

For the purposes of this report, some terminology to be familiar with are presented below.

Table 1: Terminology used in this report

Term used	General interpretation
'Without development' –	A scenario where diversions for consumptive purposes in the model are zero, a scenario used to describe pre-development conditions.
'Full uptake' –	A scenario where all the water that could be taken under entitlement is taken (but still limited by applicable system rules and physical constraints)
'BDL/SDL' or 'WRP' models –	Scenarios representing various levels of development as per Basin Plan requirements. In the SDL scenario, environmental water is 'used' (or not diverted). WRP scenarios represent the conditions anticipated over the life of State Water Resource Plans (2019–29).
BP model (or similar)	Either the BDL or SDL models used in the development of the Basin Plan
BDL model	Typically refers to the updated BDL model prepared as outlined in DEWLP (2017).
WRP model	The model that is the primary subject of this assessment, representing catchment conditions over the life of the WRP. This model is proposed to be used as the method for determining permitted take, and must demonstrate that the limit it produces relates to the SDL
WMPP and WMPI	Wimmera Mallee Post-Pipeline accredited Cap model, similar level of development to the BDL Wimmera Mallee Post-Irrigation accredited Cap model, similar level of development to the WRP model
'REALM' –	REALM stands for Resource Allocation Model and simulates harvesting and bulk distribution of water resources within a water supply system.
'Sacramento' or 'Hydrolog' or 'SimHyd' –	Modelling tools used to generate the streamflow inputs into the model (sometimes referred to as catchment model)
'Crop model' or 'PRIDE' –	A tool used to generate the agricultural water demand input for the model for relevant scenarios, sometimes not relevant in the 'full uptake' scenario.

Temporal periods in models

Models can be calibrated or operated over a historical period longer than specified by the Basin Plan (1895–2009) and is often desirable. So, by way of example, a model can be calibrated over 1991–2011 but then a simulation can be 'run' over 1891–2017 or even a period outside the calibration such as 2020–2029. For model runs longer the Basin Plan period (e.g. 1891–2017), results can then be extracted for the Basin Plan period only.

Other model uses

The scope of this assessment pertains primarily to informing the accreditation of a Water Resource Plan. For completeness, it should be recognised that the model will be used for other purposes beyond this scope. Other uses include Water Resource Plan development for inter-connected systems, policy development and review, scenario planning, research, river operations, and so on.

Information in this assessment may be useful in informing those other processes where relevant.

1.5 Assessment process and materials

Prior to commencing this assessment, the DEWLP provided a number of documents, and model files used to inform the reports, to the BP modelling team. Some further material was sourced from previous review processes including accreditation for Cap, for purposes of building a complete history of model development. Some of the documentation forms part of Victoria's WRP submitted for accreditation.

The documentation considered to inform this assessment include:

- Bewsher (2011), *Wimmera-Mallee Valley – Independent Audit of Cap Model*. Prepared for the MDBA. Bewsher Consulting Pty Ltd, Epping NSW, Australia
- DSE (2011), *Report for Wimmera-Glenelg REALM Model Update: Volume 1 - Model Setup Report*, unpublished, Department of Sustainability and Environment
- DSE (2012a), *Wimmera-Mallee Post Pipeline Cap Model: Accreditation for the Murray Darling Cap*
- DSE (2012b), *Wimmera-Mallee Post Irrigation Cap Model: Accreditation for the Murray Darling Cap*
- SKM (2014), *Bulk and Environmental Entitlements Operations Review Project – Modelling Assessment*. Prepared for GWMWater. Unpublished
- DEWLP (2016), *Wimmera-Mallee Baseline Diversion Limit and Sustainable Diversion Limit Models: Implementation of a Generalised Accounting Module*
- GWMWater (2016), *Storage Management Rules: Wimmera - Mallee System Headworks*. Version: 2.02. In respect of the Bulk Entitlements and Environmental Entitlements granted for the Wimmera-Mallee System Headworks
- GWMWater (2017), *Wimmera-Glenelg REALM Model 2016-17 Data Update*
- DEWLP (2017), *Hydrologic Model for Basin Plan Compliance in Wimmera-Mallee (Surface Water) Water Resource Plan Area*, Baseline Diversion Limit and Sustainable Diversion Limit. Surface Water Assessment and Modelling Team, DELWP, VIC, February 2017
- DEWLP (2018), *Wimmera-Mallee Water Resource Plan Model*, DRAFT
- DEWLP (2018a), *Wimmera-Mallee Water Resource Plan – Part 8*, DRAFT

The model files considered in this assessment are:

File type or parameter	Vic BDL model	Vic WRP Model
System file	HW05.sys	WP01.sys
Streamflow files	WIMMflow_1891_16.prn INFW_105_16.prn	(*as per BDL*)
Streamflow (calibration data)	WIMM_chflows_1891_16.prn WIMM_hdwkfl1_1891_16.prn WIMM_hdwkfl2_1891_16.prn	(*as per BDL*)
Climate files	WIMMrain_1891_16.prn WIMMevap_1891_16.prn CLIM_103_16.prn PRIDEclimate_1891_16.prn PRIDEcropfactor_1891_16.prn	(*as per BDL*)
Demand files	WIMMdemd_1891_16.prn WIMMdemd2_1891_16.prn HAMDEM_1891_16.prn ENVDEM_16.prn	WIMMdemd_1891_16.prn WIMMdemd2_1891_16.prn HAMDEM_1891_16.prn ENVDEM_16_ForWIASale dump 2000 Jul_Nov.prn
Run period	1891–2016	1891–2016

Victoria submitted an updated version of the BDL model as well as a new WRP model.

An 'SDL' version of the model, HW04.sys – representing BDL conditions minus water recovery – was also provided. A preliminary review was previously carried out on this version (D18/3461). The primary issue with this model was that it did not incorporate GWMWater operating rules that would be in place over the life of the WRP. Preliminary feedback was provided on this basis (Jan 2018), prompting Victoria to produce the WRP version of the model that uses current GWMWater operating rules (May 2018). The WRP model is proposed as the method to determine permitted take each year.

The documentation and model materials were first reviewed on an 'assist' phase basis (i.e. preliminary) and the MDBA consolidated a response. Some informal assistance was also ongoing during this process in the form of phone discussions to answer questions and clarify issues.

The BP modelling team ran the models to verify the model results reported by the State. Some interrogation of the model files was carried out where an understanding of specific changes was required, typically by comparisons of old files with new ones to understand the changes made. Otherwise the review against the assessment criteria is primarily informed by the documentation available.

The assessment centred on providing a response to the materials using the criteria of PS 3C, which goes to forming a view on whether Basin Plan requirements have been met.

2. Comparison of Basin Plan model and WRP Model

This section of the report presents a brief comparison between the State model, used to prepare the Basin Plan (BP), and the WRP model.

The purpose of this comparison is to consider the structure of the model, and any changes, and inform the assessment of whether the structure is reasonable and consistent with the Basin Plan. It is expected that any major changes to the model, since a previous version, should be accompanied with an explanation about why the change has occurred. This comparison goes to informing the assessment of PS 3C 'model structure' criteria primarily, but also impacts on all other criteria indirectly.

This section also includes a comparison of model outputs, specifically flows and a water balance. These are standard tools for investigating whether there are errors in the model, and are indicative of the predictive capacity of the model. This goes to informing the 'prediction' criteria.

Wimmera–Mallee REALM model

The model discussed in this section is the revised version of Wimmera–Mallee REALM model received 2018 from the DELWP, Victoria. The model includes the improvements carried out subsequent to the discussions with MDBA on the initial version of model.

2.1 Model differences

The model(s) – in reference to all the scenarios – has undergone a few changes since development of the Basin Plan, including:

- Minor improvements to baseline operating conditions, demands and supply configurations2
- Improvements to model functions to allow carryover to be properly implemented in the model.
- Implementation of new storage management rules (GWMWater 2016) – specific to the WRP model

The history of the model prior to the accreditation of the model for Cap purposes is documented in Bewsher (2011). Model development prior to this period will not be revisited, except where continuity is important to a review criterion.

Carryover functionality was partly prepared in the original BP baseline model but was disabled because its implementation had not been completed. A review of GWMW operating rules occurred in 2013-14 and SKM prepared a significant report outlining a suite of options. To allow for proper assessment of a variety of options, SKM implemented carryover in the model – as documented in SKM (2014).

[2] See SKM (2014) pp. 3-24

In 2016 DEWLP prepared new candidate Basin Plan BDL and SDL models, using the previously accredited (6 Nov 2013) Post-Pipeline and Post-Irrigation Cap models as the basis for their respective development.

The changes to the WMPP and WMPI models, to arrive at the new BDL and SDL models, included:

- Minor adjustments to the destination of supply from Rocklands Reservoir to Wannon Water (on advice from Wannon Water)
- Minor correction of an error in the modelled configuration of supply to Horsham and Natimuk
- Various changes to better match the operating rules and assumptions in the Bulk and Environmental Entitlement Orders3
- Changes to the reserve rule to match Storage Management Rules (2011)
- Adopting the carryover of unused allocation rules that were incorporated in the model as part of the SKM 2014 update
- Application of a generalised accounting module to handle carryover (to standardise the way carry-over is handled by Victoria's models)
- Further updates to include the latest changes made to Storage Management Rules (GWMW 2014), as a result of the operating rules review – outlined in DEWLP (2018).

2.2 WRP representation

The Wimmera–Glenelg REALM BDL/WRP models simulate water harvesting, allocation and usage across the Wimmera–Glenelg Water Supply System. This water supply system comprises numerous headworks storages and an extensive distribution network including rivers, gravity supply channels and pipelines.[4]

The Wimmera–Mallee WRP model was developed to represent current infrastructure, operational rules and entitlements to water (based on best available information at the time of development of the model), and the levels of demand scaled (to apply full utilisation) to produce a long-term annual diversion limit.[5]

In Victoria, Bulk Entitlements define the amount of water that an entitlement holder is permitted to extract from the regulated supply system. The conditions of the Bulk Entitlements are configured into rules to supply consumptive 'demands', in accordance with those water sharing arrangements. Other constraints to supply are included in the model, such as infrastructure and operating rules. These are extensively documented in the material provided by Victoria.[6]

The WRP model represents[7]:

- regulated rivers in the system;
- some unregulated waterways that supply urban commitments under GWMWater's bulk entitlement;

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[3] DEWLP (2016) pp 12-13
[4] GHD (2011)
[5] DELWP (2018)
[6] GHD (2011), SKM (2014), DEWLP (2016)
[7] DEWLP (2016)

- water supply headwork infrastructure, including reservoirs and pipelines;
- consumptive demands and environmental releases;
- operating rules; and
- losses from the system.

The models does not represent take from groundwater. Nor does the model represent unregulated diversions under 'take and use' licences or unregulated diversions under Bulk Entitlements for Avoca, Amphitheatre, Redbank, Landsborough-Navarre, Willaura, Elmhurst, Buangor, or Willaura.

2.3 Valley-wide water balance comparison

The valley wide water balances for the different versions of the Wimmera models for 114 years of data from July, 1895 till June 2009 is shown in Table below:

Table: Valley-wide summary water balance of the two models

Water balance item	BP Model# (BDL)	WMPP for Cap*	Vic BDL model**	Vic WRP Model
Inflows (GL/y)	295.53	282.43	281.50	271.85
Watercourse diversions (GL/y)	66.42	66.90	66.87	43.84
Losses (GL/y)	207.75	187.48	186.30	198.58
End of System Flow (GL/y)	28.42	35.46	35.53	36.53
Storage flux (GL/y)	-7.89	-8.29	-8.11	-7.94

The BDL model used in preparation of the Basin Plan

* Cap accredited post-pipeline model (effectively the same as the BP BDL model)

** The updated BDL model Victoria have prepared and documented in DEWLP (2107)

The water balance check:

- verifies that the model is conserving water and that there are no unaccounted 'sinks' or 'sources'; and
- it allows the relative magnitude of all the various water inputs and outputs to be quantified. This is a particularly useful in understanding the water management process within the valley.

Changes to overall diversions between the BP model (BDL) and the new Vic BDL model are negligible (< 1 GL/y). This indicates that the system representation has not significantly altered since the making of the Basin Plan (and the accreditation of the model for Cap accounting). A more detailed water balance is provided in Appendix 3, including for some other related scenarios considered over the course of the review work.

Input files to models are recurrently updated and improved, hence the difference in 'inflows' between the BP model (Sept 2011) and the Vic BDL model (Oct 2017) are difficult to fully account for, despite extensive documentation of the various updates. Furthermore, 'inflows' include transfers from the Glenelg (via Rocklands) into the Wimmera, which accounts for some of the difference.

The change in transfer of water to the Glenelg accounts for the full difference in the difference in inflows between Vic BDL model and WRP models. Regardless, good agreement is seen between the post-pipeline accredited Cap model and the Vic BDL model.

Watercourse diversions in the WRP model are 23 GL lower than the BDL, representing the closure of the Wimmera irrigation district and sale of associated 28 GL entitlement, including 9 GL distribution losses, to the Commonwealth Environmental Water Holder (CEWH) – finalised on 21 December 2012.

2.4 Diversions summary

The comparison of long term average simulated diversions at important sites for the models is shown in the table below. These comparisons are for 114 years period from July, 1895 to June, 2009. DEWLP (2018) provides more details of the areas supplied by each off-take site.

Table: Summary of consumptive diversions in model scenarios

Water balance item (Off-take sites)	**BP Model (BDL)**	**WMPP for Cap***	**Vic BDL model**	**Vic WRP Model**
	Diversion (ML/year)	**Diversion** (ML/year)	**Diversion** (ML/year)	**Diversion** (ML/year)
Bunganally channel	3,576	3,777	3,734	0
Brimpaen storages*	2,202	2,235	2,233	2,244
Dad and Dave Weir	4,508	4,732	4,654	4,685
Taylors Lake Outlet	34,496	36,542	37,691	24,906
Lake Bellfield outlet or tail gauge	17,571	15,555	14,494	8,007
Lake Bellfield (pump station)	256	253	254	246
Lake Fyans outlet (pump station)	3,576	3,803	3,813	3,748
Fyans Creek (Stawell) Diversion Weirs (2 Nos.)				
Mt Cole Reservoir				
Langhi Ghiran Reservoir				
Panrock Reservoir				
TOTAL	66,422	66,899	66,874	43,835

* Cap accredited post-pipeline model

3. Assessment against 3C criteria

3.1 Documentation and model overview

A number of reports were supplied by Victoria to support the history of development of the Wimmera model and allow peer review consistent with 3C evaluation criteria. A complete list is provided in the references section. The reports, along with subsequent correspondence and model files, contains everything required for peer review of Basin Plan compliance. Overall, the reports are readable and clear, presented in plain English with results tables, and significant details about key assumptions and how they are represented in the model.

The key documentation with relevance to this review is DEWLP (2016) and DEWLP (2018). In DEWLP (2016), the information and assumptions used to development the revised BDL and SDL models is laid out in detail. In DEWLP (2018), a 'scenario report', the details of the preparation of the WRP model and results are provided to demonstrate the production of the long-term diversion limit and how it relates to the SDL.

As discussed in the previous section, the model was accredited for Cap compliance purposes in 2013, and the review work was available for this assessment. The WRP area and the SDL resource unit to which the model has been applied is also clearly defined in Chapter 3 of DEWLP (2018).

A clear statement of purpose is provided up front (DEWLP 2018), outlining the relationship between the model and chapter 10 of the Basin Plan, to act as the method for determining permitted take for the Wimmera (surface water) water resource plan area. The forms of take represented by the model are listed.

The interpretation of the SDL in Schedule 2 is outlined in Chapter 4 of DEWLP (2018), and has been correctly implemented. The interpretation of the BDL is also laid out clearly, and has been correctly implemented.

Overall, the reporting available has established that the model can be used to provide a practical and reliable method to determine the annual permitted take.

The scenario report comprehensively reports on all the model diversions components that make up the total take. DEWLP also provided the relevant model system files that align with their reporting.

In 2011, the independent audit report for the previous cap model (BP model) noted some potential improvements, listed in priority order. These are presented in Appendix 1, with an assessment of whether these issues have been subsequently addressed. Most of the issues are associated with data inputs, and have been addressed. Since about 2002, input data used in the model has been subject to regular updates, usually annually. Regular 'update reports' are prepared to describe the additional input data provided for each update.

Table: Annual input data updates for the Wimmera–Mallee REALM model

Update Period	Author[8]
– June 2002	SKM
July 2002 – June 2003	SKM
July 2004 – December 2006	Unknown
November 2006 – June 2008	GHD
July 2008 – June 2009	Godoy Consulting
July 2009 – June 2013	Godoy Consulting
July 2013 – June 2017	GHD

An example report of the most recent data update was provided for this assessment. It is deemed not necessary to see every data update, noting however that progressive model improvement are made with each update, particularly to climate and inflow input datasets.

The diversion results are well reported in a summary table outlining the off-take site and the areas supplied. Victoria consider that the diversions reported by the model represented the regulated system – noting however there are some minor unregulated components that are included.[9] Basin Plan modelling confirmed (in consultation with Surface Water Partnerships) that these unregulated diversions are not double-counted in the unregulated take reporting under the WRP.

Conclusion: The Wimmera model is documented to a high standard. The interpretation of BDL and SDL are clear and appropriate as outlined in DEWLP (2018). The reports describing the model development and application are comprehensive and provide significant detail about the data informing the model, the spatial coverage (maps) and its conceptualisation in the model (node-link), the calibration, and model runs required. The objectives are considered in the scenario report, and the SDL is appropriately interpreted in the model runs. The forms of take – surface water diversions only – and all classes of water right are adequately outlined in the scenario report. The WRP model provides for a practical method to determine permitted take each year.

Overall, strong evidence is presented to support the view that this WRP model is fit for purpose and is an improvement on historical versions.

[8]Bewsher (2011), GWMWater (2017)
[9] These include the Mt Cole, Langi Ghiran, Panrock Creek and Fyans Creek diversions in the upper reaches of the Wimmera Basin, and are considered to be part of the overall regulated supply system.

3.2 Data analysis

The different types of data used in the Wimmera model include data about catchment and physical layout, stream flow, climatic (rainfall and evaporation), water infrastructure information, historical surface water extraction, water allocations information and crop model data. A brief recap of each type of data used in the model is presented below:

- Climate inputs (rainfall and evaporation) and climate dependent demand inputs (including PRIDE) are all based on SILO datasets. Use of SILO datasets is standard practice. The data update report (GWMW, 2017) goes into significant details on update of these datasets for the model. The SILO data is quality checked against actual station records.
- Derivation of streamflow inputs to the Wimmera–Glenelg model were first comprehensively prepared by SKM in 2005, extending records back to 1891 using a HYDROLOG/MODHYDROLOG rainfall-runoff model. SKM provided statistical coefficients to describe calibration quality, and the results were mixed. Progressive updates (via data update reports) has improved some of these streamflow inputs, which is well documented in GMWW (2017).
- The majority of the streamflow gauge data required for the Wimmera–Glenelg model inputs is currently collected and processed by a contractor through the Regional Water Monitoring Partnership (RWMP), while others are monitored by Grampians Wimmera–Mallee Water (GWMW). Daily streamflow data and companying quality codes can be sourced from the DELWP Water Measurement Information System (http://data.water.vic.gov.au/monitoring.htm). For streamflow gauging stations monitored by GWMWater, the data is obtained from GWMWater's records. DEWLP should consider adding this data to their WMIS if it has not already.
- A complete list of streamflow inputs is provided in the data update report (GWMW, 2017). Data gap periods are listed and infilling process well documented. No groundwater data is considered in the model.
- Demands are updated or extended using regression equations or a repeating time series of monthly average demands. Demands were updated to reflect the closure of the Wimmera irrigation district and sale of the associated 28 GL entitlement to the Commonwealth Environmental Water Holder (CEWH). The majority of the remaining demands relate to delivery to the WMPP supply systems and urban centres. It appears that an analysis of actual demand data has not been reconsidered since Cap accreditation information was prepared in 2009. SKM (2014) recommended that the model be re-calibrated once several years of post-pipeline data had been collected over a range of climate conditions. No evidence suggests that this has ever occurred, probably because the associated risks are so low.[10]

[10] This is evident in MDBA water take reports – i.e. Wimmera–Mallee take under entitlement take is far below full entitlement, 2016-17 take was 14 GL of the 40 GL adjusted annual cap target (see Transition Period Water Take Report 2016-17 pp 40). Similarly, for Basin Plan purposes, the model is applying a full utilisation of entitlement scenario to produce the diversion limit. Ironically, the greatest risk with this approach is that the Wimmera is likely to produce significant cumulative credits over the life of the WRP.

Conclusion: Standard practice methods have been used to compile climate data for input into the model using SILO or stations in the valley. Demands are extended typically using an approach outlined in a manual prepared by GHD in 2012, and is well documented. Some residual risk exists because actual demand data has not been analysed, however this risk is very low because full utilisation is employed and actual diversions are considerably less than assumed in the model – a conservative assumption commonly used to generate diversion limits.

Overall, the evidence presented in the reports supports the view that the input data used is fit for purpose.

3.3 Model structure

The Wimmera model represents the GWMW regulated headworks system, comprised of numerous storages, an extensive distribution network including river, gravity supply channels and pipelines. Significant details are provided in the available documentation including maps and schematics, and a clear description of the model structure in terms of node link diagram and its spatial coverage was available – in DSE (2011), SKM (2014) and GWMW (2017) etc. The monthly time-step is adequate for strategic planning purposes and determining long-term diversion limits, given associated risks are low in this case.

Progressive changes to system representation have been documented over the suite of reports available for this assessment, the details which are comprehensively documented. The system conceptualisations appear to be appropriate for a WRP model to be used to determine permitted take.

Key observations on model system representation and its documentation include:

- Principal climate inputs and demands are well documented in GWMW (2017)
- Key system rivers, storages, channels, and pipes, associated reach losses (via loss functions) are represented appropriately (significant detail is provided in DSE 2011). WRP system conceptualisation is based on modifying the Wimmera–Mallee Post Irrigation (accredited) model, and a list of changes has been provided in DEWLP (2018) primarily as a result of the update to GWMW operating rules in 2014 (as per GWMW 2016).
- Diversions are set to full entitlement level of demand (DEWLP, 2018), the details of this process are fully described (in DSE 2011). This is consistent with the definition of the BDL for the Wimmera in the Basin Plan.
- Passing flow rules, as per Schedule 1 of the Wimmera & Glenelg Environmental Entitlement 2010, are incorporated into the model (as described in DSE 2011).
- Full utilisation of environmental entitlement via delivery to key locations within the model, as documented within DSE (2011), and GWMW (2017) – i.e. model is configured such that any

unused environmental allocation is released from the headwork storages in June each year – distributed on a 40:60 percent share between Glenelg and Wimmera[11] systems respectively.

- Storage operation rules were updated to match the most recent version of the operating rules outlined in GWMW (2016), and these changes have been documented in DEWLP (2018). The majority of these changes are relatively minor, except the new method for determining risk of spill which is complex.
- No documentation was supplied to describe the changes in the model itself, so some basic checks were carried out on the system file, and were found to match the operating rules. This check could not be carried out for the risk of spill rule – it needs to be documented.
- Carryover is implemented as outlined in DEWLP (2016) via the generalised accounting module.

DEWLP provided the BP modelling team with the system files for the model, in which all the key features of the system are represented as per the documentation provided. The model is operated over 1895-2009 consistent with the Basin Plan, and the diversion limit meets the SDL.

Conclusion: The WRP model and associated model documentation describes the system adequately, and the reported system components are represented in the model, primarily entitlements with associated conditions and catchment features such as tributaries. All of the primary features are appropriately represented including water entitlements, allocations and carryover of unused allocation. Groundwater interaction is not considered in the model. Water held by CEWH is represented, and use of environmental water is set to full use of entitlement by delivering water to key locations. Consumptive demands are set at full entitlement, so any actual growth in use cannot exceed the entitlement limits.

Therefore the model addresses the 10.12 provisions.

The model results are presented for the historical 1895-2009 period consistent with the Basin Plan, and the diversion limit meets the SDL – demonstrating against 10.10(4).

3.4 Calibration / Validation / Testing

No documentation has been submitted indicating that any significant re-calibration of the model has occurred since the model was submitted for accreditation in 2012-13. Therefore the available information in the cap accreditation review process has been drawn upon with regard to the calibration.

Both SKM (2014) and GWMW (2017) indicate that the model should be re-calibrated once several years of post-pipeline data has been collected. The Cap audit report noted the fragmented nature of the calibration, having been carried out at different times for different purposes, as a ‘deficiency in the Cap Report’.

[11] GH & W CMA (2009) Discussion Paper Defining Environment’s Preferred flow regime at key sites (environmental demands), August 2009

As noted by Bewsher (2011) the original calibration of the REALM model carried out by DSE (then DNRE) in 2002 for the purposes of supporting negotiations within the Bulk Entitlement conversion project. The aim of the calibration process at that time was to achieve a good fit of the model results with the historical records over a range of climatic conditions including wet and dry years. The calibration period began in January 1993 and ended in June 2000. This is a relatively short calibration period and does not contain the very dry years which occurred after 2000.

SKM (2005) prepared a detailed report of the calibration of the HYDROLOG model for the derivation of inputs, including parameterisation, statistical performance indicators and plots.

In 2008 GHD built on the previous system calibration (carried out by DNRE) by calibrating over the period November 2000 to October 2004. This period represented a drier climatic period than had previously been used and had much lower storage levels. It was thought that by including this drier period, it would increase modelling accuracy during years when water availability was constrained. GHD 'validated' the model by examining historical and modelled storage levels, winter channel releases and total diversions within the valley. The results were presented by plotting actual and model values in various charts within their report. Overall, the fit was reasonable.

In 2009, W&D reviewed GHD's calibration and made further improvements to the model's fit of historical records and its overall convergence stability. Calibration was only carried out over 4 years of data, 2000-2004, providing limited insight, however a longer period was used for validation 1991-2004. The validation shows a relatively good fit for total system storage and cumulative demands over the period. Unfortunately these outputs are the primary data available that demonstrating the model performance. This is a clear deficiency.

It is not clear why more recent plots have been produced to establish the predictive capacity of the mode in more recent years. DEWLP (2011) noted in the model setup, that "it is not possible to validate this updated REALM model to observed data as the model represents new operating regime and no observed data is available under the new operating regime. In the future, when adequate data is available, it is recommended that the model validation be undertaken."

Given seven years have subsequently passed, it would be prudent to complete a model validation, even if it was a rough estimation of predictive performance. There are reasonable avenues available for verifying the predictive capability of the model that have not been explored, such as plotting storage curves for a longer period (under current level of demands).

However a counter-argument exists that, because current actual demands are significantly below full entitlement, the predictive performance of the model with respect to storage and demands is of limited importance. Essentially, the WRP model exists as a hypothetical scenario, because it represents a water use scenario set far into the future for which there is no experience to draw upon. Also, the model has not changed significantly since it was accredited for cap, and most of the changes are likely to produce negligible change to model predictions.

Therefore the calibration and validation information presented in the Cap accreditation, which indicates that the model does reasonably predict the system, could be considered a sufficient basis for the WRP model.

Furthermore, DEWLP (2018) has indicated that it is working towards an implementation in Source at a daily time-step 'post-2020', which would be a significant step forward.

Conclusion: DEWLP has not provided any new information about calibration or validation of the model to indicate predictive performance. This is a clear deficiency in the reporting. Historical information about the calibration and validation of the model over 2008 and 2009 for Cap compliance is still the current best available information to describe the predictive performance of the model.

It is noted that calibration/validation is difficult given the limited data available for the post-pipeline system, however there are reasonable avenues available for verifying the performance of the model that have not been explored. No new calibration has been done, thus the model relies on its last calibration over 2008 and 2009. It is recommended that an updated calibration and validation be carried out for the new Source model that DEWLP (2018) have indicated will be prepared.

Overall, the calibration is considered acceptable based on the findings from the Cap accreditation in 2013.

3.5 Prediction

The Wimmera WRP model is run for the historical period from Jan 1891 till June 2017 (inclusive) and can be run for the period 1895-2009 as required for the Bain Plan (typically it is run for 1891-2017 and results extracted for 1895-2009). Table 3 of the scenario report provides the mean diversion limit values for different entitlements, and more details to enable comparisons across model versions has been prepared as part of this review (presented in Appendix 2).

The BDL estimate is compared with the Basin Plan estimate in the scenario report. The differences are plausible and primarily driven by the changes to system operating rules.

A water balance was not provided but one has been prepared as part of this review, also for all the relevant model versions to allow for a comparison (presented in Appendix 3). The water balance verifies that the model is conserving mass and that there are no unaccounted 'sinks' or 'sources', indicating the model is generally working as anticipated.

The water balance also confirms that the model has not changed significantly since it was accredited for Cap purposes, as indicated in DEWLP (2018). This applies to both the revised BDL model and the WRP model and their relevant predecessor models.

Bewsher (2011) previously analysed the predictive performance of the Cap accredited models (prior to accreditation), finding that:

> A statistical comparison between the recorded annual diversions (adjusted for savings as described in Section 5.7) and the cap model diversions, over the 25 year period from July 1983 to June 2008, identified that:
>
> - the correlation coefficient r2 = 0.81;
> - the mean error = +0.2 GL or +0.1% of the long-term average diversion cap;
> - the standard error = 27.4 GL or 17% of the long term average diversion cap.

Conclusion: The revised BDL estimate has been compared with the Basin Plan estimate in the scenario report. The differences in the BDL are minor, indicating that the changes have not had a material impact. Basic diversions information is provided in the scenario report outlining the model run comparisons, which is sufficient. The WRP model demonstrates that the WRP is compliant with the SDL.

The water balance demonstrates that the changes to the models, since Cap accreditation, are very minor. Therefore the predictive performance as described in the Cap accreditation is still relevant and is adequate. However the predictive performance of the model may become more uncertain over time, as new system operating rules are applied in the post-irrigation Wimmera system.

3.6 Sensitivity and uncertainty analysis

DELWP (2018) did not carry out any sensitivity analysis or discuss uncertainty in any detail. The only indication that the potential uncertainties had been considered was to suggest the SDL cumulative balance compliance trigger (i.e. Basin Plan 6.12) should be increased from 20% to 35% of long term average diversion limit for SDL compliance in Wimmera–Mallee WRP area. The claim to support this argument is that long-term diversion limits have significantly reduce by that model accuracy will probably not have.

No other basis for the development of the 35% trigger is provided, so no analysis of the merit of the figure can be conducted, and is outside the scope of the assessment regardless. However, given the evidence that 158 GL of cumulative Cap credit[12] that has been accrued, the suggestion that there is some risk of exceeding the diversion limit is not warranted. The model has been shown to be not too different to the Cap version of the model, therefore this trend of accumulation of credits is likely to continue under the operation of the WRP as the method for determining permitted take.

Conclusion: Lack of sensitivity and uncertainty analysis is a deficiency in the DEWLP (2018) reporting.

The potential limitations and uncertainties are documented in the Cap audit report and are still relevant and are sufficient.

DEWLP (2018) recommend increasing the compliance trigger under Basin Plan 6.12 to 35%, but no evidence is provided to support this, and this is outside the scope of the model review.

3.7 Model improvements

DEWLP (2018) have indicated that a Source model will be the next step of development of the method to determine permitted take. This would be a significant step forward for the predictive capacity, functionality and transparency.

[12] Transitional Period Water Take Report (2016-17), pp. 40

Therefore any suggestion of improvement for the REALM model is not applicable.

Conclusion: Not applicable, as DEWLP have indicated the next stage of development is to move to the Source platform. It is recommended that DEWLP address limitations of the current calibration and predictive performance of the model in the new Source model.

3.8 Quality assurance

The quality assurance procedures for data updates are well documented in the data update report (GWMW, 2017). Typically these updates follow guidance development by GHD in 2012.

The model run information, including the data input files, are well documented as described in the Section 2 of the report and the files were provided to the MDBA for the purpose of this assessment. Note that REALM 6.33 was used by DEWLP to develop the WRP scenario, but only REALM 6.30 was available for this review. Regardless, the results showed near exact agreement with the results reported in DEWLP (2018).

The model does not rely on inputs from other modelled valleys, therefore no details of any other model were required to be provided.

Conclusion: The model version and associated detail is reported in the scenario report DEWLP (2018). The model and model runs were submitted to the BP modelling team for review. DEWLP provided the BP modelling team with the system files for the updated BDL and WRP models, in which the key features of the system are represented as per DEWLPs documentation provided.

The numbers reported by DEWLP were replicated adequately by the BP modelling team.

3.9 Determination of Actual Take (s10.15) – if relevant

Not applicable in this assessment, because the model is not used to determine actual take.

References

Bewsher (2011), *Wimmera-Mallee Valley – Independent Audit of Cap Model.* Prepared for the MDBA. Bewsher Consulting Pty Ltd, Epping NSW, Australia

Bulk Entitlement (Wimmera and Glenelg Rivers – GWMWater) Conversion Order 2010.

DEWLP (2016), Wimmera-Mallee Baseline Diversion Limit and Sustainable Diversion Limit Models: Implementation of a Generalised Accounting Module

DEWLP (2017), *Hydrologic Model for Basin Plan Compliance in Wimmera-Mallee (Surface Water) Water Resource Plan Area*, Baseline Diversion Limit and Sustainable Diversion Limit. Surface Water Assessment and Modelling Team, DELWP, VIC, February 2017

DEWLP (2018), Wimmera-Mallee Water Resource Plan Model, DRAFT

DEWLP (2018a), Wimmera-Mallee Water Resource Plan – Part 8, DRAFT

DSE (2011), *Report for Wimmera-Glenelg REALM Model Update: Volume 1 - Model Setup Report*, unpublished, Department of Sustainability and Environment

DSE (2012a), *Wimmera-Mallee Post Pipeline Cap Model: Accreditation for the Murray Darling Cap*

DSE (2012b), *Wimmera-Mallee Post Irrigation Cap Model: Accreditation for the Murray Darling Cap*

GWMWater (2016), *Storage Management Rules: Wimmera - Mallee System Headworks*. Version: 2.02. In respect of the Bulk Entitlements and Environmental Entitlements granted for the Wimmera-Mallee System Headworks

GWMWater (2017), Wimmera-Glenelg REALM Model 2016-17 Data Update

MDBA (2012), Basin Plan 2012 Water Act 2007, Murray Darling Basin Authority Canberra.

MDBA (2015a), *Approach to monitoring and compliance – Water Resource Plans*. MDBA publication no: 01/17.

MDBA (2015b), Position Statement 3C, Method for determining take, Basin Plan Water Resource Plan Requirement, Murray Darling Basin Authority.

SKM (2005), *Wimmera-Mallee REALM Model – Derivation of Daily Inputs*, prepared for Wimmera Catchment Management Authority (document version Final A)

SKM (2014), *Bulk and Environmental Entitlements Operations Review Project – Modelling Assessment*. Prepared for GWMWater. Unpublished

W&D Engineering and Legal Services (2009), "*Murray-Darling Basin Cap Model Accreditation Submission, Wimmera-Mallee Cap River Valley.*" Prepared on behalf of Grampians Wimmera Mallee Water (GWMWater), with assistance from the Victorian Department of Sustainability and Environment (DSE). This report is hereafter referred to as the 'Cap Report'

Appendix 1 – 2011 CAP audit model improvement suggestions

Issue identified in Bewsher (2011)	Assessor comment
Rainfall on Lakes Lonsdale and Wartook is not modelled explicitly but is included in inflows to these storages and the gross evaporation is applied to the storages in the model. The methodology for derivation of inflows to these storages should be revised to separate rainfall from inflows which would allow net-evaporation to be applied to the storages in the model.	Rainfall/Evaporation is now explicitly modelled for these storages. The last data update lists Lonsdale and Wartook with rainfall datasets. Unsure exactly when this update was made. The GHD (2011) report certainly lists the same issues as Bewsher. Issue is resolved by the time SKM prepared SKM (2014). Probably an annual data update fixed the issue.
Review rainfall-runoff model for 'MtWILLIAM PICKUP' with a focus on ensuring the flow estimates represent the observed flow regime behaviour over the recent dry years.	The Mount William Pickup is an area-based transposition from catchment inflow to Lake Lonsdale, and there is no metering to validate this. So not sure how this could ever be improved. The assumptions made are transparently presented clearly in the data updates.
Review rainfall-runoff models for 'MT COLE' and 'DAIRY CREEK INFLOW' inputs, in light of a recent study undertaken by SKM (2008).	The latest data update outlines a suite of improvements these inputs and now they are derived differently.
Revisions to Waranga Western Channel inflows in the model to make them consistent with those assumed in the Goulburn/Broken/Loddon cap model.	Done each year via data updates*
Review Fyans Creek inflows – high flow cut off, causes problem with low flow dataset.	Done each year via data updates*
Review Avoca flow datasets for inconsistencies in the flows for pre and post 1963 periods.	Done each year via data updates*
Review the SKM (2004) methodology for updating climatic inputs for the period January 1891 to date with a view to replacing this with readily available SILO data.	Done each year via data updates*
Review the SKM (2004) methodology for deriving urban demands for Ararat, Stawell, and Great Western to represent climatically varying demands at 1993/94 levels of development, consistent with the other modelled demands.	Done each year via data updates*

*Data updates are significant pieces of work that aim to extend inputs datasets to the model, and make improvements where necessary.

Appendix 2 – Summary of diversions for key scenarios

Table: Comparison of diversions for scenarios: Basin Plan Baseline, Cap: Post-Pipeline, and Vic BDL

Water balance item (Off-take Site)	Water System Supplied	BP-baseline (Run 845)	CP11	BDL
Off-take Site	**Areas Supplied**	**Take limit** (ML/year)	**Take limit** (ML/year)	**Take limit** (ML/year)
Bunganally channel	Gross supply to Horsham Irrigation and Quantong Irrigation	3,576	3,777	3,734
Brimpaen storages *	GWMWater's gross supply to Wimmera– Mallee Pipeline customers (urban, D&S and future growth) on supply system 6	2,202	2,235	2,233
Dad and Dave Weir	GWMWater's gross supply via Mt Zero channel to Horsham and Natimuk	4,508	4,732	4,654
Taylors Lake Outlet	GWMWater's gross supply from Taylors Lake to: (1) irrigators, (2) recreation lakes, (3) wetlands, (4) Wimmera–Mallee Pipeline customers (urban, D&S, Supply-by-Agreement, and future growth) on supply systems 1, 2, 3 and 4, (4) Coliban Water Customer	34,496	36,542	37,691
Lake Bellfield outlet or tail gauge	GWMWater's gross supply from Lake Bell field to: (1) recreation lakes, (2) wetlands, (3) Wimmera–Mallee Pipeline customers (urban, D&S, Supply-by-Agreement, and future growth) on supply systems 1, 2, 3, 4 and 7.	17,571	15,555	14,494
Lake Bellfield (pump station)	GWMWater's gross supply from Lake Bellfield to towns direct off Wimmera–Mallee system headworks (Halls Gap and Pomonal)	256	253	254
Lake Fyans outlet (pump station)	GWMWater's gross supply to Stawell, Ararat, Great Western	3,576	3,803	3,813

Water balance item (Off-take Site)	Water System Supplied	BP-baseline (Run 845)	CP11	BDL
Fyans Creek (Stawell) Diversion Weirs (2 Nos.)	and Supply-by-Agreement customers.			
Mt Cole Reservoir				
Langhi Ghiran Reservoir				
Panrock Reservoir				
TOTAL		**66,422**	**66,899**	**66,874**

Table: Comparison of diversions for scenarios: Basin Plan SDL Target, Cap: Post-Irrigation, and Vic SDL

Water balance item (off-take site)	Water Supply System	BP-2800 Run 971	CP15	SDL	WRP
			Diversion limit (ML/year) run CP15	Diversion limit (ML/year) run SDL	Diversion limit (ML/year) run SDL
Pine Lake (outlet)	Disconnected				
Bunganally channel	Gross supply to Horsham Irrigation and Quantong Irrigation	0	0	0	0
Brimpaen storages*	GWMWater's gross supply to Wimmera– Mallee Pipeline customers (urban, D&S and future growth) on supply system 6	2,225	2,295	2,253	2,244
Dad and Dave Weir	GWMWater's gross supply via Mt Zero channel to Horsham and Natimuk	4,812	5,123	4,757	4,685
Taylors Lake Outlet	GWMWater's gross supply from Taylors Lake to: (1) irrigators, (2) recreation lakes, (3) wetlands, (4) Wimmera–Mallee Pipeline customers (urban, D&S, Supply-by-Agreement, and future	17,370	19,651	22,510	24,906

Water balance item (off-take site)	Water Supply System	BP-2800 Run 971	CP15	SDL	WRP
	growth) on supply systems 1, 2, 3 and 4, (4) Coliban Water Customer				
Lake Bellfield outlet or tail gauge	GWMWater's gross supply from Lake Bell field to: (1) recreation lakes, (2) wetlands, (3) Wimmera–Mallee Pipeline customers (urban, D&S, Supply-by-Agreement, and future growth) on supply systems 1, 2, 3, 4 and 7.	15,714	13,076	10,275	8,007
Lake Bellfield (pump station)	GWMWater's gross supply from Lake Bellfield to towns direct off Wimmera–Mallee system headworks (Halls Gap and Pomonal)	256	252	252	246
Lake Fyans outlet (pump station)	GWMWater's gross supply to Stawell, Ararat, Great Western and Supply-by-Agreement customers.	3,800	3,787	3,795	3,748
Fyans Creek (Stawell) Diversion Weirs (2 Nos.)					
Mt Cole Reservoir					
Langhi Ghiran Reservoir					
Panrock Reservoir					
TOTAL		**44,177**	**44,185**	**43,842**	**43,835**

Appendix 3 – Summary water balances for key scenarios

	BP-baseline	WMPP	BDL	Diff BDL-CP11	BP-2800	WMPI	SDL	Diff SDL-CP15	WRP
Wimmera water balance	**WMPP2046**	**WMPPcp08**	**HW05**		**WMPP2046** with changes	**WMPPcp15**	**HW04**		**WP01** REALM 6.30
Run Number	845				971				
Scenario Name	B0H000	B0H000	B0H000		P0H000	P0H000	P0H000		
Date results Uploaded	09/09/2011				24/01/2014				24/07/2018
CHANGE IN STORAGE									
Storage in 1895	930.64	961.28	942.41	- 18.87	939.99	955.53	931.92	- 23.62	929.36
Storage in 2009	31.13	16.32	17.69	1.36	27.01	15.61	16.48	0.86	24.38
Total change in storage	- 7.89	- 8.29	- 8.11	0.18	- 8.01	- 8.24	- 8.03	0.21	- 7.94
INFLOWS									
Inflows (directly and indirectly gauged)	270.88	253.64	253.79	0.15	270.88	253.64	253.79	0.15	253.79
Transfers from other basins	24.65	28.79	27.70	- 1.08	16.84	17.50	16.91	- 0.59	18.05

	BP-baseline	WMPP	BDL	Diff BDL-CP11	BP-2800	WMPI	SDL	Diff SDL-CP15	WRP
Total Inflows	**295.53**	**282.43**	**281.50**	**- 0.93**	**287.73**	**271.15**	**270.70**	**- 0.44**	**271.85**
DIVERSIONS									
Licenced private diversions	27.44	27.16	27.22	0.06	27.49	27.30	27.30	0.00	27.49
Urban diversions	12.71	12.83	12.78	- 0.05	12.94	13.11	12.83	- 0.29	12.66
Irrigation (incl loss)	22.58	23.19	23.18	- 0.01	-	-	-	-	-
Pipeline and balancing storages losses	3.70	3.73	3.70	- 0.03	3.75	3.77	3.72	- 0.05	3.68
Total Consumptive Diversions	**66.43**	**66.91**	**66.88**	- 0.03	**44.18**	**44.19**	**43.85**	- 0.34	**43.84**
Wetland diversions	0.93	0.92	0.92	0.00	0.94	0.93	0.93	0.00	0.91
Total Diversions	**67.36**	**67.82**	**67.80**	- 0.03	**45.12**	**45.12**	**44.77**	- 0.35	**44.75**
LOSSES									
Evaporation from lakes	146.59	141.14	141.79	0.65	161.37	152.68	156.07	3.39	154.31
Evaporation and loss from headworks storages and channels	33.67	22.29	20.44	- 1.85	28.64	19.34	14.85	- 4.49	17.49
River unattributed loss	27.48	24.04	24.07	0.03	31.41	26.58	27.00	0.42	26.78

	BP-baseline	WMPP	BDL	Diff BDL-CP11	BP-2800	WMPI	SDL	Diff SDL-CP15	WRP
Total Losses	**207.74**	**187.47**	**186.30**	- 1.17	**221.43**	**198.60**	**197.91**	- 0.69	**198.58**
OUTFLOWS									
D/S Lake Buloke	16.89	26.91	26.91	-	16.89	26.91	26.91	-	27.60
Yarriambiack Creek	5.39	5.37	5.43	0.06	5.18	5.03	5.36	0.33	5.31
D/S Lake Brambruk	2.05	1.44	1.43	- 0.01	3.26	2.10	2.15	0.04	1.91
Small Grampian storages	3.53	0.94	0.95	0.02	3.53	0.93	0.94	0.01	0.92
Internal model spills	0.55	0.81	0.81	0.00	0.56	0.81	0.80	- 0.01	0.79
Total Outflows	**28.42**	**35.46**	**35.53**	**0.07**	**29.42**	**35.78**	**36.16**	**0.37**	**36.53**
UNATTRIBUTED FLUX (GL)									
Total Unattributed Flux (GL)	- 0.10	- 0.04	- 0.02	0.02	- 0.23	- 0.11	- 0.10	0.00	- 0.08

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