Independent review of models to assess their representation of the baseline conditions specified in the Basin plan and estimating BDLs

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Executive Summary

Barma Water Resources (BWR Pty Ltd) was engaged by the Murray Darling Basin Authority (MDBA) to undertake a high level independent expert review of the surface water models used to provide information for formulation of the proposed Basin Plan.

The review has focused on any changes that have occurred to the baseline models since their initial development for the relevant plan or policy (ie Water Sharing Plans for NSW, Resource Operation Plans for Qld, and Cap for Victoria), and any future amendments planned by the Jurisdiction together with their relevance and significance to the Baseline Diversion Limit definition and the estimated Baseline Diversion Limit (BDL).

For the purposes of this review, the modelled component of the BDL has generally been defined as the long-term annual average limit on the quantity of water that can be taken from regulated rivers and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

Variations to this broad definition do occur from valley to valley, for example exclusions for water recovered under by the Living Murray and by Water for Rivers.

This review has not sought to determine model compliance with the BDL. As models by their very nature are continually being improved on the basis of new information and understanding. Therefore the surface water models have been assessed with respect to the extent that they represent the BDL definition and their ability to generate a robust baseline diversion limit estimate. In cases where provision of updated models to the Authority is recommended, this should be part of an agreed upon framework for updating models between the Authority and the Jurisdictions. This framework should specify the triggers for updates which may include but not be limited to:

- Specified model update frequencies
- Significance of model change
- The process by which model updating can be Quality Assured

Updated models may be required in order to improve representation of the BDL definition of improve the Baseline Diversion Estimate. A model with an improved representation of the BDL definition may not necessarily result in an alteration to the BDL estimate.

Model Representation of Baseline Diversion Limit Definition

New South Wales

With the exception of the NSW Murray and Lower Darling, determination of water course diversions in New South Wales (NSW) regulated river systems and the unregulated Barwon Darling is undertaken using the Integrated Quantity and Quality Model (IQQM).

There are a number of models for which the representation of the baseline diversion definition for the relevant SDL resource unit can be improved through provision of more up to date models. These are the Border Rivers, Gwydir, Macquarie, Barwon Darling, Lower Darling and NSW Murray.

Improved representation of the BDL definition for the Murray and Lower Darling can be achieved through the model modifications outlined in sections 2.10 and 2.1. This includes the creation of a LTAAEL scenario. In the case of the Lower Darling, longterm diversion volumes assumed to apply to the 250GL of water recovered under the Living Murray Program should be checked to ensure they align with the 35,500ML figure stated in the LTAAEL definition in the NSW Water Sharing Plan for the Murray and Lower Darling Regulated Rivers.

Whilst satisfactory, the Lachlan and Namoi modelled BDL definition requires clarification with respect to treatment of surface and groundwater connectivity. The Peel, and Murrumbidgee models appear to require no updating at this stage.

Victoria

Modelling in Victorian regulated systems is undertaken using REALM (Resource Allocation Model).

Victoria has not yet formally advised on the definition / interpretation of Baseline Diversion as at 30 June 2009 and has a number of queries. These include how diversions from storages on small streams for urban use that are not included in the large system models reviewed here are treated; and whether the 30 June 2009 cut-off date literally applies if a rule has changed post this date. For example some setting associated with Victorian carryover rules.

Based on the interpretation of the BDL definition for this review, the following valley models used by the Authority can be replaced by more up to date models held by DSE in order to improve representation of the BDL definition. These consist of the:

- Goulburn Simulation Model (Including the Goulburn, Broken, Loddon, Campaspe)
- Murray Simulation Model
- Wimmera Model

The Kiewa and Ovens models appear to satisfactorily represent the BDL definition as interpreted for this review. However, in the case of the Murray portion of the model proposed improvements may further improve BDL representation. This includes representation of the Victorian Murray 30% carry over arrangements as at June 2009. Additionally, if the definition queries raised by Victoria are confirmed then the Murray model will also require further amendment.

Queensland

Modelling in Queensland's regulated (or supplemented) and unregulated (or unsupplemented) river systems is undertaken using the Integrated Quantity and Quality Model as in New South Wales.

Five of the six Queensland Basin river system models have had amendments subsequent to provision to the Authority. More recent versions of these models should be supplied to the Authority to allow improved representation of the BDL definition. In decreasing order of significance, these are the:

- Condamine Balonne
- Warrego
- Nebine
- Moonie
- Paroo

No amendments to the Border Rivers model have been made.

South Australia

The Murray Simulation Model model is also considered to be representative of the baseline definition for South Australia. However, improvements in BDL representation are likely to occur through adoption of the proposed improvements as listed in the NSW Murray section of this report.

Baseline Diversion Limit Estimation

A comparison between longterm average diversions from the models used by the Authority in formulation of BDL estimates in the proposed Basin Plan and the latest version of those same models for common simulation periods are presented in Table E1. At the time of this review longterm average diversions for all of the model versions currently existing for each valley were not available for the 1989 to 2009 period. Consequently, for comparative purposes alternative reporting periods have been used in some instances.

As can be seen from Table E1 the percentage differences in longterm average diversions between the versions of the models are small. This is also likely to be the case for total BDL estimates (which include a modelled component) and thus there is no urgency for updated models to be adopted by the Authority at this stage. However, when updated models are supplied then as stated previously, it should be part of an agreed upon framework between the Authority and the Jurisdictions for updating models. Not with standing this the following observations with respect to BDL estimates are made for each Jurisdiction.

New South Wales

Based on the results of Table E1, at some point updated models should be supplied to the Authority for use in determining baseline diversion estimates for the following valleys:

- Gwydir.
- Border Rivers.
- Macquarie.
- Barwon Darling

The Authority is in possession of the most up to date and appropriate models for baseline diversion estimation for the Peel, Murrumbidgee, Murray, and Lower Darling.

In the case of the Namoi and Lachlan, there is a need for resolution of the appropriate flux volume to represent surface and groundwater interaction. This should be resolved by NSW and the Authority so as agreement as to which model is the most appropriate for baseline diversion estimation can be made.

Whilst the current Murray model appears to be satisfactory for determining baseline diversions, a revised estimate of the NSW Murray LTAAEL should be developed jointly between NSW and the Authority (refer to section 2.11.1). Revisions may result in changes to the current BDL estimate.

Victoria

An updated version of the Goulburn Simulation Model should at some stage be adopted by the Authority for use in determining baseline diversion estimates. This is particularly the case for the Campaspe valley. The current model used by the Authority, whilst not the most up to date is considered to be satisfactory for preliminary baseline diversion estimation for the Goulburn, Broken, Loddon.

Models currently used by the Authority for the Wimmera, Ovens, Kiewa, and Murray Valleys are also considered appropriate for preliminary BDL estimation. However an updated MSM model run which includes inflows from updated tributary BDL models would be required as part of an updated BDL estimate.

Queensland

Baseline diversion estimates are considered to be satisfactory for the Border Rivers, Moonie, Warrego, Paroo. Baseline diversions estimates for the Condamine Balonne, and Nebine can be improved through adoption of updated models by the Jurisdiction to the Authority.

South Australia

The baseline estimates for the South Australia Murray are based on the Authority's Murray Simulation Model and are considered to be satisfactory.

Table E1 - comparison between longterm average diversions from the model used by the Authority in formulation of BDL estimates in the proposed Basin Plan and the latest version of that model.

Valley	Longterm Average Diversions from the Model Supplied and Used by the Authority to contribute to the Baseline Diversion Limit Estimate (GL/Yr)	Latest Model Longterm Average Diversion (GL/Yr)	Difference (GL)	Percentage Difference	Climatic Period
New South Wales					
NSW Border Rivers	191.4	193.7	2.3	1%	1890-2004
Gwydir	329.6	318	-11.6	-3%	1892-2000
Namoi	261	254	-7	-3%	1892-2000
Peel	15.1	15.1	0	0%	1892-2001
Macquarie	389.5	381 (estimate only)	-8.5	-2%	1895-2001
Lachlan	311	311	0	0%	1898-2000
Murrumbidgee	1890	1890	0	0%	1892-2000
Barwon Darling	195.1	209.8	14.7	7%	1895-2009
Lower Darling	137	137	0	0%	1891-2006
NSW Murray	1789	1789	0	0%	1891-2006
Victoria					
Goulburn	1551.6	1549.9	-1.7	0%	1895-2009
Broken	13.2	13.1	-0.1	-1%	1895-2009
Loddon	88.6	88.9	0.3	0%	1895-2009
Campaspe	110.9	116.1[1]	5.2	4%	1895-2009
Wimmera	65.7	65.7 (estimate only)[2]	0	0%	1895-2009
Ovens	25	25	0	0%	1895-2009
Vic Murray	1657	1657	0	0%	1895-2009
Kiewa	7	7	0	0%	1895-2009
Queensland					
Qld Border Rivers	250	250	0	0%	1890-2000
Condamine Balonne	717.5	729	11.5	2%	1922-1995
Moonie	34.4	34.4	0	0%	1889-1998
Warrego	47.3	47.3	0	0%	1889-1999
Paroo	0.2	0.2	0	0%	1889-1999
Nebine	6.4	6.9	0.5	7%	1889-1999
South Australia					
Metro Adelaide	100	98	-2	-2%	1891-2006
Country Town	48	48	0	0%	1891-2006
AOP	450	449	-1	0%	1891-2006
Lower Swamps	94	93	-1	-1%	1891-2006

[1] Model yet to be provided to the Authority

[2] Victoria is yet to supply its latest BDL model and estimate for the Wimmera. Though it is unlikely to significantly change from the current estimate used by the Authority.

Summation and Overall Recommendations

This review has assessed the surface water models used to establish baseline diversions estimates for 24 valleys as part of the proposed Basin Plan. Representation of the baseline diversion definition and the models ability to determine baseline diversion estimates have been assessed. Due to the nature of river system models, and their continual improvement as a consequence of new data or information, the degree of representation of the BDL may be improved over time.

All models have been found to be representative of their respective baseline definitions. However a number of models have been found to require updating in order for representation of the baseline diversion definition and associated diversion estimates to be improved.

The baseline diversion definition as currently presented in the proposed Basin Plan is potentially open to interpretation. In order to overcome this, the Authority should consider the development of a set of guidelines which assist in development model scenarios that appropriately represent the baseline diversion definition and produce robust baseline diversion estimates. Definition interpretation issues that should be considered in development of guidelines include:

- Clarify the definition of the 30 June 2009 cut-off. For example how it effects:
  - Policy Changes
  - Operating rule changes
- How interconnected systems are represented under the definition.
- How water recovered for the environment is represented in the river system models.
- Other key assumptions such as the accounting framework, and assumed release patterns.

It is suggested that a diversion definition register similar to that developed for application of the MDB Ministerial Council Cap be created in order to ensure consistency in diversion reporting from the baseline models.

The term “excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers” when used in the context of the BDL definition requires clarification in the context of model scenario establishment. It is recognised that a set of longterm Cap equivalent factors (called Longterm Diversion Limit Equivalent Factors) have been approved by Ministerial Council for use in determining the volumes associated with water recovery. However, in the absence of a formal method for representation of recovered volumes in the river system models, diversions associated with water recovery initiatives in the baseline models are not always equal to the

longterm Cap equivalent. For example, in Victoria, water recovery entitlements are represented explicitly in the river system models and have diversions associated with 2009 development levels and are not forced to equal a pre-agreed longterm Cap equivalent. Whereas in the NSW models (including the Murray), the BDL estimate has been based on a diversion associated with the longterm Cap equivalent. Resolution with respect to whether the diversion is based on longterm Cap equivalents, longterm average annual yield (as adopted by the Commonwealth) or 2009 levels is required along with the development of a formal method for inclusion in the models to ensure consistency baseline diversion estimation.

This review has demonstrated the wide range of baseline diversion estimates that can occur for the same model. It is likely that estimates of baseline diversions for each valley will continue to change over time as models continue to be improved. Consequently, the Authority should consider a strategy relating to how and when changes in baseline diversion estimates can best be disseminated to end users. This strategy is best initiated through the development of an agreed upon framework for updating models between the Authority and the Jurisdictions.

1 Introduction

1.1 Background

Barma Water Resources (BWR Pty Ltd) was engaged by the Murray Darling Basin Authority (MDBA) to undertake a high level independent expert review of the surface water models used to provide information for formulation of the proposed Basin Plan.

The review has been completed in just over 1 month and has covered 24 models. Consequently, a detailed assessment of the inner working of each model, processes used to calibrate the models and establish scenarios (including checking parameter values) has been unable to be undertaken. Rather, the review has focused on any changes that have occurred to the baseline models since their initial development for the relevant plan or policy (ie Water Sharing Plans for NSW, Resource Operation Plans for Qld, and Cap for Victoria), and any future amendments planned by the Jurisdiction together with their relevance and significance to the Baseline Diversion Limit Definition and the estimated Baseline Diversion Limit (BDL).

For the purposes of this review, the modelled component of the BDL has generally been defined as the long-term annual average limit on the quantity of water that can be taken from regulated rivers and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

Variations to this definition do occur from valley to valley, for example exclusions for water recovered under by the Living Murray and by Water for Rivers. These are further discussed within this report.

1.2 Audit Terms of Reference

The scope of this review has been limited to the component of the BDL that is modelled and scope of work has not included reviewing estimates of diversions which are not in the models.

The core questions to be addressed by this consultancy were to:

- Review models setup for their representation of the baseline conditions stipulated in Schedule 3 of the proposed Basin Plan.
- Review the suitability of the models for use for estimating BDLs.
- Identify any additional work needed to update the models to meet the requirements of the proposed Basin Plan.

1.3 Models Assessed

As stated in MDBA 2012, the MDBA is using 24 hydrological models linked together to represent the Basin's surface water resources. The individual models of the major river systems were originally developed by the Basin States, except for the Murray which has been developed by MDBA and two models by Snowy Hydro Limited and CSIRO. These models have been run in combination for over 40 years, but were first linked by CSIRO as part of its Murray–Darling Basin Sustainable Yields (MDBSY) project. The MDBA has built on the work of the states and the linkage put in place by CSIRO, and updated the methods and tools to adapt them for the specific needs of the Basin Plan.

1.4 Information Supplied and Reviewed

Modelling Reports detailing the types of climatic data, parameters and methods used to develop and calibrate the models for Cap purposes for each Valley were provided at the commencement of the review by MDBA. A number of additional reports relating to the modelling conducted by the Authority in preparation of the proposed Basin Plan were also provided. In particular information contained in the following reports was of particular relevance in the review.

- Comparison of watercourse diversion estimates in the proposed Basin Plan with other published estimates (MDBA 2011a)
- River System Models used for the Development of the Basin Plan (MDBA 2010)
- Water resource assessments for without-development and baseline conditions. Supporting information for the preparation of proposed Basin Plan (MDBA 2011b)
- Hydrologic Modelling to Inform the Basin Plan – Methods and Results MDBA 2012

In addition, in order to complete this project in the desired timeframes, questionnaires were sent to each Jurisdiction for each relevant model. Responses have been used to evaluate each model against the above mentioned terms of reference.

1.5 Meetings and Correspondence

A number of meetings were held during the review in order to gain further clarification in relation to aspects of model configuration, amendments and planned future development. These included:

- MDBA staff on the 23/3/2012, and 10/4/2012.
- NSW Office of Water Staff on the 29/3/2012
- Qld Department of Environment, Resources and Mines staff on the 4/4/2012
- Vic Department of Sustainability and Environment staff on the 3/5/2012
- South Australian Department for Water 26/4/2012

Principle contacts for the review were:

- Mr Craig Johanson - Principal Hydrologist Queensland Department of Environment, Resource Management
- Mr Richard Beecham - Senior Hydrologist New South Wales Office of Water
- Mr Seker Mariyapillai - Water Entitlements & Strategies Division, Vic Department of Sustainability and Environment
- Ms Chrissie Bloss – Senior Hydrologist - South Australian Department for Water
- Pradeep Sharma – Basin Plan Modelling Director, Murray Darling Basin Authority
- Ingrid Takken - Hydrologist, Murray Darling Basin Authority

1.6 Report Structure

Chapters 2 to 5 summarise the current status of the surface water models with respect to the baseline definition, and associated diversion estimates. An assessment of any proposed improvements to each model and their consequences have also made for each Jurisdiction. Chapter 6 presents review conclusions and recommendations with respect to the models representation of the BDL definition and their suitability for estimating baseline diversions.

2 New South Wales Jurisdictional Models Current Status and Future Amendments

2.1 Introduction

With the exception of the NSW Murray and Lower Darling, determination of water course diversions in New South Wales (NSW) regulated river systems and the unregulated Barwon Darling is undertaken using the Integrated Quantity and Quality Model (IQQM). IQQM has been developed for use as a tool for planning and evaluating water resource management policies at the river basin scale. The model can be applied to regulated and unregulated streams, and is capable of addressing water quality and environmental issues, as well as water quantity issues. The model operates on a continuous basis and can be used to simulate river system behaviour for periods ranging up to hundreds of years. It is designed to operate at a daily time step but some processes are simulated at shorter time steps. It is anticipated that the IQQM models will be eventually replaced with models developed under the eWater Source platform. This may also result in changes to baseline diversion estimates.

2.2 NSW Border Rivers

2.2.1 Jurisdictional Model Current Status

The Border Rivers IQQM that is most appropriate for estimation of baseline diversions is the longterm average annual extraction limit (LTAAEL) model. This has undergone a number of changes since provision of the model to the Authority. Changes in diversions are presented in Table 1. These changes have resulted in alterations in the baseline diversion estimate of approximately 2 GL/Yr.

Changes from the original model supplied to the Authority and the model used in development of the Border Rivers Regulated Rivers Water Sharing Plan consists of:

- LicVol (total) increased by 1,000ML;
- LicVol (“A class”) increased by 60ML
- Pump Capacity Increases by 100ML/d
- Allocation system changed to approximate continuous accounting
- Improved representation of system inflows (in particular Macintyre Brook System Inflows)

Changes from the model used to formulate the Water Sharing Plan to the latest model held by the Office of Water are minor and consist solely of modification to some of the input flow and climate data.

Table 1 - NSW Border Rivers Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1890 -2004)
(1) Border Rivers Valley longterm average diversions as per baseline (longterm extraction limit) model supplied to the Authority.	191.4
(2) Border Rivers Valley longterm average diversions stated in Statutory Water Plan as per baseline (longterm extraction limit) model (BR0609U4.s7_, IQQMV6.73.4 (CSIQQM))	193.3
(3) Border Rivers Valley longterm average diversions as per latest baseline (plan limit) model held by the Jurisdiction run over the same climatic period as (1) (IQQMV 6.73.4 (CSIQQM) System File test2011.s7_)	193.7

2.2.2 Jurisdictional Model Proposed Improvements

Proposed improvements to the Border Rivers IQQM model include:

- Use of an updated crop model for Irrigator groups upstream of the Dumaresq Macintyre Junction
- Representation of environmental flow rules contained in the Border Rivers Regulated Water Sharing Plan. Specifically:
    - Pindari minimum flow releases of Jun-Aug – 200 ML/d and minimum of 10ML/d at all times. These releases are to be protected from extractions till confluence between the Severn River and Frazers Creek.
    - A stimulus flow of 4,000 ML/year stored and released from Pindari if Pindari inflow on any day within Apr-Aug window is >1,200 ML/d;
    - Low flow tributary protection (up to 100 ML/d) deliverable to Mungindi.

- Implementation of rainfall harvesting
- Modelling of groundwater access to supplement surface water flows and meet Crop Water Requirements (especially in dry/low water availability years)
- Incorporate variable river surface area. This will provide a better representation of varying evaporation from the water surface based on stream flow and, consequently, better representation of the source of losses and gains within a river reach.
- Better representation of tributary inflows.
- Recalibration of flows, diversions and irrigator behaviour to incorporate data from the recent drought.

Some of these changes are significant and are likely to alter the baseline diversion estimate.

2.2.3 Baseline Model Amendments made by MDBA

The only modification to the model supplied to the MDBA (model 1 inTable 1) as mentioned in MDBA 2011a, has been to change the period of simulation from 1890-2004 to 1895-2009.

2.2.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the purposes of this review, the NSW Border Rivers system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

Note: It is suggested that this definition needs to be amended in the proposed Basin Plan Schedule 3 to *State water management law as at 1 July 2009* to align with the Border Rivers Water Sharing Plan Gazettal date.

Given the above note, for the purposes of determining Border Rivers modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long term average annual extraction from the New South Wales section of the Border Rivers valley under the New South Wales – Queensland Border Rivers Intergovernmental Agreement 2008. Given effect, through the Water Sharing Plan for the Border Rivers Regulated Water Source and application of the rules defined in this Plan.

Whilst differences in estimates of longterm average diversions are small (approximately 2GL/yr) for the various models, model 3 in Table 1 is judged to best represent the definition of the BDL, and for estimating associated diversions. The updated model should be provided to the Authority by the NSW Office of Water in accordance with an agreed upon model updating framework (refer to Chapter 6). .

2.3 Gwydir

2.3.1 Jurisdictional Model Current Status

The Gwydir IQQM model relevant to baseline diversion estimation is the LTAAEL model. This has undergone a number of changes with alterations in diversion estimates ranging

from a longterm average diversion of 392GL/Yr to the current NSW Office of Water estimate of 318GL/Yr. These are presented in Table 2. Differences between model (3a) and model (3b) are solely due to software upgrades. However, as can be seen from the Table, the difference in the diversions between the model 2 currently held by the Authority and Model (3b) held by the NSW Office of Water is 11.6GL/Yr. This difference is attributable to:

- Model 3b having an allocation system based upon an October to September water year and the MDBA supplied model 2 having the same system but based on a July to June water year.
- Alteration in representation of residual catchment inflows
- Errors in the connection between the model and input data in the MDBA model - As a result, the system inflow in MDBA's baseline model as well as Basin Plan model is lower than in the Office of Water's WSP/Plan Limit model by ~ 26GL/year for the simulation period from 07/1895 to 06/2009.
- A change in the modelled representation of the Stock & Domestic replenishment. This change was not reported to MDBA. Consequently, changes have not been implemented into the latest models used by MDBA for this round of Basin Plan modelling. This change increases longterm average diversions by about 700 ML/year.

Table 2 – Gwydir Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** 1892 to 2000 (Oct to Sep)
(1) Gwydir Valley longterm average diversions stated in Statutory Water Plan as per baseline (longterm extraction limit) model (IQQMV6.61.106 System File WSP8TST6.SQQ)	392
(2) GwydirValley longterm average diversions as per baseline (longterm extraction limit) model supplied to the Authority (IQQMV7.67.4, GWYD_A0_01_V01_Jul-Jun.sqq)	329.6
(3a) Gwydir Valley longterm average diversions as per latest baseline (plan limit) model held by the Jurisdiction (IQQMV7.50.23 System File dev9900+wsp05_11_newS&D.sqq)	313
(3b) Gwydir Valley longterm average diversions as per latest baseline (plan limit) model held by the Jurisdiction (IQQMV7.67.4) System File dev9900+wsp05_11_newS&D.sqq)	318

2.3.2 Jurisdictional Model Proposed Improvements

In summary proposed improvements to the model consist of

- Updates to reflect change in water year from October–September to July-June
- Representation of Tareelaroi Weir, Boolooroo Weir, Tyreel Weir, Combadello Weir.
- Updates to a new crop model which better represents farmer behavioral practices
- Improved representation of ECA use
- Better and more accurate representation of FPH in the model
- Better and more accurate representation of Rainfall Harvesting in the model
- Better representation of channel capacity constraints within the Lower Gwydir.
- Modeling of groundwater access to supplement surface water flows and meet Crop Water Requirements (especially in dry/low water availability years)
- Incorporate variable river surface area. This will provide a better representation of varying evaporation from the water surface based on stream flow and, consequently, better representation of the source of losses and gains within a river reach.
- Better representation of tributary inflows.
- Better representation of the Gwydir Wetlands
- Recalibration of Flows, Diversions and Irrigator Behaviour to incorporate data from the recent drought.

All of these amendments are likely to change the baseline diversion estimate by some amount.

2.3.3 Baseline Model Amendments made by MDBA

The model supplied to the MDBA for baseline diversion purposes has been modified to run on an allocation and accounting system for a July to June water year. This came into effect during Gazettal of the Gwydir regulated river water sharing plan. Whilst this modification is easily made to the model, changes to the water year accounting periods are likely to alter irrigator behaviour. This has not been captured in the current model and would require the model to be recalibrated.

The model provided to the MDBA (model 2 in Table 2) has also been amended to reflect changes to the period of simulation from 1892- 2000 to 1895-2009.

2.3.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the purposes of this review, the river system model component of the BDL for the Gwydir Regulated River Water Source is the long-term annual average limit on the quantity of water that can be taken from regulated rivers and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

For the purposes of determining Gwydir regulated river modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual extraction from this water source that would occur with the water storages and water use development that existed in 1999/2000, the share components existing at the commencement of the water sharing plan for the Gwydir Regulated River Water Source and application of a limit on supplementary water access licence extractions of 1 megalitre per unit share and the other water management rules defined in this Plan.

Based upon this definition, model 3b and not model 2 (which is currently held by the Authority) would appear to be most representative of the baseline definition. This is due to model 2 requiring recalibration due to the water year being changed from October to September to July to June, and amendments to inflows and stock and domestic release patterns subsequent to the model being provided to the Authority.

Whilst there are a number of future model improvements which are likely to alter the baseline diversion estimate (as stated in section 2.3.2). Provision of model 3b to the Authority should occur as part of an agreed upon updating framework to allow updated diversion estimates to be made.

2.4 Namoi

2.4.1 Jurisdictional Model Current Status

The Namoi IQQM LTAAEL model is considered to be the most appropriate for estimating baseline diversions. The model has undergone a number of changes since its use in establishing the LTAAEL in the Namoi Regulated River Water Sharing Plan. Longterm average annual diversions from the various models are presented in Table 3. Longterm average diversion changes from the original model and that supplied to the Authority are 19.6GL/Yr. Changes from the original model and that supplied to the Authority relate to:

- The original model having an allocation system based upon an October to September water year and the MDBA supplied model having the same system but based on a July to June Water year.
- Inclusion of Mollee Weir
- On farm storage operational amendments to include end of water year filling and initial storage volumes
- Changes to efficiency and soil moisture store size parameters in crop model
- Changes to supplementary access conditions to reflect additional data.
- Changes to overbank flow thresholds
- Changes to Rainfall Harvesting Assumptions
- Operational delivery constraints Upstream of Keepit, Pian Creek at Rossmore, Gunidgera Ck, and Goangra.
- Improvements in representation of Stock and Domestic Demand
- Split Rock to Keepit Loss Functions
- Pian Creek Order times.

Changes from the model supplied to the Authority (model 2, Table 3) and the Current model held by the jurisdiction (model 3,Table 3) are in the order of 6GL/Yr. This difference is due to 6.6 GL/y of modelled unregulated diversion included the result for Model 2 (according to MDBA reporting), while numbers reported for models 1 and 3 (by NSW) do not include these diversions. In the current model (model 3 in Table 3) groundwater/surface water connectivity values have also been set to zero.

Table 3 - Namoi Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** 1892 to 2000 (Oct to Sep)
(1) Namoi Valley longterm average diversions stated in Statutory Water Plan as per baseline (longterm extraction limit) model (IQQM run number 9078. Version 6.61.101)	238 (Does not include Stock and Domestic demand of 1,5GL/Yr)
(2) Namoi Valley longterm average diversions as per baseline (longterm extraction limit) model supplied to the Authority IQQM 7.67.4,Namo_A0_01.sqq	261 (GW/SW flux set to zero)
(3) Namoi Valley longterm average diversions as per latest baseline (plan limit) model held by the Jurisdiction IQQM Version 7.67.4 System File Namo_A0_01	254 (GW/SW set to zero) Average from October 1892 to Sept 2000. Water year is July to June. Initial conditions different from (1).

2.4.2 Jurisdictional Model Proposed Improvements

Proposed improvements to the Namoi model consist of:

- Representation of Weirs within the model.
- Updates to a new crop model which better represents farmer behavioral practices
- Improved representation of ECA use
- Better and more accurate representation of FPH in the model
- Better and more accurate representation of Rainfall Harvesting in the model
- Better representation of Domestic and Stock replenishments for Pain Creek
- Better representation of tributary inflows.
- Incorporate variable river surface area. This will provide a better representation of varying evaporation from the water surface based on stream flow and, consequently, better representation of the source of losses and gains within a river reach.
- Converting the model from GUI IQQM to Source Rivers
- Recalibration of Flows, Diversions and Irrigator behaviour to incorporate data from the recent drought.

These amendments are all likely to change the baseline diversion estimate by some amount.

2.4.3 Baseline Model Amendments made by MDBA

The model provided by the NSW Office of Water to the MDBA (model 2) has been modified to represent losses due to Surface and Groundwater interaction at 2030. As stated in MDBA 2011 an additional loss of 11.2GL/y has been included. This has reduced the longterm average diversion from the 260.7GL/y presented in the Table to 258.7GL/y.

The model provided to the MDBA (model 2 in Table 3) has also been amended to reflect changes to the period of simulation from 1892- 2000 to 1895-2009.

2.4.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the purposes of this review, the Namoi regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

For the purposes of determining Namoi modelled watercourse diversions state water management law as at 30 June 2009 is taken to mean the long-term average annual extraction from these water sources that would occur with the water storages and water use development that existed in 1999/2000, the share components existing at the commencement of the water sharing plan for the Upper Namoi and Lower Namoi regulated river water sources plan and application of the water management rules defined in this Plan,.

Model 2, Table 3 (currently held and modified by the Authority) or Model 3, Table 3 appear to both be representative of the BDL definition. With the only difference prior to MDBA modification being reporting of diversions. However the choice of the most appropriate volume for losses associated with Surface and Groundwater interaction still seems to be in contention. This issue should be resolved by NSW and the Authority so as agreement as which model is the most appropriate for baseline diversion estimation can be made.

2.5 Peel

2.5.1 Jurisdictional Model Current Status

The Peel IQQM LTAAEL model is considered to be the most appropriate model for estimating baseline diversions. Unlike other models for NSW, the Peel IQQM model most suitable for baseline establishment has not gone under any modifications by the

New South Wales Office of Water. Consequently, the model held by the Authority is the same as that held by the Office of Water.

Table 4 - Peel Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1892 -2001)
(1) Peel Valley longterm average diversions stated in Statutory Water Plan as per baseline (longterm extraction limit) model (IQQM version 7.67.4 scenario run number 'W59'.)	15.1
(2) Peel Valley longterm average diversions as per baseline (longterm extraction limit) model supplied to the Authority run over the same climatic period as (1) (IQQM version 7.67.4 scenario run number 'W59'.)	15.1
(3) Peel Valley longterm average diversions as per latest baseline (plan limit) model held by the Jurisdiction run over the same climatic period as (1) (IQQM version 7.67.4 scenario run number 'W59'.)	15.1

2.5.2 Jurisdictional Model Proposed Improvements

Crop Areas in the Peel Valley are not only a function of local water availability, but also regional demands for Lucerne and Pasture. This has been replicated in the model through crop area and rainfall relationships. NSW has indicated that this relationship may change in the future if better information comes to hand.

It is also envisaged that the model will be converted from GUI IQQM to Source Rivers in the future.

These improvements are likely to change the baseline diversion estimate.

2.5.3 Baseline Model Amendments made by MDBA

As mentioned in MDBA 2011a, amendments to the model provide to the MDBA (model 1 in Table 4) consisted solely of changes to the period of simulation from 1892- 2001 to 1895-2009.

2.5.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the purposes of this review, the Peel regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

Note: As the Peel Water Sharing Plan was gazetted on the 1 July 2010, it is recommended that the BDL definition in Schedule 3 of the proposed Basin Plan be amended to "State water management law as of 1st of July 2010".

For the purposes of determining Peel modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long term average annual extraction from this water source that would occur with the water storages and water use development that existed in 2007/2008, the share components existing at the commencement of the Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources and the application of the rules defined in this Plan, plus the long term average annual extraction from Dungowan Dam water storage by a local water utility access licence.

Given the recent gazettal of the Peel Water Sharing Plan, the current model held by the Authority is considered to be representative of the BDL definition and is suitable for use in estimating baseline diversions.

2.6 Macquarie

2.6.1 Jurisdictional Model Current Status

The Macquarie Valley IQQM LTAAEL model is considered to be the most appropriate for BDL estimation. The model has undergone a number of modifications since it was first used in development of the Macquarie and Cudgegong Regulated River Water Sharing Plan. Changes from the original model to that supplied to the Authority consist of:

- Modification to the modelled representation of the Wildlife Allocation which was changed to include a translucent (96GL) and fixed (64GL) component.
- Burrendong dam inflows (from Chifley section) were recalibrated for a more realistic representation during low flows.
- A software update.

Minor changes have also occurred from the model supplied to the Authority and the current model held by the NSW Office of Water. These are likely to only produce small changes in the longterm average diversions and consist of changes to:

- Irrigation Crop Model Demand parameters
- Representation of system tributary and residual catchment inflows
- Transmission Loss Representation

Table 5 – Macquarie Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1890 -2001)
(1) Macquarie Valley longterm average diversions stated in Statutory Water Plan as per baseline (longterm extraction limit) model (IQQM run number MacWSP06)	391.9 (1890-2001) 383.2 (1895-2001)
(2) Macquarie Valley longterm average diversions as per baseline (longterm extraction limit) model supplied to the Authority run over the same climatic period as (1)	389.5 (1895-2001) Not available for 1890 – 2001, but when run over period from 1895 to 2001 shows a difference in longterm avg diversions to model 1 of 6.3 GL/Yr
(3) Macquarie Valley longterm average diversions as per latest baseline (plan limit) model held by the Jurisdiction run over the same climatic period as (1)	389.7 (1890-2001)

2.6.2 Jurisdictional Model Proposed Improvements

Proposed improvements by the NSW Office of Water to the Macquarie IQQM model that relate to the baseline definition and estimate of longterm average diversions include:

- Better representation of the use of planned and held environmental water
- Amendment to the Cudgegong storage reserves to reflect new minimum inflows sequences.
- Improvements in farmers behaviour representation to reflect better information on planting decisions in years of low water availability.
- Potential inclusion of floodplain and rainfall harvesting practices.
- Improvements in the representation of transfer of water from Windermere Dam to Burrendong Dam.
- Better representation of the wetlands of the Macquarie Marshes.
- Overall recalibration of the model to incorporate additional data from the recent drought.

All of these improvements are likely to alter the estimate of the BDL. However the degree of alteration to the existing estimate is unclear at this stage.

2.6.3 Baseline Model Amendments made by MDBA

Amendments to the model provided to the MDBA (model 2 in Table 5) consisted solely of changes to the period of simulation from 1890- 2001 to 1895-2009.

2.6.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the purposes of this review, the river system model component of the BDL for the Macquarie and Cudgegong Regulated Rivers is the long-term annual average limit on the quantity of water that can be taken from regulated rivers and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law (as if the applicable water sharing plan was not suspended) as at 30 June 2009; and

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

For the purposes of determining Macquarie modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual extraction from this water source that would occur with:

- the water storages, private water management infrastructure and cropping mix that existed in 1999/2000,
- the share component existing at the commencement of the Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source,
- the maximum crop area and the crop planting behaviour representative of baseline conditions used for assessment of Cap under Schedule F of the Murray Darling Basin Agreement,
- the environmental water provisions specified in clauses 15 (2), 15 (3), 15 (6), 15 (7), 15 (8), 15 (12), 15 (16) and 15 (22) of the Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source, and
- the other water management rules applying at the commencement of the Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source.

Model 3 in Table 5 is considered to be the most appropriate model for representing the BDL definition and for estimating associated diversions. As mentioned in section 2.6.1, differences between the longterm average diversions produced by this model and the one currently held by the Authority (model 2) are likely to be minor. However, not withstanding this, the updated version of the model should be supplied to the Authority

under an agreed upon updating framework in order for an updated estimate of the BDL to be made.

2.7 Lachlan

2.7.1 Jurisdictional Model Current Status

The Lachlan IQQM LTAAEL model is considered to be the most appropriate model for use in BDL estimation. The model has been subject to a number of modifications with resulting longterm average diversions presented in Table 6.

Changes from the original model to the latest model held by the NSW Office of Water relate to:

- Recalibration of Wyangla Dam Inflows
- Refinement of the algorithm used for representing the rules relating to the filling of Lake Cargelligo.
- A software change from the DOS version of IQQM to the GUI version.

There are no changes from the latest model held by the Jurisdiction and the model supplied to the Authority.

Table 6 – Lachlan Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1898 -2000)
(1) Lachlan Valley longterm average diversions stated in Statutory Water Plan as per baseline (longterm extraction limit) model (IQQM run number E229)	305
(2) Lachlan Valley longterm average diversions as per baseline (longterm extraction limit) model supplied to the Authority (no SW/GW loss) (LACHSAO5.SQQ)	311
(3) Lachlan Valley longterm average diversions as per latest baseline (plan limit) model held by the Jurisdiction. (no SW/GW loss) (LACHSAO5.SQQ)	311

2.7.2 Jurisdictional Model Proposed Improvements

There are a number of significant proposed improvements to the Lachlan IQQM model. Of which the main one relates to alteration of the allocation system from annual allocation with carry over to continuous accounting. Early indications from the Office of Water are that this change is not expected to significantly alter diversions given that the definition of the longterm extraction limit contained in the Lachlan Regulated River Water

Sharing Plan restricts representation of user behaviour to that at 93/94 levels of development.

2.7.3 Baseline Model Amendments made by MDBA

Two amendments to the model supplied by NSW to the Authority (model 2, Table 6) have been made. These have consisted of inclusion of a surface water ground water loss (flux) amount, and as mentioned in MDBA 2011a, a change to the period of simulation from 1898- 2000 to 1895-2009.

2.7.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For this review, the Lachlan regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

For the purposes of determining Lachlan regulated river modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual extraction from this water source that would occur with:

- the water storages, private water management infrastructure, cropping mix that existed in 1999/2000,
- the share components existing at the time of commencement of the water sharing plan for the Lachlan regulated river water source,
- the maximum crop area and the crop planting behaviour adopted as representative of baseline conditions used for assessment of Cap under Schedule F of the Murray Darling Basin Agreement, and
- application of the water management rules defined in the water sharing plan for the Lachlan regulated river water source.

The model most appropriate for estimating baseline diversions and which is considered to be most representative of the BDL definition is model 2 or 3 (Table 6) with suitable adjustments for surface water and groundwater interaction. Comment on the appropriateness of the flux volume to be used was sought from the NSW Office of Water but not obtained during the course of this review. It is recommended that the volume of loss associated with surface and groundwater interaction be agreed upon by NSW and the Authority to allow an updated estimate of the BDL to be made.

2.8 Murrumbidgee

2.8.1 Jurisdictional Model Current Status

The model most appropriate for estimating baseline diversions in the Murrumbidgee regulated river system (the WSP model used to determine the longterm average extraction limit - LTAAEL) has under gone a number of modifications. Changes in the longterm average diversions from the original model used to develop the water sharing plan are presented in Table 7. Changes from the original model to that supplied to the Authority have included

- Carryover limit increased from 15% to 30%.
- Approximately 140GL of GS converted to HS

These changes have not altered the longterm average annual diversion estimate.

Diversion changes from the original model to the latest model held by the NSW Office of Water are in the order of 35GL/Yr. This change relates to amendments to the Balranald flow target as per clause 14 of the Water Sharing Plan.

Table 7 – Murrumbidgee Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1892 -2000)
(1) Murrumbidgee Valley longterm average diversions stated in Statutory Water Plan as per baseline (longterm extraction limit) model (IQQM scenario run number '50 EWA1 plus TT'.)	1925
(2) Murrumbidgee Valley longterm average diversions as per baseline (longterm extraction limit) model supplied to the Authority	1925 (Prior to MDBA Ammendment for Balranald Flow Target) 1890 (After MDBA Ammendment for Balranald Flow Target)
(3) Murrumbidgee Valley longterm average diversions as per latest baseline (plan limit) model held by the Jurisdiction	1890

2.8.2 Jurisdictional Model Proposed Improvements

There are a number of proposed improvements to the Murrumbidgee LTAAEL model highlighted for implementation by the NSW Office of Water (pers com Ilan Salbe 2012):

- Update the Murrumbidgee Irrigation Area (MIA) sub- model:
    - Change the loss model therein.

- Use MIA's latest GIS based crop data info.

- Introduce surface-groundwater interaction or another process that could explain the high losses seen Dams to Narrandera during the last drought.
- Include the small volume of OFS present in the valley.
- Abandon the substitution assumption for supplementary periods, as in drought periods it is inappropriate.

These changes will improve model performance in dry periods. Whilst the baseline diversion estimate is likely to change it is likely to only be by a small amount.

2.8.3 Baseline Model Amendments made by MDBA

Amendments to model 2 (refer to Table 7) made by the Authority in order to establish a baseline diversion estimate are summarised in MDBA 2012 and consist of:

- The baseline Murrumbidgee model was linked to the Upper Murrumbidgee and Snowy Scheme models to derive a better representation of the ACT and Snowy scheme impacts on the Burrinjuck Dam and Blowering Dam inflows.
- The model has been extended to include the Jounama catchment upstream of Blowering Dam.
- Water recovery for TLM (48.9 GL/y average water use for Basin Plan modelling) was added to the baseline conditions model by MDBA and in conjunction with advice from the NSW Office of Water. TLM modelling was subsequently updated to include all purchases to date (52.1 GL/y longterm Cap equivalent average annual use) for the Legislative Instrument version of the baseline conditions model, however this update had occurred after the Basin Plan modelling effort described here was completed.
- The Balranald end of system flow demand was updated to include the Water Sharing Plan minimum flow rule which has come in effect from 2008-09.
- Inputs from the Murray system which are utilised in the Murrumbidgee model (Finley Escape, along with Lake Victoria storage levels and Murray announced allocations for Lowbidgee diversion determination) were updated based on the most recent information produced by the MDBA Murray model.

Note, for determining baseline diversion estimates, water recovery for Water for Rivers is not included in the model but is accounted externally by subtracting the impact of various water recovery programs on total modelled diversions.

2.8.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the purposes of this review, the Murrumbidgee regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law (as if the applicable water sharing plan was not suspended) as at 30 June 2009 (but excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers); and

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

For the purposes of determining Murrumbidgee modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual extraction from this water source that would occur with the water storages, access licence share components and water use development that existed in 1999/2000 and the water management rules defined in the Murrumbidgee Regulated River Water Source Plan with adjustments for environmental water recovery under TLM and Water for Rivers program..

Based on the above definition and the differences between models 1 to 3 in Table 7, it would appear that the model current held by the Authority is most representative of the baseline definition and is appropriate for estimating baseline diversions after the amendments as listed in section 2.8.3 have been made.

Note: The term “excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers” when used in the context of the BDL definition requires clarification with respect to model scenario establishment. In the case of the Murrumbidgee model TLM recovered water has been included in the model and diversions have been reduced equal to their agreed longterm Cap equivalent (LTCE). Entitlements recovered under the Water for Rivers purchase are not included in the model but their LTCE diversions are subtracted from the longterm average diversion estimate.

2.9 Barwon Darling

2.9.1 Jurisdictional Model Current Status

The Barwon Darling models of relevance to BDL estimation are the Cap model and the current conditions model. Longterm average diversions under current conditions are

restricted to the Cap. The various applicable Barwon Darling models and associated longterm diversions for each are presented in Table 8.

Table 8 - Barwon Darling Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (Period, as indicated)	**Comment**
(1A) Barwon-Darling longterm average diversions stated in Cap model (Ver **6.54.1901** System File **93940001.sys**)	191.0 (Modeling period 1922 – 2000)	CAP base model developed in 2001 and utilizing the then CAP inflows
(1B) Barwon-Darling longterm average diversions stated in Cap model (Ver **7.50.04** System File **Cap_Gui.sqq**)	192.2 (Modeling period 1922 – 2000)	Above CAP model transitioned to new GUI platform in 2009, inflows unaltered
(1C) Barwon-Darling longterm average diversions stated in Cap model (Ver **7.67.04** System File **Bden17.sqq**)	192.0 (Modeling period 1922 – 2000)	Same CAP GUI model running on New Version in 2009, correcting & adding a Gwydir wetlands inflow plus MDBC Menindee inflows (1922-2000)
(1D) Barwon-Darling longterm average diversions stated in Cap model (Ver **7.67.04** System File **Bden18.sqq**)	195.1 (Modeling period 1895 – 2009)	Above CORRECTED CAP model in 2010 with revised & extended inflows from latest **CAP & ROP** tributary models
(1E) Barwon-Darling longterm average diversions stated in Cap model (Ver **7.67.04** System File **Bden16.sqq**)	200.5 (Modeling period 1895 – 2009)	Above CORRECTED CAP model in 2010 with revised & extended inflows from latest **WSP & ROP** tributary models
(2A) Barwon-Darling longterm average diversions as per latest CAP model held by the Jurisdiction run over the same 1895-2009 climatic period as (1) (Ver **7.67.19** System File **bd007e6.sqq**)	209.2 (Modeling period 1895 – 2009)	Same model as 1D except all irrigation demand modules were recalibrated during 2011. Uses extended inflows from latest **CAP & ROP** tributary models
(2B) Barwon-Darling longterm average diversions as per latest baseline model held by the Jurisdiction run over the same climatic period as (1) (Ver **7.67.19** System File **R062new_ex.sqq**)	209.8 (Modeling period 1895 – 2009)	Above recalibrated irrigation demand modules incorporated into model representing 2009/10 levels of irrigation development, access & accounting rules. Plus an attempt at **trading** unused or under used entitlements. Uses extended inflows from latest **WSP & ROP** tributary models

Given the large number of changes in the models, staff from the NSW Office of Water have provided the following advice in relation to the model currently held by the Authority and differences that exist between in and the current conditions model.

The model supplied to the Authority was the then CAP model. This approach was adopted because the models that represented the then current irrigation infrastructure development, entitlements, accounting system and access rules (ie 2008/09 conditions)

did not include trading of entitlements. This omission would have caused a considerable under estimate of diversions.

At the time of transfer of the model to the Authority (October 2009 to February 2010) the accepted CAP model was still the provisional model (ie Model # 1A). However as part of the transfer steps were taken to use upgraded software and revised and extended system inflows (ie Model # 1D). Provision was also incorporated into the model to make irrigators pass downstream environmental flow orders. (Pers com R. Cooke)

Changes from the original Cap model to the Cap model supplied to the Authority have consisted of:

- Provision for all irrigators to pass a downstream environmental flow 'order' was incorporated.
- For ease of transfer of data from Gwydir model, an irrigator which previously had used a combined supplementary and floodplain harvesting input file was separated into its components. Causing changes to direct access flow file and tributary irrigator node.
- The original CAP inflows (1922-2000) were replaced with revised & extended inflows from latest WSP & ROP tributary models
- Corrections were made to Gwydir Floodplain node (flow pointer was to incorrect inflow file). Also outflows from the increased aerial extent of Gwydir model (ie Gingham Watercourse) was incorporated into model, as was the additional inflows at Menindee requested by MDBC.
- Version 6.54.1901 was replaced with Version 7.67.14
- Six (6) hour routing time step was replaced with twenty four (24) hour. Note this increases average annual metered usage by 0.6 GL (+0.3%) and overall diversions by *0.3 GL (+0.15%).*

Office of Water Staff have also advised that with the proposed introduction of the WSP, considerable changes have occurred to the NOW models since the time of the previous transfer to the Authority (October 2009 to February 2010).With the most significant change being the recalibration in irrigation demand and the submission of that model for accreditation (ie model 2A) (Pers Com R. Cooke).

Also there is now a model representing 2009/10 levels of irrigation development, access & accounting rules (the current conditions model). Plus an attempt at trading unused or under used entitlements (ie model 2B). However the trading in this model is still incomplete as longterm river diversions are some 2.6% less than the 196 GL of distributed entitlements (Pers Com R. Cooke).

2.9.2 Jurisdictional Model Proposed Improvements

Proposed improvements to the Barwon Darling models include:

- Inclusion of a dead storage components for the individual cells that make up the OFS
- A suggestion by the independent auditor of CAP models, that a provision for late season “pre-watering” after a drought sequence should be added to models.
- At request of the independent auditor of CAP models, NOW is currently amending its CAP model to incorporate pumping embargoes when Menindee Lakes drops to a level when human needs are at risk.
- Further development of trading of unused or under used entitlements to more active irrigators required. Target is to achieve near 100% utilization of the 196 GL of distributed entitlements.
- Use of IQQM Version 7.67.19 or beyond to model WSP accounting rules.
- Models to be run on six (6) hour routing time step

2.9.3 Baseline Model Amendments made by MDBA

No amendments to the Barwon Darling model by the MDBA appear to have been made.

2.9.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the purposes of this review, the Barwon Darling river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from unregulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken in accordance with Schedule E to the Agreement for each year of the historical climate conditions, and

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

For the purposes of determining Barwon Darling modelled watercourse diversions, in accordance with the Schedule E to the Agreement is taken to mean the mean the long-term average annual extraction from this water source that would occur with the water storages, water access entitlements, water management rules and water use development that existed in the water source as at 30 June 2009 within the constraints of the Cap.

The model currently held by the Authority for estimating baseline diversions (model 1D in Table 8) is out of date and should be replaced with model 2B in order for a revised

estimate of baseline diversions to be made. In addition the current model held by the Authority does not appear to best represent the intent of the BDL definition. Model 2B is more appropriate and should be provided to the Authority as part of an agreed upon model update framework.

2.10 Lower Darling

2.10.1 MDBA Model Current Status

The model most appropriate for use in estimating baseline diversions is the Murray Monthly Simulation Model. Based on discussions with Authority staff the Water Sharing Plan LTAAEL scenario model run for the Lower Darling does not appear to explicitly exist and the Cap model run for the Lower Darling is currently used to determine baseline diversion estimates. Cap model estimates for the Lower Darling are currently estimated at 137GL/Yr over the 1891 to 2006 climatic period (MDBA 2011a).

Given the absence of a specific Water Sharing Plan LTAAEL scenario model for the Lower Darling it is recommended that an estimate of the LTAAEL for the Lower Darling Regulated River Water Source be jointly determined by the Authority and NSW for use in baseline diversion estimation.

2.10.2 MDBA Model Proposed Improvements

The Lower Darling Cap model is currently under going model accreditation. A number of recommendations have already been implemented by the Authority in the model. The main future improvement to the model relates to on farm water management practices for Tandou. This change is not expected to greatly alter the baseline diversion estimate.

2.10.3 Baseline Model Amendments made by MDBA

Amendments made to the Cap model in order for it to represent the baseline definition in Schedule 3 of the proposed Basin Plan are included as part of the amendments to the Murray Model. These are outlined in section 0.

2.10.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the purposes of this review, the Lower Darling regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law

(as if the applicable water sharing plan was not suspended) as at 30 June 2009 (but excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers); and

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

For the purposes of determining Lower Darling modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual extraction from the water source that would occur with the water storages, share components and water use development that existed in the water source in 2000/2001, and the share components of the access licences issued as part of the arrangements that replaced the replenishment flow provisions in clause 60 of the Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources, and the water management rules defined in this Plan, minus 35,500 ML per year[3] with adjustments for environmental water recovery under TLM and Water for Rivers program.

The representation of the BDL definition by the model can be improved through incorporation of the modifications described in section 2.10 and 2.11. This includes the creation of a Lower Darling LTAAEL scenario that represents the LTAAEL as at State water management law 30th June 2009. Longterm volumes assumed to apply to the 250GL of water recovered under the Living Murray Program should also be checked to ensure they align with the 35,500ML figure stated above.

2.11 New South Wales Murray

2.11.1 MDBA Model Current Status

The model most appropriate for use in estimating Baseline diversions is the Murray Monthly Simulation Model. Based on discussions with Authority staff the LTAAEL scenario model run for the Murray has not been updated since its use in formulating the NSW Water Sharing Plan for the Murray and Lower Darling Regulated Rivers

In the absence of a specific NSW Murray LTAAEL scenario estimates of the LTAAEL are based on 97% of the longterm average Cap diversion. Updates to the cap model are presented in Table 9.

Recent updates to the MSM model likely to affect LTAAEL estimation include: (ref MDBA 2010):

[3] The 35,500 ML per year subtracted in this paragraph is the estimated long-term extraction associated with the 250,000 shares of supplementary water access licence share component purchased under the Living Murray Program and retired from the bulk access regime.

- Changes to the loss and operational reserves set aside during resource assessment
- Updated Snowy Dry inflow sequence volume based on Snowy model outputs,
- Updated resource assessment statistics for minimum tributary inflows based on recent data,
- Changes to storage volume relationships for Menindee Lakes based on Updated Bathymetric Data
- Changes to Lake Victoria Storage levels to reflect new operating targets
- Additional Groundwater loss of 47 GL/y by 2030 due to surface water development.
- More detailed representation of key icon sites eg Hattah Lakes, Lindsay Walpolla and Chowilla floodplain, Edward Gulpa wetlands including revision of loss estimates,
- Revision of some routing and reach loss relationships,
- MSM model extended to include South Australian section of the river including Lower Lakes.
- Revised pattern of delivery of South Australian water requirement based on recent drought experience including SA reserve for meeting critical human water needs,
- Includes South Australian storage water,
- Changes to the drought management strategy for Broken Hill.

Given the large number of changes to the model since its use in formulating the NSW Murray Regulated River Water Sharing Plan it is recommended that a specific LTAAEL Murray scenario be developed jointly between the Authority and NSW and a revised estimate of the LTAAEL for the Murray Regulated River Water Source be determined.

Table 9 - Murray Modelled Longterm Average Diversion

Description	**Diversion (GL/Yr)** (1891-2006)
(1) The NSW Murray LTAAEL as defined in the Murray Lower Darling Regulated Rivers Water Sharing Plan	1825 (Murray Valley long term average diversions stated in WAM report less 55GL per Annum)
	1847 (Murray Valley long term average diversions stated in Cap model run 22542 less 57GL per Annum)

2.11.2 Baseline Model Amendments made by MDBA

Amendments made to the model in order for it to be more representative of the baseline definition in Schedule 3 of the proposed Basin Plan in addition to those listed in section 2.11.1 consist (as outlined in MDBA 2012) of:

- Water trade within the baseline includes permanent entitlement trade to June 2009. This level of trade is used for the entire modelling period. This includes increases or decreases in the NSW, Victorian and SA Cap as result of permanent trade. The model also includes the ability for Tandou to trade in up to 20 GL when required and when Menindee Lakes is in MDBA control. Apart from this, no inter-valley temporary trade is modelled.
- Additional dilution flows (ADF) as specified under the MDB Agreement.
- Darling anabranch environmental releases during periods of off-allocation on the Lower Darling;
- Environmental water allocation of up to 150 GL/y for Barmah-Millewa Forest, and the associated watering rules (MDBC 2006a, 2006b);
- Representation of the NSW component of water recovery for TLM initiative (excluding the 9GL recovered from Poon Boon Lakes)
- Representation of the water recovered as part of the Water for Rivers program (excluding 7GL recovered by Edward Gulpa Wetland Works)
- A range of TLM Environmental Watering Rules

2.11.3 MDBA Model Proposed Improvements

There are a number of proposed improvements to the mode which are likely to affect LTAAEL estimates for the NSW Murray, albeit by minor amounts. These consist of:

- General software bug fixes, and
- Review of pre release rules and updating of statistics used for their calculation.

These will consequently also affect the baseline diversion estimate. There are a number of proposed improvements which will solely affect the baseline diversion estimate. These potentially include

- Operational practices relating to the delivery of environmental water.
- Coordination of environmental water delivery through held and rules based holdings.
- Update TLM/WfR accounting configuration such that all environmental water supply accounted.
- Implementation of carry over policy changes with respect to the Victorian Murray.

2.11.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For this review, the Murray regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law (as if the applicable water sharing plan was not suspended) as at 30 June 2009 (but excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers); and

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

For the purposes of determining Murray modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual extraction from this water source that would occur with the water storages, share components and water use development that existed in the water source in 2000/2001, and the water management rules defined in the Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources, minus 17,800 ML per year (associated with the 100GL supplementary license purchase from MIL) with adjustments for environmental water recovery under TLM and Water for Rivers program..

Improved representation of the BDL definition for the Murray can be achieved through the creation of a LTAAEL scenario (developed jointly between NSW and the Authority) and implementation of the amendments in section 2.11.3. Whilst the current Murray model appears to adequately produce baseline diversions a revised estimate of the NSW Murray LTAAEL may result in changes to the current BDL estimate.

As for the Murrumbidgee (refer to section 2.8.4), the use of the term *"excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers*" when used in the context of the BDL definition requires clarification with respect to model scenario establishment. In the case of the Murray model TLM and Water for Rivers recovered entitlements have been included in the model and diversions have been reduced by the agreed longterm Cap equivalent (LTCE).

2.12 Conclusions

2.12.1 Baseline Diversion Estimates

At some point updated models should be supplied to the Authority for use in determining baseline diversion estimates for the following valleys:

- Gwydir.
- Border Rivers.
- Macquarie.
- Barwon Darling

The Authority is in possession of the most up to date and appropriate models for baseline diversion estimation for the Peel, Murrumbidgee, Murray, and Lower Darling.

In the case of the Namoi and Lachlan, there is a need for resolution of the appropriate flux volume to represent surface and groundwater interaction. This should be resolved by NSW and the Authority so as agreement as to which model is the most appropriate for baseline diversion estimate can be made.

Whilst the current Murray model appears to be satisfactory for determining baseline diversions, a revised estimate of the NSW Murray LTAAEL should be developed jointly between NSW and the Authority (refer to section 2.11.1). Revisions may result in changes to the current BDL estimate.

2.12.2 Representation of the BDL Definition

There are a number of models for which the representation of the baseline diversion definition for the relevant SDL resource unit can be improved through provision of more up to date models. These are the Border Rivers, Gwydir, Macquarie and Barwon Darling, Lower Darling and NSW Murray. The Peel, Namoi, Lachlan, and Murrumbidgee, appear to require no updating at this stage.

Improved representation of the BDL definition for the Murray and Lower Darling can be achieved through the model modifications outlined in sections 2.10 and 2.1. This includes the creation of a LTAAEL scenario. In the case of the Lower Darling, longterm diversion volumes assumed to apply to the 250GL of water recovered under the Living Murray Program should be checked to ensure they align with the 35,500ML figure stated in the LTAAEL definition in the NSW Water Sharing Plan for the Murray and Lower Darling Regulated Rivers.

3 Victorian Jurisdictional Models Current Status and Future Amendments

With the exception of the Murray, modelling in Victorian regulated river systems is undertaken using REALM (Resource Allocation Model). REALM is a mass balance model that uses nodes and carriers to represent the catchment or water supply system. The configuration of the nodes and carriers broadly reflects the physical configuration of the channels that make up each river system and the location of processes that affect the volume of water in the river.

The baseline definition and corresponding diversion estimate in Victorian Regulated River systems is dependent on two river system model scenarios. This first being the Cap model which produces a longterm average annual Cap diversion estimate, the second being the model scenario which best represents the baseline diversion definition (the baseline conditions model). Both scenarios are discussed where relevant in the following sections.

3.1 Goulburn Simulation Model

The Goulburn Simulation Model (GSM) includes modelled diversions for the Goulburn, Broken, Loddon and Campaspe Valleys. The status of the model with respect to each of these systems is discussed in the following sections.

3.1.1 Jurisdictional Current Status

Goulburn Valley

Longterm average diversions for the Goulburn component of the Cap and baseline conditions models are presented in Table 10. Changes in diversions from the model originally developed to determine the Cap and that currently used by the Authority for baseline diversion estimation relate to the development of a model scenario that represents the Goulburn BDL definition.

Table 10 – Goulburn Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** 7/1895 to 6/2009
(1) Goulburn Valley component longterm average diversions stated in Cap model.	1828 (REALM Version 6.14. Log file B900.log, System File GoulR888.sys)
(2) Goulburn Valley component longterm average diversions as per baseline models supplied to the Authority	1551.6 (Sent 12 Aug 2011, REALM Version 6.14d, GoulD898.sys) (Used by the Authority for estimating the BDL)
(3) Goulburn Valley component longterm average diversions as per baseline models supplied to the Authority	1549.9 (Sent 14 Nov 2011, REALM Version 6.14d, GoulL898.sys) (Not currently used by the Authority)
(4) Goulburn Valley component longterm average diversions as per latest baseline model held by the Jurisdiction	(REALM Version 6.15, System Goul0906.sys) Note this model is under development, the latest version of the BDL model has not been issued.

In developing the baseline model, changes have been made to a large number of components of the Cap model to reflect changes in management rules, trade and water recovered for the environment between 1983 and 2009. Individual changes are too numerous to fully describe in this report but major aspects are as highlighted in Table 11. Once changes have been made, demands are scaled to ensure that longterm average diversions are equivalent to those produced by the Cap scenario less any adjustments required under the baseline definition (refer to section 3.1.4). Consequently, the decrease in longterm average diversions in Table 10 of 278.1 is primarily due to adjustments for permanent trade, water recovery by the Living Murray, and Water for Rivers. The estimate of longterm average diversions under the Cap (row 1 in Table 10) is unchanged.

Importantly adjustments for entitlement associated with water recovery are based on modelled use at 2009 development and not on the LTCE of the individual water recovery projects. As stated in section 2.8.4 and 2.11.4, a decision as to whether usages adjustments for BDL estimation are based on LTCEs or modelled 2009 development use needs to be made.

Table 11 – Changes to the Goulburn Simulation Model (Cap to Baseline Model)

Aspect	**Changed** (Indicated with X or √)
Entitlements, Allocation and Accounting System	
Entitlements and Volumes	√
Entitlements and Allocation System Type and settings	√
Public and Private Infrastructure	
Headwater and Enroute (River Weirs) *(DSE interpretation: Major works such as Pipelines, Pump Stations)*	√
Pump Capacity	√
Underlying Level of Demand	
Irrigation Demand (Crop Model)	√ (Only adjusted for savings / purchase)
Access Rules	
Priority of access	√
Environmental Flow Rules	√
Off Quota Access	√
Low Reliability Water Share Access	√
Operational Constraints	
Operational constraints *(DSE interpretation: Changes to operational policy e.g. reserves, drought response planning)*	√
Physical delivery constraints *(DSE interpretation: Changes such as increased channel (or model carrier) capacities*	√
Operational Minimum Flow Requirements and Replenishment Flows	
Operational Minimum Flow Requirements	√
Domestic and Stock Replenishments	√
Trade/Water Recovery	√ (Permanent trade to June 2009 included, Temporary trade is not modeled.)
Software Update	√

Broken Valley

Longterm term average diversions from the various versions of the GSM that are applicable for determining baseline diversion estimates are presented in Table 12. Row

(2) represents the model version that has been used by the Authority for baseline diversion estimation.

Table 12 – Broken Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1891-2004)	**Diversion (GL/Yr)** (1895-2009)
(1) Broken Valley longterm average diversions stated in Cap model	31.2 (REALM Version 6.14. Log File B900.log, System File GoulR888.sys, B900.scn).	30.8 (REALM Version 6.14. Log File B900.log, System File GoulR888.sys, B900.scn).
(2) Broken Valley longterm average diversions as per baseline model supplied to the Authority.	13.4 (Used by the Authority) (Sent 12 Aug 2011) GoulD898.sys, REALM Version 6.14d.	13.2 (Used by the Authority) (Sent 12 Aug 2011) GoulD898.sys, REALM Version 6.14d.
(3) Broken Valley longterm average diversions as per baseline model supplied to the Authority.		13.1 (Sent 14 Nov 2011, GoulL898.sys, L898.scn, L898.log, REALM Version 6.14d.)
(4) Broken Valley longterm average diversions as per latest baseline model held by the Jurisdiction	Note this model is under development, the latest version of the baseline diversion model has not been issued. (REALM Version 6.15, System File Goul0906.sys)	

As the Goulburn, Broken, Campaspe and Loddon are represented in one model, changes between the Cap and the baseline model in the Broken are as presented in Table 11.

Loddon Valley

Longterm average annual diversion for the various versions of the GSM that have been supplied to the Authority for the purposes of estimating baseline diversions are presented in Table 13. Row 2 in Table 13 represents the model version that has been used by the Authority for baseline diversion estimation.

Table 13 – Loddon Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (7/1895 to 6/2009)
(1) Loddon Valley longterm average diversions stated in Cap model	100.3 (REALM Version 6.14, System File GoulR888.sys, B900.scn)
(2) Loddon Valley longterm average diversions as per baseline model supplied to the Authority	88.6 (Used by Authority) (Sent 12 Aug 2011 GoulD898.sys, REALM Version 6.14d)
(3) Loddon Valley longterm average diversions as per baseline model supplied to the Authority.	88.9 (Sent 14 Nov 2011 GoulL898.sys, L898.scn, L898.log, REALM Version 6.14d.)
(4) Loddon Valley longterm average diversions as per latest baseline model held by the Jurisdiction	Note this model is under development, a formal baseline diversion model has not been issued. (REALM Version 6.15, System File Goul0906.sys)

Changes in the Loddon from the GSM Cap model to the baseline model are as presented in Table 11. The majority of change in the Loddon is associated with volumetric adjustments for water recovered for the environment by the Victorian Government.

Campaspe Valley

Longterm average annual diversions for the GSM Cap model and the baseline conditions model for the Campaspe are presented in **Error! Reference source not found.**. A number of changes between model versions are apparent. The Cap model which formed the starting point for baseline diversion estimation (row 1) has a longterm average diversion of 119GL/Yr. Victoria has recently amended this model on the basis of more accurate diversion data and has recalculated the longterm average Cap diversion as 124.3GL/Yr (Row 2).

The current baseline diversion model used by the Authority (Row 4) produces a longterm average diversion of 110.9 GL/Yr. This is likely to change as a consequence of the revised Cap diversion estimate from the amended model which was approved by the MDBA as the accredited Cap model on 10th May 2012. It should also be noted that model represented at Row 5 appears to have been provided to the Authority but not used in estimation of the BDL to date. The version of the model presented at Row 6 of **Error! Reference source not found.** incorporates all updates including diversion adjustments. This version of the GSM has yet to be provided to the Authority.

Table 14 – Campaspe Modelled Longterm Average Diversions

Description	Diversion (GL/Yr) (1891-2004)
(1) Campaspe Valley longterm average diversions stated in Cap model, current at the time of Basin Plan modelling to estimate the BDL	119 (Run L867 REALM 6.00a System File GoulD877.sys)
(2) Campaspe Valley longterm average diversions stated in Cap model, accredited on 10 May 2012	124.3 (Run B900 REALM 6.00a System File GoulD888.sys) Approved by Authority 10/5/2012
(4) Campaspe Valley longterm average diversions as per baseline model supplied to the Authority	110.9 Used by Authority (Sent 12 Aug 2011 GoulD898.sys, REALM Version 6.14d.)
(5) Campaspe Valley longterm average diversions as per baseline model supplied to the Authority	113.2 (Sent 14 Nov 2011 GoulL898.sys, L898.scn, L898.log, REALM Version 6.14d)
(6) Campaspe Valley longterm average diversions as per latest baseline model held by the Jurisdiction	116.1 Note this model is under development, the latest version of the baseline diversion model has not been issued or provided to the Authority. (GoulL0906.sys, REALM Version 6.15)

The major changes in diversions between the Cap and baseline models are due to water recovery purchases under the Living Murray program. Recovery volumes are based upon modelled usage volumes and not LTCEs. As stated previously in this report, a

resolution with respect to how diversion adjustments under the various water recovery programs are represented within the model scenarios needs to be made in order to ensure consistency in BDL estimation.

Aspects of the Cap model that have been changed in order to produce the baseline model for the Campaspe are presented in Table 11.

3.1.2 Jurisdictional Proposed Improvements

A number of modifications to the baseline model are planned by Victoria. These include:

- Verification of entitlements including matching to register and representation of all permanent trade entitlements.
- Updating of the allocation configuration to ensure resource assessment parameters such as loss assumptions are representative of current conditions.
- Reviewing the configuration of environmental water needs within the model.
- Initiate updates to irrigation cropped area representation subject to data availability.
- Verification of all accounts. This includes Living Murray and Intervalley trade accounts to ensure modelled accounting rules match what occurs in practice in 2009.
- Continuously improve the model as better information becomes available.

It should also be noted that the Victorian DSE advised that as at 30 June 2009 Victoria had a 30% carryover rule which is not currently represented in the GSM baseline diversion model.

There are currently no proposed improvements to the Cap model for the Goulburn, Broken or Loddon. Amendments to the Campaspe are completed and approved by the Authority as discussed above.

3.1.3 Baseline Amendments made by MDBA

As mentioned in MDBA 2011a, amendments to the model provided to the MDBA consist solely of changes to the period of simulation where appropriate to 1895-2009.

3.1.4 Representation of the BDL Definition and Suitability for Estimating BDL

Goulburn Valley

For this review, the Goulburn regulated river system modelled component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law as at 30 June 2009 (but excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers); and

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

For the purposes of this review and determining Goulburn modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual Cap extraction from this water source that would occur with the water storages, water access entitlements, water management rules and water use development that existed in the water source as at 30 June 2009.

Whilst the baseline conditions model held by the Authority is satisfactory for producing the preliminary baseline diversion estimate (ie the longterm average annual Cap less adjustments), the representation of the baseline diversion definition could be improved through an adoption of the amendments mentioned in section 3.1.2, appropriate adjustment for water recovered for the environment, and use of the most up to date version of the GSM. It should also be noted that DSE have also acknowledged that improvements and understanding of how best to represent baseline conditions in the model will continue to occur.

The definition of the BDL also means that any changes to the Cap model and associated longterm diversion will also impact on the baseline diversion estimate. As indicated by the Jurisdiction, future amendments to the Cap model are not planned but the adjustments to improve model accuracy are possible and allowed under the Cap model accreditation process.

Broken Valley

For the purposes of this review, the Broken regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law as at 30 June 2009 (but excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers); and

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

For the purposes of determining Broken modelled watercourse diversions in this review, State water management law as at 30 June 2009 is taken to mean the long-term average annual Cap extraction from this water source that would occur with the water

storages, water access entitlements, water management rules and water use development that existed in the water source as at 30 June 2009.

The baseline diversion estimate for the Broken appears to be appropriate. Representation of the BDL definition will be improved when the 30% carry over rule is included in the model.

A revised GSM baseline model for the Broken with suitable amendments should be provided to the Authority as part of an agreed upon model updating framework.

Loddon Valley

For the purposes of this review, the Loddon regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law as at 30 June 2009; and

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

For the purposes of determining Loddon modelled watercourse diversions in this review, State water management law as at 30 June 2009 is taken to mean the long-term average annual Cap extraction from this water source that would occur with the water storages, water access entitlements, water management rules and water use development that existed in the water source as at 30 June 2009.

Comments relating to baseline diversion definition representation and estimation of longterm average diversions are similar to those for the Goulburn and Broken Valley. The baseline diversion estimate for the Loddon appears to be appropriate, despite issues relating to assumed volumes associated with environmental water recovery. The current baseline model will more thoroughly represent the baseline definition when the 30% carry over rule is included in the model. A revised baseline model with suitable amendments for the Loddon should be provided to the Authority as part of an agreed upon model updating framework.

Campaspe Valley

For the purposes of this review, the Campaspe regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law

as at 30 June 2009 (but excluding held environmental water recovered by the Living Murray Initiative); and

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

For the purposes of determining Campaspe modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual Cap extraction from this water source that would occur with the water storages, water access entitlements, water management rules and water use development that existed in the water source as at 30 June 2009.

The baseline GSM currently held and used by the Authority can have its representation of the BDL definition and diversion estimate improved. This can be achieved through the version of the GSM in Row 6 of **Error! Reference source not found.** being provided to the Authority. Improved representation of the BDL definition will also require some of the planned future amendments of 3.1.2 to be adopted; in particular, the inclusion of carry over arrangements. Provision of an updated baseline GSM for the Campaspe to the Authority should occur as part of an agreed upon updating framework.

3.2 Wimmera

3.2.1 Jurisdictional Model Current Status

Longterm average diversions for the Wimmera Cap and the baseline conditions model are presented in Table 15. Changes from the model originally developed to determine the Cap and that currently held by the Authority for baseline diversion estimation relate to the development of a current conditions scenario that represents the Wimmera BDL definition.

It should also be noted that Victoria is proposing to submit the BDL model as a revised Cap model for approval by the MDBA. This will more than halve the average Cap diversion.

Table 15 – Wimmera Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)**
(1) Wimmera Valley longterm average diversions stated in Cap model	158.3 (1/7/1891 to 30/06/2008) (REALM Version 5.16, PRIDE Version W2.0, Log, Scenario and System Files - 5370.log, 5370.scn, WMPP5370.sys)
(2) Wimmera Valley longterm average diversions as per baseline model supplied to the Authority.	65.7 (1/7/1895 to 30/6/2009) (Sent 12 May 2011) WMPP2122.sys, REALM Version 5.16
(3) Wimmera Valley longterm average diversions as per latest baseline model held by the Jurisdiction	The model is being upgraded as part of storage management rules refinement and the latest BDL model has not been issued; hence the diversion is not yet calculated.

As for the other Victorian valleys, changes have been made to a large number of components of the Cap model in developing a current baseline conditions model. Individual changes are as highlighted in

Table 16.

The decrease in longterm average diversions from the Cap model to the baseline model is primarily due to water savings due to the Northern Mallee and Wimmera Mallee pipelines.

It should be noted however that the Victorian DSE has indicated that the models are currently undergoing updates, and the Wimmera diversions are expected to vary from the diversions presented in Table 15. Furthermore, scaling diversions back to Cap will not be required for the Wimmera model due to future versions of the BDL and Cap model being the same in terms of longterm average diversions.

Table 16 – Wimmera Modelled Longterm Average Diversions

Aspect	**Changed** (Indicate with X or √)
Entitlements, Allocation and Accounting System	
Entitlements and Volumes	√
Entitlements and Allocation System Type and settings	√
Public and Private Infrastructure	
Headwater and Enroute (River Weirs) *(DSE interpretation: Major works such as Pipelines, Pump Stations)*	√
Pump Capacity	√
Underlying Level of Demand	
Other Demands	√
Access Rules	
Priority of access	√
Environmental Flow Rules	√
Off Quota Access	√
Low Reliability Water Share Access	√
Operational Constraints	
Operational constraints	√
Physical delivery constraints *(DSE interpretation: Changes such as increased channel (or model carrier) capacities*	√
Operational Minimum Flow Requirements and Replenishment Flows	
Operational Minimum Flow Requirements	√
Domestic and Stock Replenishments	√
Representation of System Inflows	
Transmission Loss Representation	
Trade/Water Recovery	√
Software Update	√

3.2.2 Jurisdictional Model Proposed Improvements

Proposed improvements to the baseline model/revised Cap model are similar to that of other Victorian regulated valleys, and consist of:

- Verification of entitlements including matching to register and representation of all permanent trade entitlements.
- Updating of the allocation configuration to ensure resource assessment parameters such as loss reserves are representative of current conditions,

Proposed improvements to the baseline model consist of:

- Reviewing the configuration of environmental water needs within the model.
- Continuous model improvement on the basis of better information.

Note; As DSE is preparing to re-issue a new Cap model comparisons between the current Cap model and the baseline model (model 2) may be outdated in the near future.

3.2.3 Baseline Model Amendments made by MDBA

Amendments to the model provided to the MDBA (model 2 in Table 15) consisted solely of changes to the period of simulation where appropriate to 1895-2009.

3.2.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

The Wimmera regulated river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law as at 30 June 2009 (but excluding held environmental water recovered under the Northern Mallee Pipeline Project); and

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

For the purposes of this review and for determining Wimmera modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual Cap extraction from this water source that would occur with the water storages, water access entitlements, water management rules and water use development that existed in the water source as at 31st October 2010.

Note Victorian DSE have suggested that 30 June 2009 is not an appropriate reference for the Wimmera System, a more appropriate definition would relate to completion of the pipeline and associated Bulk Entitlements (31st October 2010).

The current baseline conditions model held by the Authority (model 2 Table 15) is considered to be suitable for determining preliminary baseline diversion estimates. The release of a new Cap model will reduce the modeled component of the Cap to the modeled component of the BDL. However, despite this, representation of the baseline diversion definition (after suitable revisions) could be improved through an adoption of the amendments mentioned in section 3.2.2 and provision of a new model to the Authority.

3.3 Victorian Murray, Kiewa, Ovens

The Murray Simulation Model (MSM) represent diversions for the Murray, Kiewa and Ovens Valleys. The status of diversions in these valleys with respect to the BDL definition are discussed in the following sections.

3.3.1 MDBA Model Current Status

Ovens

Longterm average diversions for the various models applicable to baseline diversion examination in the Ovens Valley are presented in Table 17. Changes in the longterm average diversion from the Cap estimate to the BDL estimate are due to use of different model platforms and totally different way of modelling the Ovens system within each platform (ie MSM for model 1 and REALM for model 2). The MSM applies a simple regression equation that estimates total Ovens diversion from monthly climatic variables. REALM models the diversions over 126 separate demand nodes within a complex weekly simulation model.

Table 17 - Ovens Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1891-2009)
(1) Ovens Valley long term average Cap – regression equation within MSM model	23 (MSM Cap Model used for WAM report)
	23 (latest Cap model, Run 22546)
(2) Ovens Valley long term average diversions as per latest baseline REALM model	25 Run #871

Kiewa

Longterm average diversions for the various models applicable to baseline diversion examination in the Kiewa Valley are presented in Table 18. The MSM applies a simple regression equation that estimates total Kiewa diversion from monthly climatic variables. There have been no changes in the longterm average diversion for each model version.

Table 18 - Kiewa Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1891-2009)
(1) Kiewa Valley long term average Cap diversions – regression equation within MSM Model	7 (MSM Cap Model, used for WAM report)
	7 (latest MSM Cap model, Run 22546)
(2) Murray Valley long term average diversions as per latest baseline model held by the MDBA	7 Run #871

Murray

Longterm average annual diversions for the Victorian Murray Cap model and baseline conditions model are presented in Table 19. Changes made to the Cap model to derive the baseline model are discussed in the following section.

Table 19 - Victorian Murray Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1895-2009)
(1) Murray Valley long term average Cap diversions model	1650 (MSM Cap Model used for WAM report)
	1664 (latest Cap model, Run 22546)
(2) Murray Valley long term average diversions as per latest baseline model held by the MDBA	1657 Run #871

3.3.2 Baseline Model Amendments made by MDBA

In the case of the Murray, changes from the Cap model to the baseline model that are listed for the NSW Murray and also apply to the Victorian Murray (refer to section 2.11.1 and 0).

Additional changes to the Victorian portion of the model to establish the baseline model include:

- Representation of the Victorian component of water recovery for TLM initiative
- Representation of the water recovered as part of the Water for Rivers program
- A range of TLM Environmental Watering Rules

In the case of the Kiewa changes relate solely to changes to the period of simulation where appropriate to 1895-2009. In the Ovens the model platform has been changed from MSM to REALM.

3.3.3 MDBA Model Proposed Improvements

Ovens

The Ovens REALM model has been used for estimating the BDL for the Ovens. The author is not aware of any proposed improvements to this model.

Kiewa

The Kiewa is represented as part of the MDBA Murray model. Consequently, amendments to the model are identical to those listed for the NSW Murray model in section 2.11.

One area specific to the Kiewa which may be amended in the future relates to the diversion demand relationship. For the baseline model this has been based on recorded data from 1993/94 to 2006. Extension of this period to 2009 in line with the baseline definition may result in some small alterations to the demand relationship.

Murray

Proposed improvements that relate to the Victorian Murray baseline model include those listed for the NSW Murray model in section. 2.11. In addition, any improvements in BDL models for tributaries of the Murray and inclusion of the Victorian Murray 30% carry over arrangements in place at June 2009 will in turn improve the Murray baseline model.

Based on discussions with staff from the Victorian DSE, it is likely that historical diversions for the Yarrawonga offtake will be revised in the future on the basis of more accurate data obtained through installation of an ultrasonic meter. This is likely to result in a new Cap and BDL estimate for the Victorian Murray.

3.3.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

Ovens

For the purposes of this review, the river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law as at 30 June 2009; and

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

For the purposes of determining Ovens modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual Cap extraction from this water source that would occur with the water storages, water access entitlements, water management rules and water use development that existed in the water source as at 30 June 2009.

The baseline diversion estimate for the Ovens is considered to be satisfactory. The model is also considered to adequately represent the definition of the BDL. However, as stated in MDBA 2011a, Ovens demands in the Cap model are based on a regression equation, however BDL diversions have been determined using REALM model. Agreement between the Authority and DSE on the best representation of Ovens demands in both the Cap model and the baseline model should be made.

Kiewa

For the purposes of this review, the Kiewa river system model component of the BDL is the long-term annual 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 for each year of the historical climate conditions under State water management law as at 30 June 2009; and

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

For the purposes of determining Kiewa modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual Cap extraction from this water source that would occur with the water storages, water

access entitlements, water management rules and water use development that existed in the water source as at 30 June 2009.

The current model held by the MDBA is considered to be representative of the baseline diversion definition and produce a satisfactory estimate of the baseline diversion. However an assessment of whether the adopted diversion demand relationship for the Kiewa would change with the inclusion of additional diversion date up to 2009 should be made at some point.

Murray

For the purposes of this review, the river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law as at 30 June 2009 (but excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers); and

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

For the purposes of determining Victorian Murray modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long-term average annual Cap extraction from this water source that would occur with the water storages, water access entitlements, water management rules and water use development that existed in the water source as at 30 June 2009 with adjustments for environmental water recovery under TLM and Water for Rivers program. It is also assumed that the definition implies that inflows to the model from contributing Valleys are representative of their respective valley BDL definition.

The Victorian Murray baseline conditions model held by the Authority produces the preliminary baseline diversion estimate satisfactorily. However, as mentioned previously for other valleys representation of the baseline diversion definition could be improved through an adoption of the amendments referred to in section **Error! Reference source not found.**

3.4 Conclusions

3.4.1 Baseline Diversion Estimates

An updated Goulburn Simulation Model should at some stage be adopted by the Authority for use in determining baseline diversion estimates. This is particularly the case for the Campaspe valley. The current model used by the Authority, whilst not the most up to date is considered to be satisfactory for preliminary baseline diversion estimation for the Goulburn, Broken, Loddon.

Models currently used by the Authority for the Wimmera, Ovens, Kiewa, and Murray Valleys are also considered appropriate for preliminary BDL estimation. However, an updated MSM model run, which includes inflows from updated tributary BDL models would be required as part of an updated BDL estimate.
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3.4.2 Representation of the BDL Definition

Victoria has not yet formally advised on the definition / interpretation of Baseline Diversion as at 30 June 2009 and has a number of queries. These include how diversions from storages on small streams for urban use that are not included in the large system models reviewed here are treated; and whether the 30 June 2009 cut-off literally applies if a rule changed post this date. For example some Victorian carryover rule settings.

Based on the interpretation of the definition for this review, the following valley models held by the Authority can be replaced by more up to date model versions in order to improve representation of the BDL definition. These consist of the:

- Goulburn Simulation Model (Including the Goulburn, Broken, Loddon, Campaspe)
- Murray Simulation Model
- Wimmera Model

The Kiewa, Ovens model appear to satisfactorily represent the BDL definition as interpreted for this review. However, in the case of the Murray portion of the model proposed improvements may further improve BDL representation. This includes representation of the Victorian Murray 30% carry over arrangements as at June 2009. Additionally, if the definition queries raised by Victoria are confirmed then the Murray model will also require further amendment.

4 Queensland Jurisdictional Models Current Status and Future Amendments

4.1 Introduction

Modelling in Queensland's regulated (or supplemented) and unregulated (or unsupplemented) river systems is undertaken using the Integrated Quantity and Quality Model as in New South Wales. Migration of the current model platform from IQQM will occur to eWater Source when the platform is finalised.

4.2 Qld Border Rivers

4.2.1 Jurisdictional Model Current Status

As advised by Queensland the most appropriate model for estimating baseline diversions is considered to be the model that reflects the 2008 New South Wales and Queensland Inter Governmental Agreement (IGA) on Water Sharing in the Border Rivers. Only one version of the model exists and details of this are presented in Table 20.

Table 20 - Qld Border Rivers Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1890 -2000)
(1) Border Rivers Valley longterm average diversions stated in IGA Model and reflected through Authorisations in Statutory Resource Operations Plan (Ver 6.73.4 System File Bor0609u IGA)	250

A break up of diversions from this model is presented in Table 21.

Table 21 - Breakup of Border Rivers Modelled Diversions (ML/Yr)

Summary			CAP	Modelled
		Unsupplemented Water Allocations	152159	152171
		Supplemented Water Allocations - High	3250	3273
		Supplemented Water Allocations	48600	47725
		Unallocated Water	5000	5136
		OLF and Unconverted Licences	41300	42575
		TOTAL	**250309**	**250880**

4.2.2 Jurisdictional Model Proposed Improvements

No improvements to this model are currently proposed for the model by the Jurisdiction. However, the model is yet to be independently reviewed and accredited for Cap auditing purposes. This may result in additional future amendments that may alter the baseline diversion estimate.

A separate model has also been developed for the Granite Belt. Outflows from this model do not currently form inflows to the Border Rivers model. Inflows to the Border Rivers model are currently based on gauged streamflows. The model has minimal data both in recorded flows and no extraction data that could be utilised in its development. The model has been used to estimate diversions for cap and assess changes in the Granite Belt as part of the Water Resource Plan development. The 4500ML of unallocated water is included in the diversions totals.

With the collection of better data, use of modelled inflows in the future as opposed to gauged flows may occur. The extent to which use of modelled as opposed to gauged inflows may affect the baseline diversion estimate is unclear at this stage.

4.2.3 Model Amendments made by MDBA

Amendments to the model provide to the MDBA (model 1 in Table 20) consisted solely of changes to the period of simulation from 1890- 2000 to 1895-2009.

4.2.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

In the case of the Qld Border Rivers, the river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from watercourses and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

For the purposes of determining Border Rivers modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the long term average annual extraction from the Queensland section of the Border Rivers valley under the New South Wales – Queensland Border Rivers Intergovernmental Agreement 2008.

Given effect through the water authorisations and water management rules detailed in the Gazetted Border Rivers Resource Operations Plan as of 30th June 2009.

Note: The Authority should also consider clarifying with the Jurisdiction whether unallocated water is or isn't considered to be part of the BDL. All unallocated water has been assumed to be part of the BDL for the purposes of this review. Any clarification should also be included in a set of guidelines which assist in development model scenarios that appropriately represent the baseline diversion definition and produce robust baseline diversion estimates (Refer to Section 6).

The model which is most representative of the baseline diversion definition and is most appropriate for use in estimating baseline diversions is model 1, in Table 20). This model has been supplied to the Authority.

4.3 Condamine Balonne

4.3.1 Jurisdictional Model Current Status

The model has undergone a number of changes to date. The original model ((Ver 6.73 System File 909B)) was supplied to the Authority and produced a longterm average annual diversion of 717.5 /Yr for the climatic period 1922 to 1995. This model represented the ROP for the Upper and Middle Condamine, but not for the St George and Distributary systems. The finalised ROP model used for establishing entitlement volumes (Ver 6.73 System File 909B for the Upper and Middle, 1002A for St George and 1005A for the Distributary system) produced a longterm diversion of 728GL/Yr for the same climatic period. The latest model, revised after an internal review for Cap auditing purposes (Ver 6.73 System File 1009G) has a longterm average diversion of 729GL/Yr.

Table 22 – Condamine Balonne Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1922 -1995)
(1) Condamine Balonne Valley longterm average diversions as per baseline model supplied to the Authority by Jurisdiction (Ver 6.73 System File 909B)	717.5
(2) Condamine Balonne Valley longterm average diversions stated in Statutory Resource Operations Plan as per baseline model (Ver 6.73 System File 909B for the Upper and Middle, 1002A for St George and 1005A for the Distributary system	728
(3) Condamine Balonne Valley longterm average diversions as per latest baseline model held by the Jurisdiction for Cap purposes (Ver 6.73 System File 1009G)	729

Alterations in the model from the model first supplied to the Authority for BDL establishment and that used to finalise the ROP and Cap have included:

- Amendments to on farm storage volumes.
- Changes to unsupplemented access rules and pump rates.
- Amendments to operational constraints such as to the start of the water year in the middle Condamine model and inclusion of event management in the St George Model.
- Removal of domestic and stock demand in the upper and middle Condamine model.

4.3.2 Jurisdictional Model Proposed Improvements

Future improvements to the model by the Jurisdiction are likely to reflect redistribution of water access entitlements through trade and water recovery. Water recovery is most likely to be concentrated in the Lower Balonne. Migration of the current model platform from IQQM to eWater Source may also occur in the future.

4.3.3 Model Amendments made by MDBA

Amendments to the model provided to the MDBA (model 1 in Table 22) consisted solely of changes to the period of simulation from 1922- 1995 to 1895-2009.

4.3.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

This review has focused in the river system model component of the BDL. For the Condamine Balonne the river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from watercourses and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

For the purposes of determining Condamine Balonne modelled watercourse diversions, State water management law as at 30 June 2009 would imply that access conditions for the Lower Balonne users would be that which existed prior to the 2010 Gazettal of the Lower Balonne in the ROP. It is recommended that the BDL definition for the Condamine Balonne is amended to reflect State water management law as at 31st March 2010, thereby capturing Gazettal of the Lower Balonne in the ROP.

For modelling purposes State water management law as at 31st March 2010 is then taken to mean the greater of the long term average annual extraction from the Condamine Balonne River System under the water authorisations and water

management rules detailed in the Gazetted *Condamine Balonne Resource Operations Plan,* or the Murray Darling Basin Ministerial Council Cap..

Note: The Authority should also consider clarifying with the Jurisdiction whether unallocated water is or isn't considered to be part of the BDL. All unallocated water has been assumed to be part of the BDL for the purposes of this review. Any clarification should also be included in a set of guidelines which assist in development model scenarios that appropriately represent the baseline diversion definition and produce robust baseline diversion estimates (Refer to Section 6).

The model which best represents the baseline diversion definition and is most appropriate for use in estimating baseline diversions is model 3, in Table 22. This model has yet to be supplied to the Authority and is also awaiting review by the independent Cap Auditor Bewsher Consulting. This review may result in additional model alterations that may change the longterm diversion estimates from those presented in Table 22.

Notwithstanding any future amendments, model 3 should be supplied to the Authority for use in BDL establishment as part of a framework for updating models.

4.4 Moonie

4.4.1 Jurisdictional Model Current Status

The model has undergone a number of changes to date with alterations in longterm diversions with each relevant version of the model presented in Table 23**.** As can be seen from the Table there are no differences in longterm average diversions between the model supplied to the Authority (model 2) and the latest model (model 3). This is despite a number of modifications to the model taking place as a consequence of the Independent Audit conducted by Bewsher consulting. These modifications are summarised in Table 24.

Table 23 – Moonie Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1889 -1998)
(1) Moonie Valley longterm average diversions stated in Statutory Resource Operations Plan as per baseline model (Ver 6.73.4 System File mon0608a)	34.
(2) Moonie Valley longterm average diversions as per baseline model supplied to the Authority by Jurisdiction (Ver 6.73.4 System File mon0608a)	34.4
(3) Moonie Valley longterm average diversions as per latest baseline model held by the Jurisdiction (Ver 6.73.4 System File mon1110a)	34.4

Table 24 – Modifications to the Moonie Model

Node Number	Change
096	Pump capacity changed to 120ML/day from 86.4ML/day in accordance with ROP.
079	Maximum rate for taking water was changed to 5.6ML.day from 3.9 in accordance with ROP.
228	Limitation to pump removed as there is no limit, maximum rate for taking water changed to 5.6ML/day from 20.6ML/day in accordance with ROP.

4.4.2 Jurisdictional Model Proposed Improvements

Proposed improvements to the model primarily relate to alteration of on farm storage volume estimates and crop model assumptions for stock and domestic users. Migration of the current model platform from IQQM to eWater Source may also occur in the future.

4.4.3 Model Amendments made by MDBA

Amendments to the model provided to the MDBA (model 1 in Table 22) consist solely of changes to the period of simulation from 1889-1999 to 1895-2009.

4.4.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

The Moonie river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from watercourses and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

For the purposes of determining Moonie modelled watercourse diversions in this review. State water management law as at 30 June 2009 is taken to mean the greater of the long term average annual extraction from the Moonie river system under the water authorisations and water management rules detailed in the Gazetted Moonie Resource Operations Plan as of February 2006, or the long term average annual extraction under the Murray Darling Basin Ministerial Council Cap.

Note: The Authority should also consider clarifying with the Jurisdiction whether unallocated water is or isn't considered to be part of the BDL. All unallocated water has been assumed to be part of the BDL for the purposes of this review. Any clarification should also be included in a set of guidelines which assist in development model scenarios that appropriately represent the baseline diversion definition and produce robust baseline diversion estimates (Refer to Section 6).

Both model 2 and model 3 are suitable for baseline diversion estimates. However, despite model 2 and model 3 producing identical longterm average diversions, model 3 can be considered to be most representative of the baseline diversion definition. Therefore, at some point provision of the updated Moonie model (model 3) to the Authority should occur as part of a model update framework.

4.5 Warrego

4.5.1 Jurisdictional Model Current Status

The model has undergone a number of changes to date. The original model used to develop the 2006 Resource Operations Plan (Ver 6.73.4 System File war0608a) was supplied to the Authority and produced a longterm average annual diversion of 47.3 /Yr for the climatic period 1889 to 1999. The latest ROP model has incorporated changes to meet the requirements of the independent Cap Audit. Qld has indicated that no changes were required to be made to the values within the model. Changes were however made to names of licenses within the model to allow for easier tracking and identification.

It should be noted that the published Cap number for the Warrego is 47.9 GL (Bewsher 2010). Discussions with DERM staff that this number was incorrectly stated due to double counting of diversions at one node in the model. As a consequence the number should be amended from 47.9 to 47.3 GL/Yr.

Table 25 – Warrego Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1889 -1999)
(1) Warrego Valley longterm average diversions stated in Statutory Resource Operations Plan as per baseline model (Ver 6.73.4 System File war0608a)	47.3
(2) Warrego Valley longterm average diversions as per baseline model supplied to the Authority by Jurisdiction run over the same climatic period as (1) (Ver 6.73.4 System File war0608a)	47.3
(3) Warrego Valley longterm average diversions as per latest baseline model held by the Jurisdiction run over the same climatic period as (1) (Ver 6.73.4 System File war0902a)	47.3

4.5.2 Jurisdictional Model Proposed Improvements

Proposed improvements to the model by DERM primarily relate to alteration of on farm storage volume estimates and crop model assumptions for stock and domestic users. Migration of the current model platform from IQQM to eWater Source may also occur in the future.

As mentioned in (MDBA 2012) the modelled diversions for the NSW part of the catchment are estimates only and have not been reviewed by the NSW Office of Water. A review of these estimates may lead to revised estimates of the BDL.

4.5.3 Model Amendments made by MDBA

As mentioned in MDBA 2011a, amendments to the model provided to the MDBA (model 1 in Table 25) consisted solely of changes to the period of simulation from 1889-1999 to 1895-2009.

4.5.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

This review has focused in the river system model component of the BDL. For the Warrego, the river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from watercourses and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

For the purposes of determining Warrego modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the greater of the long term average annual extraction from the Warrego River System under the water authorisations and water management rules detailed in the Gazetted Warrego, Paroo, Bulloo and Nebine Resource Operations Plan as of January 2006 or the long term average annual extraction under the Murray Darling Basin Ministerial Council Cap.

Note: The Authority should also consider clarifying with the Jurisdiction whether unallocated water is or isn't considered to be part of the BDL. All unallocated water has been assumed to be part of the BDL for the purposes of this review. Any clarification should also be included in a set of guidelines which assist in development model scenarios that appropriately represent the baseline diversion definition and produce robust baseline diversion estimates (Refer to Section 6).

Given that all models currently produce identical longterm average diversions, the model currently held by the Authority for the Warrego is considered representative of baseline conditions and is suitable for estimating baseline diversions. However, the most recent model (model 3) should be supplied to the Authority as part of a model update framework, and efforts should be made to obtain better representations of diversions for the NSW section of the model. It is understood that NSW has a separate more detailed IQQM model for the NSW section of the Warrego, which will lead to better estimates of flows and diversions downstream of Fords Bridge. This model should ideally be joined to the existing Warrego IQQM. No changes in flows or diversions upstream of Fords Bridge are anticipated as a result of this.

4.6 Paroo

4.6.1 Jurisdictional Model Current Status

As with the Warrego, the model has undergone a number of changes to date. However, as seen in Table 26 none of these changes have affected the longterm average diversions produced by the model. The original model used to develop the 2006 Resource Operations Plan (Ver 6.73.4 System File war0608a) was supplied to the Authority and produced a longterm average annual diversion of 0.2 GL/Yr for the climatic period 1889 to 1999. The latest ROP model has incorporated changes to meet the requirements of the independent Cap Audit. However, these changes were made to names of licenses within the model to allow for easier tracking and identification. No changes to model values were made.

Table 26 – Paroo Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1889 -1999)
(1) Paroo Valley longterm average diversions stated in Statutory Resource Operations Plan as per baseline model (Ver 6.73.4 System File war0608a)	0.2
(2) Paroo Valley longterm average diversions as per baseline model supplied to the Authority by Jurisdiction run over the same climatic period as (1) (Ver 6.73.4 System File war0608a)	0.2
(3) Paroo Valley longterm average diversions as per latest baseline model held by the Jurisdiction run over the same climatic period as (1) (Ver 6.73.4 System File war0902a)	0.2

4.6.2 Jurisdictional Model Proposed Improvements

Proposed improvements are identical to the Warrego model.

4.6.3 Model Amendments made by MDBA

As mentioned in MDBA 2011a, amendments to the model provided to the MDBA (model 1 in Table 22) consisted solely of changes to the period of simulation from 1889-1999 to 1895-2009.

4.6.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the Paroo, the river system model component of the BDL is the long-term annual average limit on the quantity of water that can be taken from watercourses and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

For the purposes of determining Paroo modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the greater of the long term average annual extraction from the Paroo River System under the water authorisations and water management rules detailed in the Gazetted Warrego, Paroo, Bulloo and Nebine Resource Operations Plan as of January 2006, or the long term average annual extraction under the Murray Darling Basin Ministerial Council Cap.

Note: The Authority should also consider clarifying with the Jurisdiction whether unallocated water is or isn't considered to be part of the BDL. All unallocated water has been assumed to be part of the BDL for the purposes of this review. Any clarification should also be included in a set of guidelines which assist in development model scenarios that appropriately represent the baseline diversion definition and produce robust baseline diversion estimates (Refer to Section 6).

Given that all models currently produce identical longterm average diversions, the model currently held by the Authority for the Paroo can be considered to be representative of baseline conditions and is suitable for estimating baseline diversions. However, the most recent model should be supplied to the Authority as part of a model update framework.

4.7 Nebine

4.7.1 Jurisdictional Model Current Status

The model has undergone a number of changes to date. The original model used to develop the 2006 Resource Operations Plan (Ver 6.73.4 System File war0608a) and that supplied to the Authority have longterm average diversions that differ by 0.4GL/Yr. for the climatic period 1889 to 1999. The latest ROP model has incorporated changes to meet the requirements of the independent Cap Audit and a further difference of 0.5GL/Yr is apparent. Longterm average diversions from each model and the amendments made to the latest model are presented in Table 27 and Table 28 respectively.

Table 27 – Nebine Modelled Longterm Average Diversions

Description	**Diversion (GL/Yr)** (1889 -1999)
(1) Nebine Valley longterm average diversions stated in Statutory Resource Operations Plan as per baseline model (Ver 6.73.4 System File neb0608a)	6
(2) Nebine Valley longterm average diversions as per baseline model supplied to the Authority by Jurisdiction run over the same climatic period as (1) (Ver 6.73.4 System File neb0608a)	6.4
(3) Nebine Valley longterm average diversions as per latest baseline model held by the Jurisdiction run over the same climatic period as (1) (Ver 6.73.4 System File neb0902a)	6.9

Table 28 - Modifications to the Nebine Model

Node Number	**Change**
174	Thresholds were corrected and now this node is taking water when the conditions are met.
156	Thresholds were corrected and now this node is taking water when the conditions are met.

4.7.2 Jurisdictional Model Proposed Improvements

Proposed improvements are identical to the Warrego model.

4.7.3 Model Amendments made by MDBA

As mentioned in MDBA 2011a, amendments to the model provide to the MDBA (model 1 in Table 22) consisted solely of changes to the period of simulation from 1889-1999 to 1895-2009.

4.7.4 Model Representation of the BDL Definition and Suitability for Estimating BDL

The river system model component of the BDL for the Nebine is the long-term annual average limit on the quantity of water that can be taken from watercourses and by floodplain harvesting (excluding take under basic rights) calculated by:

(i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions calculated on the basis of the quantity of water that can be taken under State water management law as at 30 June 2009; and

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

For the purposes of determining Nebine modelled watercourse diversions, State water management law as at 30 June 2009 is taken to mean the greater of the long term average annual extraction from the Nebine River System under the water authorisations and water management rules detailed in the Gazetted Warrego, Paroo, Bulloo and Nebine Resource Operations Plan as of January 2006 or the long term average annual extraction under the Murray Darling Basin Ministerial Council Cap.

Note: The Authority should also consider clarifying with the Jurisdiction whether unallocated water is or isn't considered to be part of the BDL. All unallocated water has been assumed to be part of the BDL for the purposes of this review. Any clarification should also be included in a set of guidelines which assist in development model scenarios that appropriately represent the baseline diversion definition and produce robust baseline diversion estimates (Refer to Section 6).

The model best represents the baseline diversion definition and is most appropriate for use in estimating baseline diversions is model 3, in Table 25. Whilst the difference between this model and that supplied to the Authority is only 0.5GL per year the most recent model should be supplied to the Authority as part of a framework for model updating in order for the latest estimate of baseline diversions to be calculated.

4.8 Conclusions

4.8.1 Baseline Diversion Estimates

Baseline diversion estimates are considered to be satisfactory for the Border Rivers, Moonie, Warrego, Paroo. Baseline diversions estimates for the Condamine Balonne, and Nebine can be improved through provision of updated models by the Jurisdiction to the Authority.

4.8.2 Representation of the BDL Definition

Five of the six Queensland Basin river system models have had amendments subsequent to provision to the Authority. More recent versions of these models should be supplied to the Authority to allow improved representation of the BDL definition. In decreasing order of significance, these are the:

- Condamine Balonne
- Warrego
- Nebine
- Moonie
- Paroo

5 South Australian Jurisdictional Models Current Status and Future Amendments

5.1 South Australian Murray

5.1.1 Introduction

South Australian diversions are represented through use of the Authorities Murray Monthly Simulation model.

5.1.2 MDBA Model Current Status

Changes in South Australian diversions for relevant areas are presented in Table 29. Only minor changes in diversions have occurred between model versions.

Table 29 - South Australian Murray Modelled Longterm Average Diversions

	Metro Adelaide	Country Town	AOP	Lower Swamps
Cap (1891-2006), reported and audited	100	48	450	94
Cap (1891-2006), Latest Run 22542	98	48	449	93

5.1.3 Baseline Model Amendments made by MDBA

Amendments to the model by MDBA in order to derive baseline diversion estimates have been summarised in MDBA 2011a. Major amendments have related to adjustments of diversions for permanent trade and for water recovered under the Living Murray Initiative.

Amendments to the model have also been made to simulation period in order for it to meet requirements for baseline definition.

5.1.4 MDBA Model Proposed Improvements

Future improvements to MSM (as outlined in the NSW Section of this review) are unlikely to affect the baseline diversion estimates for the South Australian Murray.

5.1.5 Model Representation of the BDL Definition and Suitability for Estimating BDL

For the purposed of this review the South Australian Murray regulated river system model component of the BDL is the long-term annual 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 of the Agreement for each year of the historical climate conditions (but excluding held environmental water recovered by the Living Murray Initiative)); and

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

The current model held by the Authority is considered to represent the BDL definition and produce a satisfactory baseline diversion estimate.

As for other systems for which the baseline definition includes adjustments for volumes of water recovered for the environment. A definition with respect to the representation of water recovered for the environment in the baseline model scenario needs to be agreed upon given the current disparities that exist for baseline diversion estimates. In the case of the South Australian Murray modelled diversions are based in the longterm Cap equivalent.

5.2 Conclusions

5.2.1 Baseline Diversion Estimates

The baseline estimates for the South Australia Murray are considered to be satisfactory.

5.2.2 Representation of the BDL Definition

The Murray model for South Australia is considered to be representative of the baseline definition. However, improvements in representation are likely to occur through adoption of the proposed improvements as listed in the NSW Murray section of this report.

6 Summation

This review has assessed the surface water models used to establish baseline diversions estimates for 24 valleys as part of the proposed Basin Plan. Representation of the baseline diversion definition and the models ability to determine baseline diversion estimates have been assessed. Due to the nature of river system models, and their continual improvement as a consequence of new data or information, the degree of representation of the BDL may be improved over time.

All models have been found to be representative of their respective baseline definitions. However a number of models have been found to require updating in order for representation of the baseline diversion definition and associated diversion estimates to be improved.

The baseline diversion definition as currently presented in the proposed Basin Plan is potentially open to interpretation. In order to overcome this, the Authority should consider the development of a set of guidelines which assist in development model scenarios that appropriately represent the baseline diversion definition and produce robust baseline diversion estimates. Definition interpretation issues that should be considered in development of guidelines include:

- Clarify definition of the 30 June 2009 cut-off. For example how it effects:
  - Policy Changes
  - Operating rule changes
- How interconnected systems are represented under the definition.
- How water recovered for the environment is represented in the river system models.
- Other key assumptions such as the accounting framework, and assumed release patterns.

It is suggested that a diversion definition register similar to that developed for application of the MDB Ministerial Council Cap be created in order to ensure consistency in diversion reporting from the baseline models.

The term “excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers” when used in the context of the BDL definition requires clarification in the context of model scenario establishment. It is recognised that a set of longterm Cap equivalent factors (called Longterm Diversion Limit Equivalent Factors) have been approved by Ministerial Council for use in determining the volumes

associated with water recovery. However, in the absence of a formal method for representation of recovered volumes in the river system models, diversions associated with water recovery initiatives in the baseline models are not always equal to the longterm Cap equivalent. For example, in Victoria, water recovery entitlements are represented explicitly in the river system models and have diversions associated with 2009 development levels and are not forced to equal a pre-agreed longterm Cap equivalent. Whereas in the NSW models (including the Murray), the BDL estimate has been based on a diversion associated with the longterm Cap equivalent. Resolution with respect to whether the diversion is based on longterm Cap equivalents, longterm average annual yield (as adopted by the Commonwealth) or 2009 levels is required along with the development of a formal method for inclusion in the models to ensure consistency baseline diversion estimation.

This review has demonstrated the wide range of baseline diversion estimates that can occur for the same model. It is likely that estimates of baseline diversions for each valley will continue to change over time as models continue to be improved. Consequently, the Authority should consider a strategy relating to how and when changes in baseline diversion estimates can best be disseminated to end users. This strategy is best initiated through the development of an agreed upon framework for updating models between the Authority and the Jurisdictions. This framework should specify the triggers for updates which may include but not be limited to:

- Specified model update frequencies
- Significance of model change
- The process by which model updating can be Quality Assured

References

MDBA 2010 River System Models used for the Development of the Basin Plan

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

MDBA 2011b Water resource assessments for without-development and baseline conditions. Supporting information for the preparation of proposed Basin Plan

MDBA 2012 Hydrologic Modelling to Inform the Basin Plan – Methods and Results