Upper Condamine

Upper Condamine Model Results to Support Basin Plan Requirements

Water Planning and Coastal Sciences

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Contents

List of tables

List of figures

1 Introduction

The Upper Condamine Model was developed using the SOURCE Model as a platform. A detailed background to the data used, methodology, calibration and validation of the model development is documented in *Condamine–Balonne River Basin Model, Volume 1 – Calibration of Hydrological Models – to St George (GS422201F) (DSITI, 2017).*

1.1 Current model

In preparing a water resource plan (WRP) and a resource operations plan (ROP) under the *Water Act 2000* (Qld), Queensland develops a hydrologic model to test management scenarios. The current plans, viz. the Water Resource (Condamine Balonne) Plan 2004 (current WRP) and the Condamine and Balonne resource operations plan July 2015 (current ROP), uses the Integrated Quantity Quality Model (IQQM) for the catchment models.

The current ROP model for the Condamine–Balonne also forms the basis for the audited Cap model which supports Cap Reporting requirements under the Murray–Darling Basin Agreement and in the transition to the Basin Plan Section 71 reporting. Note that the current ROP and Cap models use different simulation periods but are otherwise the same.

1.2 Proposed Model

Queensland has developed a new model for the Upper Condamine as part of the review of the current WRP and ROP and for the proposed Water Plan (WP) package being developed to comply with Basin Plan requirements. This new Draft WP model differs from the current model on the following points:

- A more detailed representation of some of the upper reaches in the Upper Condamine.
- The model was extended downstream to the Loudon gauge (422333A) to give a better representation of the management of the stream flow periods in the Upper Condamine Water Supply Scheme.
- Updated Methodology – Queensland has updated the model methodology based on the learnings from previous model builds to improve the robustness of the model. This update has come from model application, internal and external audits and developments external to technology. This is addressed in Appendix A. A key driver for this update was so that the model could be used to determine the sustainable diversion limit (SDL) and the baseline diversion limit (BDL) consistent with the Basin Plan requirements i.e. Chapter 10 and Position Statement 3 C Method for Determining Take.
- Better Data – With every review more data becomes available. This is addressed in Appendix A.

It needs to be noted that, because of trading, there have been changes to water allocations between the current and new Draft WP models.

1.3 Basin Plan Requirements

The Basin Plan prescribes requirements that Queensland needs to address to meet accreditation.

The key requirements that need to be addressed by the model are:

1. BDL – Baseline diversion limit of an SDL resource unit. The Baseline diversion limits are determined based on development conditions as specified in Schedule 3 of the Basin Plan. In general, the BDL is a sum of:
    - take from water courses
    - take from regulated river
    - take by floodplain harvesting
    - take by commercial plantation
    - take from basic rights.

    The model provides a component of the take identified in Schedule 3 is the long-term annual average limit on the quantity of water that can be taken from the watercourse and from regulated rivers. The other forms of take are considered in the Water Accounting Methods Report (NRM, 2016).

2. SDL – Sustainable diversion limit of the Water Resource Plan area. The SDL is the long-term average sustainable diversion limit from a SDL resource unit as defined in Schedule 2 and 4 of the Basin Plan. Clause 10.10 of the Basin Plan specifies that the Water Resource Plan must set out the method for determining the maximum quantity of water that the plan permits to be taken for consumptive use during a water accounting period. This method may include the modelling. For the Condamine–Balonne SDL resource unit, Queensland prepared the IQQM Model to meet this requirement. As there are no SDL adjustment measures proposed for the Condamine–Balonne, the difference between BDL and SDL is achieved by Commonwealth water recovery. To simulate SDL in the model, the Commonwealth's water entitlements would have to be treated as inactive (i.e. not used for consumptive take).

3. Annual Actual Take – Determination of annual actual take must be specified. As per clause 10.15 of the Basin Plan, the determination of the quantity of water, actually or estimated, taken for the consumptive use by each form of take from each SDL resource unit will be determined after the end of a water accounting period. The method used to estimate the quantities should be same as used to determine BDL and SDL.

4. Environmental Water – Determination of the environmental water requirements of environmental assets and ecosystem functions. Clause 8.51, sub-section (1) and (2) of the Basin Plan list a number of measures to determine the environmental water requirements of an environmental asset and states that a method to estimate them may include a conceptual model.

5. SDL Adjustment Proposals – Models are an important tool for evaluating the SDL adjustment proposals. Chapter 7 of the Basin Plan states that the Authority can propose adjustments to the surface water SDLs if certain additional changes in infrastructure are proposed through the implementation of 'supply measures' and 'efficiency measures'.

Sections 10.22, 10.49 and 10.50 of the Basin Plan specify requirements that the WRP Package meet:

a) Section 10.22 states that a water resource plan must describe what was done to comply with the requirements mentioned in Part 4, Chapter 10 of the Basin Plan.

b) Section 10.49 states that:
   - A water resource plan must be based on the best available information
   - The water resource plan must identify and describe the significant sources of information on which the water resources plan is based.

c) Section 10.50 states that:
   "A water resource plan must identify any significant method, model or tool that has been used to develop the water resource plan."

This report covers the requirements outlined above.

2 Upper Condamine SOURCE Model

The Upper Condamine Model was developed by using the SOURCE Modelling platform. A detailed background to the data used, methodology, calibration and validation of the model development is documented in *Condamine-Balonne River Basin Model, Volume 1 – Calibration of Hydrological Models – to St George (GS422201F) (DSITI, 2017).* Figure 1 shows the extent of the model.

Figure 1 Model Extents

3 Model Scenarios

In this section, the model scenarios are described. The details of the model scenarios are described in Table 1.

Table 1 Detail of the Model Scenarios

Case Number	Model Name	Description	Simulation Period
1710A	Current Cap IQQM	This IQQM model was developed for MDBA Cap Reporting.	1895–2017
1811E	Current Cap IQQM Adjusted for Trades	This IQQM model was the Current Cap Model modified to reflect the trades up to June 2017.	1895–2017
1901B	New Upper Condamine Draft WP SOURCE Model	This SOURCE model was developed for the second generation Draft Water Plan representing all of the Water Allocations and licences in the basin.	1889–2013
1807C	New Upper Condamine Draft WP IQQM	This IQQM model was developed to mimic the SOURCE model to assist identify the cause of differences between the SOURCE and IQQM platforms.	1889–2013
1710B	Current Without Development IQQM	This IQQM model is the same as the Current Cap model with all demands switched off and all on-stream storages removed.	1895–2017
300A	New Without Development SOURCE Model	This SOURCE model is the same as the New Upper Condamine SOURCE Draft WP model with all demands switched off and all on-stream storages removed.	1889–2013

All of the model scenarios cover a period greater than the Basin Plan (1895–2009) so they are able to fulfil the Plan’s requirements. All results in this report are provided for the Basin Plan period.

These scenarios were used to simulate the extractions (BDL) under the Resource Operation Plan for the Upper Condamine System.

The model simulated the flows and extractions by water allocations.

3.1 Current Cap IQQM (Case 1710A)

A description of the current Cap IQQM (case 1710A) can be found in DERM (2011).

3.2 Current Cap IQQM Adjusted for Trades(Case 1811A)

The model is the same as the Current Cap IQQM, except that the allocations that have had a change in conditions have been adjusted to reflect the change in conditions. The changes to the unsupplemented allocations have been mainly changes to the volumetric limits and change to the location. The changed allocations are listed in the spreadsheets called:

Changes to Condamine Tributaries WMA.xlsx

Changes to Allocation In Upper Condamine WMA.xlsx.

There have been significant changes to the supplemented allocations as shown in the spreadsheet called

Changes to Upper Condamine Water Supply Scheme.xlsx.

3.3 New Upper Condamine Draft WP SOURCE Model (Case 1901B)

A description of the new Upper Condamine SOURCE ROP model can be found in DSITI (2017). Details of the allocations in the model can be found in the spreadsheets called ‘

Upper Condamine WMA-from RCS – Rev 2018_11.xlsx,

Upper_Condamine_Water_Supply_Scheme_Demands - QA.xlsx,

Condamine-Tributaries_WMA-from RCS - QA.xlsx,

Upper Condamine Overland Flow - QA.xlsx.

The model includes all the changes from trading up to November 2018.

3.4 New Upper Condamine Draft WP IQQM (Case 1809F)

The New Upper Condamine IQQM ROP model is a copy of the New Upper Condamine SOURCE ROP model converted to the IQQM platform. Because the IQQM model used the same flow and model network as the SOURCE model, it was used to identify the differences caused by the change in the modelling platform.

3.5 Current Without Development IQQM (Case 1710B)

The Current IQQM Without Development is essentially the same as the Current ROP model with all demands switched off and all on-stream storages removed.

3.6 New Without Development SOURCE Model (Case 300A)

The new SOURCE Without Development model is the same as the New Upper Condamine SOURCE ROP model with all demands switched off and all on-stream storages removed.

4 Reconciliation with Murray–Darling Basin Plan Schedule 3

The Basin Plan places limits on water extractions within the SDL resource units. The model 310A is proposed to estimate the available water, specifically the take from watercourses for water allocations and licences. This will support the Water Accounting Methods proposed in the Water Accounting Methods Report (NRM, 2016) for the other forms of take and classes of water access right. For the details on these proposed methods, see the report cited above.

The following section provides the comparison and of the long-term diversions between the various model scenarios, using the Basin Plan simulation period 1895–2009. Table 2 provides a comparison between the long-term diversions of the water allocations in the model scenarios for the reaches upstream of Cecil Plains. This corresponds to the reaches covered in the current ROP IQQM. Table 3 presents a comparison between the long-term diversions for the reach between Cecil Plains and Loudon Gauge. This reach is covered by the Middle Condamine ROP IQQM. Table 4 and Table 5 present comparisons between the mean annual flow predicted at various gauges by the Current ROP model and the new SOURCE model under development and without development conditions.

Table 2 Long-Term Diversions for the Reaches Upstream of Cecil Weir (1895–2009)

Demand	Current Cap IQQM (1710A) (GL)	Current Cap IQQM Adjusted for Trades (1811E) (GL)	New Upper Condamine Draft WP SOURCE Model (11901B) (GL)	New Upper Condamine Draft WP IQQM (1807C) (GL)
High Priority Demand	3	3	3	3
Medium Priority Supplemented Demand	21	22	20	22
Risk A Demand	4	4	4	4
River Water Harvesting Demand	26	26	29	26
North Branch Water Harvesting Demand	4	4	6	6
Tributary Allocation (Including Condamine upstream of Water Supply Scheme)	23	23	27	27
Overland Flow Demand	17	17	12	12
Total	98	99	101	100

Table 3 Long-Term Diversions for Reaches from Cecil Weir to Loudon Weir (1895–2009)

Demand	Current Cap IQQM (1710A) (GL)	Current Cap IQQM Adjusted for Trades (1811E) (GL)	New Upper Condamine Draft WP SOURCE Model (1901B) (GL)	New Upper Condamine Draft WP IQQM (1807C) (GL)
Town Water Demand	1	1	1	1
River Water Harvesting Demand	9	9	8	9
Tributary Water Harvesting Demand	1	1	1	1
River Former Area Licences Demand	1	1	1	1
Tributary Former Area Licences Demand	1	1	1	1
Overland Flow Demand	19	19	24	23
Lower Oakey Gowrie Water Harvesting			1	1
Total	32	32	37	37

Table 4 Long-Term Flows at Various Gauges for Development Cases (1895–2009)

Gauge	Current Cap IQQM (1710A) (GL)	Current Cap IQQM Adjusted for Trades (1811E) (GL)	New Upper Condamine Draft WP SOURCE Model (1901B) (GL)	New Upper Condamine Draft WP IQQM (1807C) (GL)
Elbow Valley (422394A)	37	37	34	34
Warwick (422310C)	83	83	76	76
Talgai (422355A0	114	113	123	120
Yarramalong (422353A0	111	109	185	169
Cecil Plains (422316A0	162	161	203	232
Lone Pine (422345A0	4	4	3	2
Loudon (422333A0	150	150	177	174

Table 5 Long-Term Flows at Various Gauges for Without Development Cases (1895–2009)

Gauge	Current Without Development IQQM (1710B) (GL)	New Without Development SOURCE Model (300A) (GL)
Elbow Valley (422394A)	37	37
Warwick (422310C)	96	85
Talgai (422355A0	141	140
Yarramalong (422353A0	154	216
Cecil Plains (422316A0	242	279
Lone Pine (422345A0	18	14
Loudon (422333A0	276	286

In the Upper Condamine upstream of Cecil Weir, there was only a slight increase in the long-term diversions caused by the change in allocations from trading during the lifetime of the current plan.

The diversions calculated by the new SOURCE model were similar to those calculated using the new IQQM ROP model showing that most of the difference between the new SOURCE model and the current ROP IQQM was caused by the revision of the flows. The medium priority supplemented diversions were lower in the SOURCE model than in the new IQQM. This was attributed to the different way SOURCE orders water to maintain the levels in the weir and the way SOURCE shares releases amongst users when the system cannot supply their full demand. The IQQM allows users to have more access to tributary inflows. Restricting the take by medium priority users in SOURCE allowed more water to be taken by the water harvesting allocations.

In the reach between Cecil Weir and Loudon Weir, the SOURCE model diversions were similar to the current ROP IQQM diversions, except for the overland flow diversions, which were higher in the SOURCE model. This was attributed to the higher revised flows resulting from the better flow estimation techniques used to develop the SOURCE model.

The revised flows were slightly lower in the SOURCE model upstream of the Water Supply Scheme. A comparison of the latest measured flows at the Warwick gauge with the measured flows used to estimate the inflows for the current ROP model shows a slight reduction in the flows of the order of 2.4 per cent suggesting change in the rating of the gauge. Within the Water Supply Scheme, the revised flows were significantly higher. The large increase at Yarramalong was due to using the Tummaville gauge to estimate the residual inflows to this reach rather than the Yarramalong gauge as it was judged to be more reliable. A comparison of the Tummaville measured flows with the Yarramalong measured flows used to estimate catchment inflows for the current ROP model showed an increase of 10.7 per cent for the period from 1989 to 1995 in the original model development.

A discussion of the reasons for the difference between the results of the models is given in Appendix A. A more general discussion of the differences between the IQQM and SOURCE model platforms can be found in DES (2018).

5 Conclusion

The new model for the Upper Condamine has benefited from additional information that has become available to update the legislative models that support the Queensland Water Resource Planning process and Murray–Darling Basin Plan requirements. The models have benefited from:

- new climatic and streamflow data
- updated methodology
- longer simulation period and better representation of climatic variability.

The Basin Plan has a simulation period from 1895 to 2009 which differs from both the current Resource Operation Plan (2008) and the new Resource Operation Plan (2017), causing some of the variation in the diversion figures between Basin Plan and State Plan. When a consistent period is applied, it is possible to compare take from watercourses by allocations for the two plans, as shown in Table 6. There are no CEWH entitlements in the Upper Condamine catchment.

Table 6 Long-term mean annual diversions from watercourses under water allocations and licences: comparison of model 1710A and 310A

Mean annual diversions (1895–2009)	Current Cap IQQM (1710A)	Draft WP SOURCE Model (1901B)
Total	130 GL	138 GL
CEWH entitlements only	0 GL	0.5 GL

As can be seen in Table 6, the Draft WP SOURCE model (1812A) estimates of mean annual diversions are nearly 5 per cent higher than the estimates provided by the Current Cap IQQM (1710A) model. The main difference between the two models is the revised stream flows are higher in the SOURCE model, which has increased the water harvesting diversions. Even with the extra diversions, the mean annual flow at the end of the model at Loudon gauge were increased by 17 per cent. There were also some smaller differences caused by the different modelling platforms that have been discussed in more detail in Appendix A and DES (2018).

The new model demonstrates Queensland's commitment to improve on the previous model's robustness and defensibility. All future models will build on the new model and use the latest information, methodologies and technology available at the time when the next new model is developed.

6 References

Department of Natural Resources and Mines (2016), *Water Accounting Methods Paper for Warrego-Paroo-Nebine Water Resource Plan, State of Queensland, February 2016.*

Department of Science, Information Technology and Innovation (2017), *Condamine-Balonne River Basin Model, Volume 1 – Calibration of Hydrological Models – to St George (GS422201F).*

DERM (2011), *Hydrology Report: Condamine-Balonne Cap Model Description* Department of Environment and Resource Management, Queensland Government.

DES (2018), *Differences Between the Source and IQQM Modelling Platforms*. Department of Environment and Science.

DSITI (2017), *Condamine River Basin. Condamine WRP Review G2 Existing Entitlement Modelling Report*. Department of Science, Information Technology, and Innovation.

ROP (2008), *Condamine and Balonne Resource Operations Plan December 2008 Amended July 2017 (Revision 5)*. Department of Natural Resources and Mines, State of Queensland.

WRP (2004), *Water Resource (Condamine and Balonne) Plan 2004*. State of Queensland.

Appendix A – Methodology and Data Differences

Methodology and Data Differences 1995 to 2013

The IQQM developed for the first Water Resource Plan was completed in 1998 with a simulation period from 1922 to 1995. The period of simulation was extended from 1895 to 2006 for the CSIRO Sustainable Yield Study and was then extended to 2009 for the Murray-Darling Basin Plan modelling. The Sacramento models developed in the 1990s were used to extend the period of simulation back to 1895.

In 2013, a new set of models were developed for the Condamine–Balonne using the SOURCE platform. These models used an extended data set, which included new gauging stations, as well as new methods for model calibration. Consequently, the flows in the SOURCE models are different from the flows in the original models.

There are also differences between how the SOURCE and IQQM models perform certain processes, which can give different simulated diversions and flows especially in complex systems.

An attempt was made to isolate the differences between the two modelling platforms by setting up an IQQM mode with the same flows and routing and loss parameters as the SOURCE model. It was found that most of the differences could be attributed to the differences in the flows.

A general discussion of the main points of difference between the two models is given below.

Rainfall and Evaporation

Different rainfall and evaporation data were used. Some of the rainfall stations used in the original model have been closed, so it was necessary to use another near-by station in the SOURCE model. SILO patched point data, which is recorded station rainfall infilled with SILO data drill (grid) data at that location, was used.

In the Sacramento modelling, new techniques were used to select rainfall stations in the calibration. Stations were chosen that gave the best agreement between the modelled and measured streamflow.

In the SOURCE models, evaporation data from the Warwick site were used for all of the catchment even though it is located in the northern section. This site had the best metrological data for the estimation of the lake and potential evaporation in the catchment. It was best to use this data rather than data extrapolated from this site. The evaporation at Warwick would be fairly similar to evaporation in these catchments and any errors are unlikely to have a large effect on the model.

Flow Data

Recorded flow data used to develop the original IQQM and the SOURCE models has varied in a number of ways:

- Different and additional gauges used.
- Longer records with flows associated with more extreme weather conditions.
- Rating changes. This will change earlier flow records if the rating curves change.
- Data may have been extracted differently. Variations include use of different time offsets and different conversion calculations used to generate flow data from levels.

In the original IQQM, stream gauges on the main stream were mainly used for estimating flows. In the SOURCE model, more tributary gauges and new gauges were used to improve the estimation of the flows.

Sacramento Calibrations

The latest Sacramento models are different to the original ones. They use different catchment areas, rainfall, evaporation and flow data (residuals were developed on numerous different modelling assumptions and for different time periods and, in some cases, flow data were extracted differently).

The main difference was the use of the FORS method to determine both catchment parameters and the rainfall stations. This methodology resulted in better agreement between the modelled and measured flows. The Sacramento models were calibrated over a longer calibration period that included a major drought and record floods, which should improve the ability of the model to predict these events.

Use of Historical Diversions in Flow Calculations

There are very few measured diversions in this catchment. The derived inflows can only be accurately adjusted if daily diversion data is available. As this data was not available, it was considered better to not include them in the estimation of inflows.

Flow Adjustment Explained (using DMM)

Once the full length inflow sequences for the whole model were included, further adjustments were made to the Sacramento parts of them to obtain a better match between the model and the long-term recorded flow data in the catchment. The program DMM was used to make the adjustments.

DMM is an adjustment process applied across multiple reaches. It is used to adjust Sacramento data in multiple reaches upstream of a long-term gauge, to bring the modelled and recorded flows into alignment. Recorded head water inflows and calculated residual inflows are not adjusted.

DMM first calculates the difference between modelled and recorded flows at the downstream gauge being adjusted to. The differences are caused by inaccuracies in Sacramento inflows due to inaccurate spatial and temporal rainfall and evaporation representation, and also by the averaging of lag and routing, and losses. DMM adjusts the Sacramento parts of the inflow sequences to produce sequences which together with the calibrated model’s assumptions, will result in better alignment of the modelled and gauge flows at the long-term gauges. It does multiple iterations to converge towards a best set of adjusted inflows and then the user decides which iteration’s inflows give the best result overall. The program usually modifies Sacramento data by scaling in proportion to the differences between the modelled and measured flow at a downstream gauge. If there is gauged flow but no modelled flow, the program distributes the measured flow over the upstream sub-catchments using a scaling factor based on the catchment area of the sub-catchments weighted by the mean annual rainfall on the sub-catchment.

DMM can be applied to align the model to multiple long-term gauges. In this case the adjustment is done to the next long-term downstream gauge and the adjusted inflow data is then excluded from adjustments to gauges further downstream.

The final residual reach inflows are used in the model validation and model simulation runs.