CONFIDENTIAL

HYDROLOGICAL MODELLING REVIEW

TRAVESTON CROSSING DAM DRAFT EIS

Mary River looking downstream from Bells Bridge

FINAL REPORT

10 June 2008

Bewsher Consulting Pty Ltd

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SUMMARY

This is a review of the Mary River Integrated Quantity and Quality Model (IQQM) that was prepared for the Traveston Crossing Dam draft EIS. The review has been carried out by Bewsher Consulting Pty Ltd for the Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) following commissioning in January 2008. The review is based largely on the documentation provided in the draft EIS and other information gained from interviews with modellers and key personnel associated with the preparation of the hydrology sections of the draft EIS. The review has not extended to an examination of the computer data files associated with the model.

The Mary River IQQM was initially prepared by the Queensland Department of Natural Resources and Water (DNRW) as part of the preparation of the Mary River Water Resources Plan (WRP) in 2006. The WRP embodies performance criteria, known as environmental flow objectives (EFOs) and water allocation security objectives (WASOs) to minimise impacts on streamflows and existing water users. Under Queensland legislation, the Mary River IQQM is the simulation tool used to assess compliance with the EFOs and WASOs for any new project in the valley such as the Traveston Crossing Dam. The draft EIS documentation has demonstrated that the project can meet all mandatory EFOs and WASOs identified in the WRP.

Using IQQM, SunWater has conducted preliminary investigations of the impact of Traveston Crossing Dam on the hydrology of the Mary River. This review found that generally the input data and assumptions underlying the modelling by SunWater are sound. However, the review identified that the following assumptions used by SunWater in the IQQM presented in the draft EIS, are simplistic and will likely be refined as the project develops:

(a) 'transparent' operation of Borumba Dam;

(b) fixed monthly supplies from the dam into the SEQ grid; and

(c) no environmental flows except for a nominal requirement to pass all inflows less than 100ML/d.

Whilst these assumptions are simplistic, they will have had the effect of over-estimating the impact of the proposed dam on the hydrology of the Mary River below the dam.

In addition, the review identified that the modelling undertaken to date has not considered the impacts of the dam in conjunction with climate change, nor has any modelling of Stage 2 of the dam and its impacts been presented in the draft EIS.

In conclusion, whilst all models are only approximations of reality and can always be improved with additional effort and resources, this review has identified that the Mary River IQQM has been rigorously established and calibrated. This model was used as the basis for the modelling by SunWater for the Traveston Crossing Dam draft EIS

and can be considered a good tool with which to assess the hydrologic impacts of the proposed dam.

1. INTRODUCTION

1.1 TERMS OF REFERENCE

In early January 2008, Bewsher Consulting Pty Ltd was commissioned by DEWHA to carry out an independent review of the hydrological modelling component of the Traveston Crossing Dam draft EIS. A copy of the terms of reference for the review is provided in **Appendix A**.

The terms of reference require an evaluation of the:

1. **IQQM model** — including the validity of the model for the purposes for which it was used in the draft EIS, and the validity and accuracy of the data and assumptions on which the modelling has been based.

2. **Model output data** — the presentation and interpretation of the model output data in the draft EIS, including the confidence that can be applied to the modelling output and associated interpretations of that output, as presented in the draft EIS.

3. **Environmental flows** — the ability of environmental flows proposed in the draft EIS, under the Mary River Water Resource Plan and other relevant framework, to mitigate the hydrological impacts of the dam.

These three components of the review are presented below in **Chapters 4, 5** and **6**, respectively.

1.2 DOCUMENTS REVIEWED

Whilst the reviewer has been provided with a full copy of the draft EIS, the following summarises the key documents which have been reviewed:

(a) *Terms of Reference for an Environmental Impact Statement, Traveston Crossing Dam Project, Stage 1*. May 2007.

(b) *Executive Summary, Traveston Crossing Dam Environmental Impact Statement*. SKM, October 2007.

(c) *Chapter 6.1 Hydrology, Traveston Crossing Dam EIS*. SKM.

(d) *EIS IQQM Modelling, Mary Basin. SunWater*. October 2007.

(e) *Mary River IQQM Report*. Department of Natural Resources & Mines (DNRM). Queensland Government. April 2005[1].

[1] Note that from discussions with DNRW, the reviewer understands various versions of this report were prepared with this date. The final version referenced here, was completed sometime in 2006.

(f) *Hydrology Report. Mary Basin — Draft Water Resource Plan. Volumes 1 & 2*. November 2005.

(g) *Audit Report — Mary River IQQM Audit*. Prepared by Kellogg Brown & Root Pty Ltd for Queensland DNRM. 19 December 2005.

(h) *Water Resource (Mary Basin) Plan 2006*. Subordinate Legislation 2006, No. 192. Made under the Water Act, 2000. Queensland Government. 2006.

(i) *Water Resource (Mary Basin) Plan 2006*. Explanatory Notes for SL 2006, No. 192. Made under the Water Act 2000. Queensland Government 2006.

1.3 MEETINGS WITH KEY PERSONNEL

Over the period 23–25 January 2008, the reviewer had the opportunity to meet with the following people who had a significant roles in the preparation of the hydrological modelling components of the draft EIS:

(a) Mr John Ruffini and Mr Matthew Gooda from the Department of Natural Resources and Water (DNRW). Mr Ruffini was the project manager of the DNRW's hydrology team that prepared various hydrologic studies and models as part of the Mary River Water Resource Plan (WRP), 2006. The hydrologic assessment procedures and models developed for the WRP are of significance to the draft EIS;

(b) Mr Tom Vanderbyl, hydrologic modellers and other officers from SunWater. Mr Vanderbyl is the Manager of Strategic Water Management at SunWater. SunWater maintains and operates key elements of the water infrastructure in the Mary River catchment, and manages bulk water deliveries. SunWater undertook the hydrologic modelling of the Traveston Crossing Dam for the draft EIS based on the earlier IQQM model prepared by DNRW for the WRP;

(c) Ms Samantha Watt, SKM. (It is understood that Ms Watt was the principal author of Chapter 6 of the draft EIS including Section 6.1 which describes the hydrological modelling activities undertaken for the draft EIS); and

(d) Mr David Murray, Queensland Water Infrastructure Pty Ltd.(QWI). Mr Murray is a Senior Project Manger for QWI and has had a role coordinating the hydrological inputs provided by DNRW, SunWater and SKM for the draft EIS.

1.4 LIMITATIONS TO REVIEW ACTIVITIES

The reviewer has examined the available documentation and conducted interviews with key DNRW and SunWater personnel involved in the preparation and operation of the Mary River IQQM. During these interviews, the staff involved provided candid and helpful responses to the various questions asked and the reviewer had no reason to believe that important information was withheld or falsely provided. The assessment of the model and its data carried out in this review has been based on these activities and the available documentation.

IQQM requires hundreds of variables to be specified in its input. Input items involving daily time-series data over the simulation period will contain nearly 40,000 values per item. Consequently the reviewer has not checked the source input data directly, nor confirmed that the data is consistent with the documentation and the answers provided during interviews. Rather the reviewer has assumed that all the information provided, precisely and accurately represents the modelling for the project.

In addition the reviewer has not re-established the model on his own computer system to confirm the results presented in the documentation. Nevertheless within the time and budget constraints of the project, the reviewer has not identified a need for such detailed auditing to be carried out.

1.5 CATCHMENT INSPECTION

In order to gain an overview of the catchment topography and land uses that affect its hydrological response, an aerial and ground inspection of the catchment was undertaken during 23–24 January 2008. This comprised:

(a) participation in an aerial charter organised by QWI which inspected the southern watershed, Borumba and Baroon Pocket Dams, the main river channel from near Maleny to Maryborough, the dam site, and the Mary River Barrage; and

(b) ground inspection of the Mary River channel and its associated floodplain and rural activities that are visible from the road crossings between Kenilworth and Miva.

1.6 REPORT FORMAT

Chapters 2 and **3** of this report provide further background. **Chapter 2** deals with the Mary River Water Resource Plan (WRP) given that much of the hydrological concepts and modelling presented in the draft EIS are directly related to those developed during the WRP. **Chapter 3** provides background details of the Mary River IQQM.

Chapters 4, 5 and **6** provide the response to the three terms of reference summarised in **Section 1.1** and reproduced in **Appendix A**.

2. MARY RIVER WATER RESOURCE PLAN (WRP)

2.1 OVERVIEW

As the hydrologic modelling undertaken in the draft EIS is based on that developed for the Mary Water Resource Plan (WRP), this section provides some background to the WRP process that has been legislated in Queensland.

The Mary River WRP was prepared in 2006 under the Queensland Water Act 2000. As noted in the *Explanatory Notes* that accompany the WRP, the principal aim of the WRP is to provide a framework for management of the surface and sub-artesian water to:

(a) meet future water requirements; whilst
(b) protecting natural eco systems; and
(c) ensuring security of supply to water users.

2.2 EFOs AND WASOs

In order to meet the aim noted above, the WRP specifies environmental flow objectives (EFOs) and water allocation security objectives (WASOs).

The EFOs are a numerical target or level of performance to be achieved and consist of a combination of mandatory and desired objectives. Under the WRP, any future decisions about water allocation and management in the Valley must comply with the mandatory EFOs. There are EFOs that relate to low flows, medium to high flows, and seasonality. Most of the EFOs are expressed as the long-term frequency of occurrence of flows within certain ranges.

Compliance with the EFOs is tested using the Mary River integrated quantity quality model (IQQM) which is legislated within the WRP. IQQM is specified in the WRP to operate over the period 1890–1999. (The Mary River IQQM was developed by DNRW for the WRP and has subsequently been updated by SunWater to include the Traveston Crossing Dam for the draft EIS).

The statistics produced by the IQQM are also used to determine compliance with the WASOs. The WASOs aim to provide security of supply to water users. They ensure that future decisions about allocation and management of water made under the WRP will not affect the probability of groups of water users receiving their water allocations.

2.3 WATER UTILISATION ASSUMPTIONS

The water management framework embodied in the WRP has been developed assuming full utilisation of existing water entitlements and the provision of additional allocations to meet future water needs.

The WRP also includes consideration of a 'strategic reserve' which is unallocated water set aside to meet the future long-term urban water needs of the region. Clause 31 of the WRP specifies that this reserve is 150GL/year. It is understood that a component of this strategic reserve will be allocated to the additional water extraction associated with Traveston Crossing Dam (which is assumed to be 70GL/yr in the draft EIS).

Assuming a repeat of the climate of the 1890–1999 period specified in the WRP, compliance with the EFOs and WASOs is tested assuming full development of the strategic reserve as well as full use of water entitlements.

In addition, a component of the EFOs in the WRP have been calculated with reference to the 'pre-development flow pattern'. The 'pre-development flow pattern' is defined in the WRP to mean *"the pattern of water flows during the simulation period, … using IQQM …, if there were no dams or other water infrastructure .. ".* This differs from natural conditions as the catchment's response to rainfall within IQQM is not altered to reflect conditions prior to European settlement.

3. MARY RIVER IQQM

3.1 IQQM SOFTWARE

The IQQM modelling software is widely used by water authorities throughout NSW and Queensland, and in other parts of Australia and some overseas countries, for the simulation of long-term surface water behaviour in catchments. The software was custom written for this purpose by the NSW Department of Water and Energy (DWE) with assistance from the DNRW.

It is undoubtedly the preferred modelling platform used by the NSW DWE and the DNRW when undertaking long-term simulations of surface water systems requiring assessments of streamflows, rural and urban water use, and the operation of major water infrastructure.

3.2 KEY IQQM ASSUMPTIONS

There are various assumptions made in any IQQM run. Some key ones include:

(a) the water management conditions within the catchment are assumed to be constant for the duration of the simulation. This includes water supply infrastructure, entitlements, etc, (i.e. there is no growth in water demands or changes in supply infrastructure during the simulation);

(b) recorded tributary inflows entering the extremity of the IQQM model will be used wherever possible. Where such records do not exist, synthetic streamflows are usually calculated from rainfall using Sacramento modelling processes which are built into IQQM;

(c) irrigation demands can be specified as fixed daily or monthly values, or can be calculated based on announced allocations, rainfall, soil moisture conditions, etc;

(d) most urban water demands including industrial and mining requirements are usually specified as fixed monthly demands;

(e) transmission losses are usually determined as a percentage of the total river flow. These percentages can vary with the magnitude of the flow and are initially determined during the calibration of the model to observed data;

(f) given the water management conditions that are assumed for a run, IQQM calculates the behaviour assuming the climate of the past reoccurs in the future; and

(g) hydraulic routing of flows within river reaches occurs using approximate hydrologic routing techniques.

3.3 SIMULATION PERIOD

The Mary River IQQM in the form set up by DNRW for the WRP, simulates daily flows throughout the catchment over the period 1890–1999. This simulation period was subsequently extended by DNRW to 2007.

The seven year extension is referred to as the 'extended period simulation' in the draft EIS and was not subject to the same modelling rigour as the original establishment of the Mary River IQQM for the WRP. In particular the model was not recalibrated noting that some of the seven years were very dry and it is likely that the assumed losses and other assumptions in the model could be improved.

SunWater also made use of the extended period simulation and widened the spatial coverage to include some parts of the Lower Mary Irrigation Area.

3.4 IQQM SCENARIOS

There are three modelled scenarios which are discussed in the draft EIS. These three scenarios were derived from modelling undertaken by SunWater and comprise:

(a) *Pre-Development Case (PD02)* — As reported in SunWater's modelling report, the pre-development case represents the behaviour within the Mary River catchment without the 'interferences' caused by water extractions and the construction of water related infrastructure. Note that this scenario does not represent natural conditions within the catchment because the runoff characteristics simulated in IQQM represent those of the developed rather than the pre-developed catchment. Nevertheless, the influences of all water supply infrastructure (e.g. dams, weirs, etc.) have been removed.

(b) *Proposed Operations Case (PO45)* — This scenario represents the current water management practice and streamflows within the catchment, assuming full utilisation of existing water entitlements. It is understood that in general terms, only some half to two-thirds of the existing entitlements are actually utilised. Note that much of the assessments carried out in the draft EIS use the PO45 results as the base case, assuming this represents 'current' conditions. In reality however, this case represents 'ultimate' conditions under the existing infrastructure and entitlements currently available (without use of the strategic reserve). The PO45 run was developed by SunWater from

DNRW's original CR45[2] run (CR45 was the base case run undertaken for the WRP).

(c) *Developed Case (EIS_70)* — This scenario was prepared by SunWater based on the PO45 scenario with the inclusion of the Traveston Crossing Dam and an additional water usage from the dam of 70GL/year.

[2] SunWater briefly described the differences between PO45 and CR45 during the interview on 25 January 2008. The differences appear to be relatively minor. Some further investigation could be carried out to quantify the impact of the differences on the resulting streamflow behaviour. Nevertheless it is the reviewer's opinion that this is unlikely to make any significant difference to the assessments of impacts that have been presented in the EIS.

4. THE IQQM MODEL

(Response to Terms of Reference No. 1 – refer Appendix A)

4.1 VALIDITY AND APPROPRIATENESS OF MODEL

4.1.1 The IQQM Platform

As discussed in **Section 3.1**, IQQM is the preferred model for long-term simulations of surface water systems in NSW and Queensland. In the context of environmental impact assessment under the EPBC Act, IQQM is also well suited for the assessment of impacts of the proposed dam on the Mary River hydrology.

Further, given its legislated role within the Mary River WRP, it is the opinion of the reviewer that the use of IQQM for hydrological analyses within the draft EIS is entirely appropriate.

4.1.2 July 2005 Model Audit Prior to Finalisation of WRP

The Mary River IQQM model has been rigorously established and calibrated and was subjected to public scrutiny as part of the preparation of the Mary River WRP in 2006. The model has also been independently audited by Kellogg Brown & Root Pty Ltd in 2005. A brief summary of the audit findings are provided in **Appendix B**.

The various issues with the model that were identified during the audit, were discussed with the DNRW modellers during the reviewer's interviews held in January 2008. These discussions and the reviewer's inspection of the available documentation revealed that the issues identified in the audit had been satisfactorily addressed in the Mary River IQQM by DNRW prior to the finalisation of the WRP. These related to:

(a) the lack of spatial coverage of rainfall data in the period prior to 1950 had caused some significant calibration issues involving the mismatch of observed and recorded streamflows. It is understood that the DNRW modellers made adjustments to some recorded rainfalls to better reproduce the recorded streamflows. Recommendations were also made for the installation of additional rainfall stations particularly on the western side of the catchment. Whilst this has addressed issues with the present coverage of rainfall stations and improved the model calibration during the period prior to 1950, a comprehensive review of the rainfall weightings applied prior to 1950 may have been a more preferable approach. Nevertheless the reviewer is satisfied with the adjustments made by DNRW and the good 'fit' observed in the calibration plots provided in the *Mary River IQQM Report*;

(b) concerns with the low flow 'fit' for the Mary Barrage inflows were also considered by the DNRW. It is noted that the recorded low flows are

derived from back calculation of storage inflows, and this process is prone to introduce errors caused by fluctuations in gauge heights and difficulties in assessing upstream demands. Further given the low flow 'fit' observed at other nearby stations such as Home Park, further adjustment to the calibration was not considered necessary;

(c) in conjunction with the rainfall changes noted above, some improvements were made to the Sacramento models which refined their calibration, whilst other improvements were scheduled for the next model update. The resulting frequency plots of the observed and recorded streamflows produced by the Sacramento models have been inspected during the current review and it considered that the current model is sufficiently robust for use in assessing the hydrological impacts of the proposed Traveston Crossing Dam.

4.1.3 SunWater's IQQM Used in the Draft EIS

For the purposes of the draft EIS, SunWater have altered the DNRW's Mary River IQQM which was developed for the WRP.

The specific model scenarios used by SunWater are discussed in **Section 3.4**.

Whilst in the opinion of the reviewer, the IQQM modelling platform and the DNRW's Mary River IQQM are sound, nevertheless any new application of an existing model will always be dependent on the appropriateness of the model input used in the application. Therefore it is important in reviewing the results of the model in the draft EIS, that the assumptions inherent in the model input be recognised.

These input data issues are discussed further in **Section 4.2** below.

4.2 INPUT DATA ASSUMPTIONS

4.2.1 Climatic and Streamflow Input Data

The validity, accuracy and precision of the model input data (such as rainfall, evaporation, streamflows, seepage rates and interaction with groundwater) have been reviewed with emphasis given to those data items likely to have the greatest effect on the model output and therefore on the estimation of hydrological impacts of the proposed Traveston Crossing Dam. This included consideration of the methods used to extend the data spatially or temporally to provide complete data sets for use in the model. This was an important issue noting that the time-series input data was required for the complete period from 1890-1999 and that there was significantly less data available in the earlier part of the period.

In carrying out these assessments, the reviewer has considered:

(a) source of data and accuracy of original recordings;

(b) representativeness and comparisons with regional data estimates, if any;
(c) appropriateness of extension and gap filling methods; and
(d) consistency of data with published estimates or accepted values.

The SunWater IQQM utilises all the climatic and streamflow data inherent in the Mary River IQQM for the 1890-1999 simulation period, consistent with that prepared by DNRW for the WRP. For the extended period modelling, recorded climatic and streamflow data for the period 1999-2007 has been used.

In addition to the above data, some additional assumptions were required for the simulation of the proposed dam in the model. These involved the determination, at each daily time step in the model, of the rainfall onto the dam surface, the evaporation from the surface and the seepage of stored waters into the underlying strata. It is understood that the potential influence on the accuracy of the simulated dam behaviour resulting from these rainfall/evaporation and seepage assumptions has arisen as a significant public concern in the community consultation carried out to date. In particular:

(a) the typical average annual evaporation rates of approximately 1.5m per annum used in the model are accurate and representative of the evaporation that would occur from the surface of an open water body if rainfall was prevented from falling onto the water surface. Nevertheless when rain falling onto the water surface is accounted for (as it is in the model), a much smaller net reduction in water surface level, typically of the order of 0.3m per annum, results. This quantity, referred to by hydrologists as the 'net-evaporation', is the reduction in water level which is observed in local farm dams and ponds. The reviewer believes the processes of evaporation and rainfall from the surface of the dam have been correctly represented in the model;

(b) the model has also assumed a constant seepage rate of 0.3m per annum into the underlying strata. The principal factors which affect the magnitude of such seepage relate to the permeability of the underlying soils and rock strata under the dam and its impoundment, and the extent to which known waterway pathways (e.g. rock joints) are sealed by grout injection or other means during construction of the dam. A proper assessment of the assumed seepage rate requires a hydrogeological knowledge and expertise beyond that of the reviewer. Therefore the reviewer is unable to make any definitive comment on the appropriateness of the assumed seepage rate, except to say that the rate appears conservative (i.e. high) compared with many other impoundments (where no net loss of water via seepage is often assumed).

Further, given the relatively high base flows in the Mary River compared with the proposed storage size, even changes of 100% in the assumed seepage rate (or similar changes in the net-evaporation rate) would be unlikely to appreciably alter any of the hydrological impacts of the proposed dam.

In addition to the assumptions about climatic and streamflow data that were made in the establishment of the IQQM model, the input data assumptions made in the preparation of the extended period modelling and the application of water management rules, are discussed further below.

4.2.2 Extended Period Modelling

The extended period modelling refers to the seven year simulation from 1999 to 2007, and was briefly discussed in **Section 3.3**. This seven year period was generally very dry, and no recalibration of the model was undertaken before using it over the extended period.

It is noted that the WRP and the associated EFOs and WASOs rely on the 109 year period from 1890–1999. Therefore there was no need to extend the model to comply with the EFO and WASO requirements of the WRP. Rather it is understood that the extended period modelling was performed principally to demonstrate to the community that the dam would not empty if a repeat of the recent severe drought was to occur.

Because the model extension has not been documented and the results from this model do not influence compliance with the EFOs or WASOs, the extended period modelling has only been briefly reviewed. The method used to extend the data for this simulation will be unlikely to have accurately represented all the water uses and transmission losses in the system. Because of the severity of the drought, estimates of the losses, ungauged streamflow inputs and other parameters might be expected to be different from those contained in the WRP model.

Nevertheless the extended model took account of these to some extent by truncating the model and utilising recorded streamflows along the upper parts of the main creek systems (as these streamflows already had the influence of the water uses and losses included in them).

Overall, the modelling of the 1999-2007 period is not as rigorous as the earlier 1890-1999 period and the draft EIS recognises some of the deficiencies in the extended period simulation. However for the purposes of assessing the likelihood of the dam emptying over the 1999-2007 period, the reviewer believes the extension method is appropriate. As this appears to be the principal use of the extended model results in the draft EIS, the reviewer considers the extension approach is acceptable. (However use of the extended period results for other purposes is not considered appropriate without further examination).

4.2.3 Assumptions Concerning Management Rules

Management rules must also be specified in the model input. As these are often more complex and can have a greater influence of the model results than the climatic input data, the reviewer has devoted considerable time to examining the assumed management rules.

Because there is some overlap with this issue and those identified in Terms of Reference No. 2, this issue has been reported in **Section 5.5**.

4.3 NEED FOR MODEL IMPROVEMENTS

The last part of Terms of Reference No. 1 requires the reviewer to identify any improvements that could increase the rigour of the modelling or the interpretations drawn from it. A response to this item is provided briefly below.

In regard to:

(a) the IQQM model software;

(b) the climatic and streamflow input data used in the model; and

(c) the assessment of the likelihood of the dam emptying during the recent drought based on the extended period modelling;

the review has not identified a need to make any improvements to the modelling used for and presented in the draft EIS.

5. MODEL OUTPUT

(Response to Terms of Reference No. 2 – refer Appendix A)

5.1 ACCURACY OF MODEL OUTPUT

The reviewer has not found any comments in the draft EIS that define the accuracy of the Mary River IQQM except for a comment in Section 6.1.1.2 which states "*errors on modelling outputs … are at best ±5%*". This is a rather meaningless statement as it does not define a typical value nor an upper limit to the errors in the model.

The Mary River IQQM, like any other simulation model, is only an approximation of reality. As such it will be good at modelling some behaviour and poor at modelling other types of flow behaviour. In particular, IQQM is generally not suitable for predicting flow behaviour on specific days of the historical record. Rather the model is calibrated and established to reproduce the observed statistics of flow behaviour over the long term.

In the opinion of the reviewer, the best statistic for characterising the behaviour is the flow duration curve[3] which is featured significantly in the performance indicators within the Mary River WRP.

In order to gain an appreciation of the accuracy of the Mary River IQQM in simulating the flow duration characteristics within the catchment, inspection of the flow duration curves reported in DNRM's IQQM report (April 2005) was undertaken. These show that over most flow ranges, the frequency of occurrence is predicted generally within 10%. This represents an 'absolute' accuracy (i.e. modelled conditions compared to actual conditions) and, as is the case with all such models, a much higher 'relative' accuracy can be expected when comparing the difference between two model runs (i.e. with and without the proposed dam).

The addition of further comments on the model accuracy would be a useful addition to the draft EIS.

Overall it is the opinion of the auditor, that IQQM will be accurately predicting the impacts on flow regime caused by the dam, subject to the assumed operating conditions for the dam. As noted in **Section 5.5**, some very simplistic operating assumptions have been made in the draft EIS and when these are altered, it can be expected that the flow behaviour immediately downstream of the dam will also change. However these operating assumptions generally over-estimate the impacts of the proposed dam on the hydrology of the Mary River below the dam.

[3] This indicates the probability of a given flow being exceeded. (Such curves can be prepared for any time varying parameter, not only flow). Flow duration curves conveniently present many of the flow characteristics of a large data set on one curve. For the Mary IQQM which produces 109 years of daily results for each output parameter, one curve can characterise about 40,000 data values.

5.2 ACCURACY OF DAM FILLING ESTIMATE

The draft EIS states that there is a 70% probability of the dam filling in one year and an 85% probability of it filling within two years. The assessment of this probability has been based on an analysis of recorded streamflows at Dagun Pocket over the period 1958-2005. As this estimate has been prepared independently of the IQQM model, the basis of the assessment has not been examined in any detail.

However given the high base flows in the Mary River relative to the size of the dam, such a short filling time seems highly probable. Nevertheless had the analysis been based on a longer climatic period including the first half of the 20th century, marginally smaller probabilities of filling would have been estimated given the prevalence of drier conditions in that period.

5.3 'CURRENT' CONDITIONS

The Terms of Reference No. 2 states that *"…the primary interest in the hydrological modelling is in allowing a comparison of flow regime under current conditions.."* . In considering this, it is important to recognise the limitations in the terminology that describes the model scenarios in the draft EIS.

As discussed in **Section 3.4** above, the 'current' conditions modelling (i.e. SunWater Model Run PO45) assumes full utilisation of the existing water entitlements. In this sense it is not 'current' but 'ultimate'. Nevertheless both the model runs used in the draft EIS to assess the impact of the proposed dam on Mary River hydrology (i.e. PO45 and EIS_70) have been carried out with this utilisation assumption.

Given that there is considerable under utilisation in the existing system, in general terms, the impact of the dam (i.e. the difference between EIS_70 and PO45) will be slightly overstated[4] using the full utilisation assumptions than if more realistic current conditions had been used.

In addition, the 'pre-development' scenario represents conditions without dam and other water management infrastructure and without water use. It should not be interpreted as 'natural' conditions which would require amendment of the runoff relationships within the model to account for catchment clearing and other impacts resulting from European settlement.

5.4 OUTPUT PRESENTATION

The following comments are made in response to the request in the second part of Terms of Reference No. 2 that "*the reviewer is to indicate whether or not it is within*

[4] It will be overstated because the extra water use assumed in the full utilisation scenario will produce increased regulation compared with current conditions. Further, the impacts of a dam will generally be greater as the degree of regulation increases.

the capability of the IQQM model to present the model output in an alternative fashion, eg time series of flows with/without the dam, mean or median monthly flows with/without the dam etc?".

IQQM simulates surface water behaviour on a daily basis over the 109 year simulation period reported in the draft EIS. Streamflows at various locations as well as storage levels, storage releases, storage evaporation and other parameters are produced each day of the approximately 40,000 days of simulation.

The principal means of presenting IQQM's flow results in the draft EIS has been flow duration curves and mean monthly values. It would be a relatively straightforward task for SunWater to provide time-series output[5] if this was requested of them.

Whilst it would be useful for some time-series flow information to be provided in the draft EIS, it remains the reviewer's opinion that the flow duration statistics are the most useful form of output from IQQM for most purposes.

One additional form of output would be to select some typical dry, medium or wet years for which model results could be presented. This additional information could be readily extracted from existing IQQM runs once the appropriate time periods from the 1890–1999 or 1999–2007 simulations were selected.

5.5 POTENTIAL INADEQUACIES IN THE EXISTING MODELLING

5.5.1 Modelling the Influence of Climate Change on the Assessment of Dam Impacts

Whilst the potential environmental impacts that will arise from the dam have been assessed in the draft EIS, the influence of climate change on these impacts has not been considered.[6]

The impacts assessed to date have been based on simulated streamflows and other hydrological behaviour, both with and without the proposed dam, assuming that the climate of the past 100 years or so, reproduces itself in the future. Climate change has the potential to alter the baseline streamflows and hydrological behaviour which in turn, may alter the potential environmental impacts of the proposed dam. Therefore it may be necessary for the sensitivity of the environmental impacts to climate change, to be identified.

[5] This data would most usefully be provided on CD for separate analysis. Linear or log plots of the time series data for the entire simulation period would probably be difficult to interpret, given the large quantity of data involved. However, plots for shorter periods of up to say one year, could be useful particularly if they included lines showing both 'with' and 'without' dam scenarios. Nevertheless the difference between these lines might also be imperceptible for long periods of time.

[6] However the reviewer understands that the potential influence of climate change on the SEQ grid demand on Traveston Crossing Dam has been considered.

Over the last couple of years through the Murray-Darling Basin Sustainable Yields Project, the CSIRO and others have developed approximate procedures to model the hydrologic impacts of climate change. This project has made use of many of the existing IQQM catchment models within the Basin and has made adjustments to the model inputs (streamflows, rainfall, evaporation) to simulate climate change. This has allowed the model to determine the streamflow and other hydrologic changes that might result over the long term under various climate change scenarios.

It would be possible, with considerable effort by SunWater, together with the provision of external climatological input, for the effects of climate change to be considered within the Mary River catchment using the Mary River IQQM. It is also likely that some of this work may already have been undertaken by DNRW.

5.5.2 More Realistic Release Rules for Traveston Crossing Dam

Whilst the draft EIS documentation of the assumed release rules for Traveston is not very clear, it appears that for the purposes of the IQQM modelling, all inflows up to 100ML/d were presumed to pass through the dam without regulation. When inflows in excess of 100ML/d occurred, the dam was assumed to release 100ML/d except if the dam was full.[7]

In the opinion of the reviewer, these are rather simplistic release assumptions that may be suitable for investigating the initial feasibility of the proposal, but will likely be considerably different in reality. The final dam release rules would be expected to preserve some inflow hydrograph shapes (i.e. 'translucent' dam release rules). (Note also that the dam is full for long periods of time and therefore the assumed maximum release of 100ML/d will not constrain releases at these times).

One implication of providing more realistic dam release rules will be that the predicted effects of the proposed Traveston Crossing Dam on streamflows will be diminished immediately downstream of the dam (see Figures 6.20 and 6.37 of the draft EIS).

5.5.3 'Transparent' Operation of Borumba Dam

Another assumption that was made by SunWater in the EIS_70 scenario involved the 'transparent' operation of Borumba Dam. This means that releases made from Borumba Dam in IQQM were assumed to be delivered to the downstream side of the Traveston Crossing Dam without any interference by the dam. It is possible that Traveston Crossing Dam could be operated in a way to replicate this type of behaviour however in reality, different operational rules will most likely apply.

It would be expected that releases from Borumba would not be made while water was available within Traveston Dam (this would preserve water in dams higher within the catchment, in accordance with normal hydrologic practice). No doubt as investigations continue towards the preparation of new operating licences, modified

[7] When full, the dam would pass all inflows downstream albeit with some attenuation due to hydrologic routing caused by the dam storage.

rules for Borumba/Traveston Crossing Dam operations will be developed. If these modified rules were simulated in IQQM it is likely this would lead to:

(a) reduced frequency of releases from Borumba Dam and a slightly higher increase in the frequency of spills from this dam;

(b) less regulation impact on streamflow behaviour within Yabba Creek, upstream of Traveston Crossing Dam;

(c) slightly higher storage levels in Borumba Dam and slightly lower storage levels in Traveston Crossing Dam, leading to marginally higher evaporation from Borumba Dam and marginally lower evaporation from Traveston Crossing Dam; and

(d) slightly reduced frequency of spills from the Traveston Crossing Dam and a slightly increased regulation impact on streamflows downstream of the proposed dam.

These effects, if considered in isolation, would tend to slightly under-estimate the impact of the proposed dam on the hydrology of the Mary River below the dam and slightly over-estimate the impacts within Yabba Creek upstream of the proposed dam.

5.5.4 Time Varying Supplies to the SEQ Grid

An important assumption in the EIS_70 scenario relates to the magnitude and frequency of water extractions which will be taken from Traveston Crossing Dam for the SEQ water grid. This assumption has the potential to alter the long-term storage behaviour within the proposed dam, and the flows passed downstream.

The modelling to date has assumed 70GL would be extracted each and every year based on a fixed monthly demand pattern. Whilst the assumptions made in IQQM are appropriate for an initial feasibility study, once the interaction of the proposed dam with other elements within the SEQ grid are further investigated and the economic and environmental objectives are optimised, most likely a quite different pattern of usage of water from Traveston Crossing Dam will emerge.

It is possible that whilst the maximum demand on Traveston Crossing Dam will not exceed 70GL in any one year, there may be many years when less than 70GL/yr will be extracted for the SEQ grid. Under these conditions, the actual impacts of the proposed dam will be less than those identified in the draft EIS.

5.5.5 Consideration of Stage 2 of the Project

IQQM would no doubt have been used to assess Stage 2 of the dam as part of the development of the SEQ water supply strategy, however no modelling of Stage 2 of the project has been reported in the draft EIS.

The larger storage volume would have considerably larger impacts than Stage 1 of the project.

5.5.6 Need for Additional Model Runs

No serious errors or mistakes in the modelling have been identified.

Some additional model runs could be undertaken, for example, to investigate the impacts of Stage 2 and the sensitivity of impacts to climate change.

Whilst further model runs including more realistic operating assumptions relating to the release rules for the dam, the transparent operation of Borumba Dam and time varying supplies into the SEQ grid, could be requested, they would be unlikely to identify any significantly greater streamflow impacts than those already identified in the draft EIS. Most likely the net effect of these more realistic assumptions will be to predict lesser impacts of the proposed dam on the hydrology of the Mary River.

6. ENVIRONMENTAL FLOWS AS MITIGATION

(Response to Terms of Reference No. 3 – refer Appendix A)

Environmental flows are releases from a dam that are made specifically for environmental purposes.

In the IQQM modelling presented in the draft EIS, no environmental flows have been included, except for a nominal allowance that up to the first 100ML/d of inflow would pass through the dam without regulation. The only other releases simulated were those that would occur when the dam was full and spilling, or were being passed downstream from Borumba Dam to meet water use requirements below Traveston Crossing Dam (see **Section 5.5.3**).

Based on the reviewer's discussions with DNRW, it is understood that the proponent will be providing environmental flows but that the final form of the flows has not yet been determined and awaits the outcome of the EIS.

The legislative process in Queensland allows for a Resource Operations Plan (ROP) to be prepared which will contain the details of the operating procedures to ensure that amongst other things, the requirements of the WRP (e.g. EFO and WASO compliance) and specific outcomes of the EIS, will be met. Further it is understood that an Interim Resource Operations Licence (IROL) is currently in preparation.

These instruments will embody the environmental flows that are yet to be determined.

It is beyond the expertise of the reviewer to comment on the adequacy of these legislative processes and instruments to provide effective environmental control.

Nevertheless the hydrological modelling undertaken to date in the draft EIS has adopted very simplistic environmental release rules so there is some potential to provide environmental improvement through additional releases from the dam. Such releases will reduce not only the storage levels in the dam, but also the volumes of spill and the security of supplies into the SEQ grid from the dam. However as the storage behaviour plots presented in the draft EIS indicate the dam remains more than half full for more than 95% of the time and never drops to the minimum operation level, there appears to be considerable scope to provide large quantities of environmental flows without altering the supply security of the dam to any significant extent.

7. CONCLUSIONS

(a) The IQQM modelling platform is an appropriate tool from which to asses the impacts of the proposed Traveston Crossing Dam on the hydrology of the Mary River.

(b) As with any model, the Mary River IQQM is only an approximation of reality and has limitations which need to be considered.

(c) The input data assumptions within the model are generally sound. Some of the assumed operating rules are simplistic and are generally conservative. That is, they over-estimate the likely future impacts of the dam.

(d) The output data provided in the draft EIS is relatively accurate. A large quantity of output data is produced by the model and only a small portion is provided in the draft EIS.

(e) Environmental flows for the proposed dam are yet to be determined and therefore have not been reviewed.

APPENDIX A

REVISED SCOPE FOR HYDROLOGY REVIEW PROVIDED BY DEWHA 5 FEBRUARY 2008

REVIEW OF HYDROLOGICAL MODELLING PRESENTED IN THE ASSESSMENT DOCUMENTATION FOR THE PROPOSED TRAVESTON CROSSING DAM

Project Scope

The Department requests that the reviewer, in a draft report due no later than 25 February provides an evaluation, and recommendations arising from that evaluation, of:

1. The IQQM model

Provide an indication of the ability/capacity of the IQQM model to provide meaningful output for the purposes of the assessment of this project under the EPBC Act, namely an evaluation of:

- the validity and appropriateness of the IQQM model for the purposes for which it was used in the draft EIS - if relevant, the reviewer can refer to previous reviews/audits conducted;
- the validity, accuracy and precision of the data and the assumptions on which the modelling (used in preparation of the Draft EIS) has been based - including: (a) input data such as rainfall, evaporation and seepage rates and interactions with groundwater; (b) the time-series of data utilised, and (c) any extensions/extrapolations to the modelling that was presented in the EIS;
- Should the evaluation highlight any deficiencies in the model/modelling, the reviewer should include suggestions of any amendments that would be required to improve the rigour of the model/modelling, its output or the interpretations drawn from it.

2. Presentation and interpretation of the model output data in the draft EIS

For the purposes of the assessment of the proposed dam under the EPBC Act, the Department is concerned with impacts on matters of National Environmental Significance (NES) that may arise as a consequence of changes to the flow regime of the Mary River and relevant tributaries if the dam were to proceed. As such, the primary interest in the hydrological modelling is in allowing a comparison of flow regime under current conditions with that which would occur if the proposed dam were to proceed. This will then be used to assess likely impacts on matters of NES protected under the EPBC Act (for example, threatened species such as the Mary River Cod, Mary River Turtle and the Australian Lungfish). As such, the Department requests that the review provides an indication of the confidence that can be applied to the modelling output and associated interpretations of that output, as presented in the EIS (with reference to both "relative" and "absolute" accuracy of outputs) and where applicable, provide recommendations of how the output presentation/interpretations can be improved for the requirements of the Department's assessment. For example:

- where specific figures are presented in the EIS documentation (e.g. impacts on flow regime downstream of the proposed dam would likely only be detectable for 25km, dissipating rapidly thereafter; 70% probability that inflows to the dam will fill it in 1 year, 85% probability the dam will fill within 2 years; dam likely to result in a 3% reduction in mean annual flows at the estuary) - indicate the accuracy/confidence of/in these figures (for example, what was the basis for calculations of filling rate - is this basis likely to represent actual operating conditions).
- the draft EIS also provides general descriptions of impacts on flow regime, for example, minimal change in the magnitude of infrequent flows (exceeded less than 4% of the time); minimal change to the magnitude of frequent flows (exceeded more than 55% of the time) etc.; in autumn impacts are focused on smaller, more frequent flows (exceeded 40 - 60% of the time). The reviewer is to indicate whether or not it is within the capability of the IQQM model to present the model output in an alternative fashion, eg time series of flows with/without the dam, mean or median monthly flows with/without the dam etc? If so, please provide recommendations on the best way of presenting the information the Department requires for its assessment.
- The Department notes that several aspects that may be relevant to the assessment of the project have not been accounted for in the modelling, including:
    - likely impacts of the proposed dam on the flow regime in other than 'average' conditions, e.g. in a dry year or run of dry years etc.;
    - likely impacts of climate change on the predicted impacts on flow regime post-dam;

- o likely impacts of Stage 2 of the dam on downstream flow regime in the Mary River;
- o an indication of how the existing water regulation infrastructure is likely to be operated in conjunction with the proposed Traveston dam, and the impacts these operations may have on the flow regime of the Mary River and its tributaries.

Please indicate if and how it is possible to incorporate these scenarios into the IQQM model and if so, how the output might be best presented for the Departments assessment purposes?

3. Environmental flows as mitigation

- Once the exact nature and extent of impacts on flow regime as a result of the proposed dam are determined, and the degree of confidence in these predictions are outlined, the Department requests that the reviewer evaluate the likely ability of environmental flows, under the MR WRP and other relevant framework, to mitigate these impacts. Essentially, the Department wishes to gauge whether or not it will be possible (under the relevant framework) for environmental flows under actual operating conditions, to be utilised to mitigate those identified impacts of the dam on downstream flow regime.
- If specific further information is required from the proponent in order for this aspect of the review to be undertaken, please indicate/recommend the extra information required.

4. Review of additional information provided

Depending on the outcomes of the review and recommendations in the Draft Report, the Department may need to seek further information from the proponent. If extra information is provided, the Department may request a review of this additional information.

5. Other advice

- A public comment period was recently held for the Draft EIS of the proposed Traveston Crossing Dam. Once the Department receives a copy of these submissions and a summary of the issues raised, the Department may have further questions relating to the hydrological modelling which they may also wish to seek the reviewer's advice on.
- In the event that the proposed dam is approved under the EPBC Act, the Department would also seek the reviewer's advice on any proposed conditions that could be attached to any such approval.

APPENDIX B

SUMMARY OF MARY RIVER IQQM AUDIT, PREPARED BY KELLOGG BROWN & ROOT PTY LTD FOR DNRM, DECEMBER 2005

1. The audit was reported in various drafts in 2005 with the final report dated December 2005. It utilised an April 2005 version of the Mary River IQQM report, and numerous reports concerning the Sacramento modelling of the twenty or so catchments in the Valley (all dated December 2002).

2. The audit involved a review of these reports together with a review of various data files including input and output data.

3. One of the primary purposes of the audit was to provide independent reassurance that the model had been adequately calibrated and was suitable to support the development of a Water Resources Plan for the Valley.

4. The audit also included a review of the rainfall, evaporation, streamflow, water use, water demand and reservoir storage data used during calibration and operation of the model. Some concerns were raised regarding the rainfall data and streamflows at stations where the low-flow rating was not stable.

5. In respect of the rainfall data, it was noted that the more remote and mountainous western portions of the catchment were poorly represented, particularly in the earlier years of the simulation period. As these areas are generally those with higher rainfalls, the absence of data from these areas in the earlier period led to some bias in the rainfall data. This initially caused problems in the prediction of streamflows at stations such as Miva.

6. The audit also reviewed the quality of the model calibration and identified that the calibrated model represented most of the recorded streamflows reasonably well except for low flows. (The worst result was for the 97% exceedence flow at the Mary Barrage where the observed flow was 1ML/d compared with a simulated flow of 40ML/d).

7. The review of the Sacramento model calibration indicated that generally the daily flows were reproduced fairly by the model, whilst the monthly totals and some low flows were not simulated well.

8. Overall the audit of the Sacramento models and the Mary River IQQM identified that calibration, model suitability and documentation were adequate but noted the following areas where improvements were required:

    (a) further rainfall stations were required to be installed in the western catchment (head waters) to reduce the spatial variability of rainfall records;

    (b) insufficient data analysis had been carried out on streamflow stations where the low-flow rating was not stable; and

    (c) improvements to some reaches of the IQQM and Sacramento model calibration were suggested to be scheduled at the next model up-date.