THE UNIVERSITY OF
NEW SOUTH WALES

Water Research
Laboratory

School of Civil and
Environmental Engineering

13th September 2010

Our Ref 10065 BMM:WLP LR100913

Department of Planning
GPO Box 39
SYDNEY NSW 2001

Attention: Ms Anna Scott

Dear Anna,

SECOND INDEPENDENT REVIEW
TILLEGRA DAM: HYDROLOGICAL AND WATER QUALITY IMPACTS ON HUNTER ESTUARY

In accordance with the consultancy agreement dated 17 May 2010 between the Department of Planning and the University of New South Wales and our proposal dated 13 May 2010, Dr Bill Peirson has completed a second review of the estuary modelling undertaken for this project.

Dr Peirson's review follows this letter.

If you have any questions with regard to the review, please do not hesitate to contact Dr Peirson or myself.

Yours sincerely,

Brett Miller
Manager.

SECOND INDEPENDENT REVIEW TILLEGRA DAM: HYDROLOGICAL AND WATER QUALITY IMPACTS ON HUNTER ESTUARY

by W L Peirson, 13th September 2010

Introductory Remarks

I would like to thank the authors of the two reports provided for addressing my questions in a systematic manner. These present reports now presents the investigations completed in a systematic manner suitable for the detailed assessment presented below.

The Eco Logical report covers new ground by considering Peirson *et al*. (2002) framework in a systematic manner and may be a significant new contribution to the environmental assessment associated with this project. The report develops ecological linkages between modified flow and potential impacts within the Hunter system. Detailed peer review of their work would require suitably qualified ecologists.

The specific brief of this review is to address the numerical modelling components. Consequently, I will restrict my comments to the report provided by BMT WBM (2010). In the text below, issues raised by the Department of Planning are shown in bold followed by my comments in plain text.

The Department requires an independent review of the hydrology and water quality impacts (including salinity) of the proposed Tillegra Dam on the Hunter Estuary (including the RAMSAR Site). The Department requires that the consultant conduct a review and comment on the following in relation to the modelling conducted:

A. The validity and appropriateness of the model used?

There is a specific concern relating to the calibration of the TUFLOW flood model, that is documented under issue D below but this does not appear to be a question of model validity or appropriateness.

There is a concern with the model TUFLOW-FV in that the value of Manning's *n* specified for the primary waterway channels is implausibly low (p. 93, n=0.010. This is, in fact, below the formal range of applicability of Manning's *n*). Numerical drag within the model is a complex combination of the assumed eddy viscosity characterisation, the model discretisation and the specified channel roughness.

There are specific problems with the model calibration in the upper estuary. Please refer to the water level calibration at Morpeth in Figure 4-40 and the flow calibration results at Hinton, Morpeth and Bolwarra in Figure 4-41.

There is a reasonable match between water level, tidal phase, discharges and salinity through both arms of the lower and middle estuary although TUFLOW-FV appears to over predict salinity intrusion during after the flood event on 19-22 March 2001 (Figure 4-44).

The TUFLOW-FV model can be said to be valid and appropriate provided that it is not applied to the upper estuary and that it is recognised that it may overpredict salinity intrusion following flood events.

There are specific limitations associated with the model ELCOM, specifically:

1. It is apparent that ELCOM has been formulated for conditions in which wind energy is the primary source of turbulence (p. 64).

2. The characteristic numerical diffusion of the model is high (p. 64).
3. There is a serious problem with the characterisation of drag in estuarine systems evidenced by the poor tidal calibrations shown in Figures 4-13, 4-14, 4-17 and 4-18.

However, there has been detailed comparison between the ELCOM and the data captured by Sanderson and Redden (2002) shown in Figures 4-24 to 4-31 in the lower reaches of the estuary. In contrast with TUFLOW-FV, ELCOM under predicts the intrusion of salinity following the flood event (see Figures 4-33 and 4-34).

The ELCOM model can be said to be valid and appropriate provided that it is not applied to the upper estuary and that it is recognised that it may under predict salinity intrusion following flood events.

B. The validity, accuracy and precision of the data and assumptions on which the modelling has been based.

There are specific issues with the model calibrations and verifications as described under point D. However, the provided reports now clearly describe the processes of model discretisation as well as specification of boundary condition and model parameterisations. The investigators have appropriately configured the models.

C. The validity, accuracy and precision of the interpretations that have been drawn (by the proponent in their assessment documentation) on the basis of modelling results;

One of the weaknesses of the report is that its conclusions are descriptive, not quantitative. However, the recasting the assembled studies should now enable them to draw quantitative conclusions. There are two conclusions of that appear to be of immediate and primary interest:

1. Flood inundation within the RAMSAR site boundaries.
   Figures 5-10 to 5-14 address this specific question. The changes in levels of inundation at 5 year ARI range from 0 to 20mm within the RAMSAR areas, depending on location along the estuary. The changes in the area inundated will depend on the local slope. In the region in the very north of the RAMSAR area, the land gradients are clearly steep and the impact may minimal. In the south, the change in level is very small and consequently, the estimated changes appear to be small. Possibly, the most significantly impacted areas are in the west, near the upstream boundary of the RAMSAR area. As an example, for the 5 year ARI results shown in Figure 5-10, I estimate a reduced area of inundation of less than 1Ha on the basis of the figures supplied. At higher recurrence intervals, the change in area inundated would appear to be smaller than this.
2. Increased saline intrusion into the estuary.
   This assessment is more complicated as two models have been used to assess the same process (ELCOM and TUFLOW-FV). It is further complicated in that different scenarios have been used for each model (compare Table 5-8, p. 122 with the numbered scenarios at the top of p. 144). It has been very confusing for the purposes of this review that the two sets of scenarios have not been reconciled against each other.

   For simplicity, this review will ignore the sea level rise scenarios. Whilst these scenarios indicate the potential impacts within the estuary of sea level rise, the potential impacts of modified flows to the Williams River are highlighted by the assessments of existing conditions.

ELCOM Assessment

For this review, it has been assumed that Table 5-8 is correct and that there is a sequence of errors in Table 5-7 (e.g. Scenario 12 is 90% flow condition as indicated in Table 5-11). There appears to be no assessment of the 25% flow scenario during the fill up conditions.

Setting the issue of fill up conditions aside for the present, the impact of revised Williams inflows on surface salinity under low flow conditions is indicated by contrasting Scenarios 11 and 16 in Table 5-11. This review has been hampered by these results not being shown graphically. Assuming an approximate mean gradient of 1.35ppt/km between 10km and 30km (5 to 32ppt) from the estuary entrance coupled with a mean change in the vicinity of -0.2ppt with the introduction of the revised flow conditions, this would indicate a seaward movement of the salinity structure under low flows of roughly 0.15km. For the 50% flow condition, similar analysis (Scenarios 1 and 3) yields a seaward shift in salinity structure of approximately 0.10km. For the 75% flow condition, Scenarios 6 and 9 yield a landward shift in salinity structure of approximately 1.05km.

This indicates that for most of the time, salinity structure is estimated to shift slightly seaward due to increased flows across Seaham weir. As flows increase and the mean saline structure is shifted towards the sea, there will be some reduction in this shift due to the more modest flow increases at Seaham weir. The predicted changes are small, less than two hundred metres under conditions of low flow.

TUFLOW-FV Assessment

Two assessments have been made using the TUFLOW-FV assessment: spells analysis in the upper estuary; and, probability distributions of nominated salinities in the lower and middle estuary. For the purposes of this review, comparison between scenario 1 (p. 144) and scenarios 4, 5 and 6 have been made.

The presentations of the spatial distributions of nominal salinities of 10 and 15 ppt, shown in Figures 5-39 to 5-40 indicate a seaward shift in salinity structure of less than a few hundred metres in the North Arm and Hunter River. Near the estuary mouth there is a landward shift in the same distributions of a few hundred metres. The scales of Figures 5-39 and 5-40 make it impossible for more accurate conclusions to be drawn. However, these findings are consistent with the ELCOM results as it is the higher percentile flow conditions which will be associated with relatively low salinity levels in the vicinity of the estuary mouth.

At a nominal salinity of 5ppt, similar behaviour can be observed but the shifts are much stronger within the Williams River, as might be anticipated.

The spells analysis shows slightly different results for lower salinities, nominally in the vicinity of 1ppt captured in the upper reaches of the main estuary arm. In Figure 5-31, for example, shifts of up to 10% can be observed but this may be due to the threshold nature of spells analysis. Please note my previous remarks (issue A) that it may not be appropriate to assess behaviour in the upper estuary using TUFLOW-FV.

The view of this reviewer is that the spatial distributions of salinity provide a clearer picture of overall shifts in estuary salinity structure and the consistency between the ELCOM and TUFLOW-FV results is encouraging.

However, it appears that no scenarios considering impacts on low flows during the filling phase of Tillegra Dam have been presented. There are no scenarios presented in either Table 5-8 or at the top of p. 144 which consider impacts at flows less than the median on the Williams River. There is some discussion on p. 123 of the report but this does not clarify this issue. This issue needs to be resolved and was raised in my previous review.

D. Is the calibration and verification of the model following due process?

TUFLOW:

- As described in the paragraph following Table 4-1 on p. 56, there is a significant irregularity in the derivation of the Hunter flood hydrograph for the 1990 flood and the consequent model validation (Figure 4-5, p. 57). Scaling recorded hydrographs as part of a calibration process is not satisfactory. The authors contend that this approach has been adopted by previous investigators. A detailed investigation and resolution of these issues is beyond the scope of this present review.
- If it is true that these modifications to the 1990 flood hydrograph have formed the basis of flood engineering practice and planning in the Hunter catchment over the past 20 years, the present planning for Tillegra Dam should remain consistent with this and the proponents have addressed this issue correctly. The statements on p. 56 need to be independently verified by the appropriate NSW state government departments.
- Nonetheless, given the evident significance of the 1990 flood hydrograph for planning and design of major infrastructure on the Hunter River, this issue must be resolved as a matter of priority by the appropriate public authorities but not necessarily as part of this investigation.

E. Should the modelling be found to be deficient in any way, the consultant is to provide suggestions of any amendments that would be required to improve the rigour of the modelling, its output or the interpretations drawn from it.

As discussed under issue C, the issue of shifts in salinity structure during the filling phase of the dam does not seem to have been addressed as was requested during my previous review.

Additionally, the Department requires the consultant to specifically comment on:

1. Is the estuary model accurately conceptualising estuary processes, function and behaviour (that is, is the model capable of modelling the hydrodynamics of the estuary)?

See issue A above for detailed discussion of the specific limitations of the capability of the models assembled in their present form.

2. Are the predicted modelled impacts on the hydrologic and water quality including salinity) characteristics of the Hunter Estuary due to the construction and operation of Tillegra Dam representative, accurate and precise?

This issue was addressed under point C above.

Nutrient budgets have been used to address questions of water quality without reference to the sophisticated modelling of flow and salinity developed for the investigation. The adopted approach is reasonable and as precise as can be reasonably achieved given the uncertainties in nutrient budgets and with the proviso that no changes in catchment development (apart from the dam itself) or modifications to pollution discharges form part of this proposal.

3. Has the contribution of tidal flows in the modelling been over-estimated?

Estuarine salinity structure is critically determined by freshwater inflows and the models adopted include representation of the role of freshwater flows. As noted under issue E above, the issue of freshwater flows during dam filling needs attention.

4. Has the estuary modelling undertaken for the Proponent assessed the worst case scenario for the hydrologic and water quality (including salinity) impacts on the Hunter Estuary (including the RAMSAR sites)?

There seems to have been no assessment of the period of filling of the dam although it is referred to during the report.

In addition to the issues raised in the original review, NSW Planning has since raised the additional issues:

5. Can you please review the method in the report "The Impact of the proposed Tillegra Dam on the Hunter River Estuary, its Ramsar wetland and migratory shorebirds" by Kingsford and Hankin for predicting changes in salinity based on changes in flow (refer to pages 34, 69, 77) and comments made in the report on the modelling of the Estuary by HWC (pages 74 and 75).

I understand that the issues of particular concern are as follows:

1. Review of the method in the report for predicting changes in salinity based on changes in flow (pages 34, 69, 77)
2. Review of comments made in the report on the modelling of the Estuary undertaken on behalf of Hunter Water (pages 74 and 75).
3. The region of most concern is the RAMSAR wetland area.

Prior to undertaking this phase of the review, the following reports supplied by NSW Planning were prepared by Dr. Brian Sanderson and various collaborators. These are referenced as follows:

[1] Sanderson, B., Redden, A. & Smith, M. (2002) Salinity structure of the Hunter River Estuary. Centre for sustainable use of coasts and catchments, Ourimbah Campus, University of Newcastle.

[2] Sanderson, B. & Redden, A. (2002) Effects of river flow on salinity and dissolved oxygen depletion in the Hunter River Estuary. Centre for sustainable use of coasts and catchments, Ourimbah Campus, University of Newcastle.

[3] Sanderson, B.G. and Redden, A.M (2006) Salinity, light and chlorophyll-a in the Hunter River Estuary.

[4] Sanderson, B.G. (2007) Seasonal and Climatic changes in salinity of the Hunter River Estuary in response to river flow modification by environmental flow rules, TUNRA.

Sanderson and his collaborators have captured one of the most detailed longer-term salinity and water quality surveys in the history of New South Wales. Important aspects of the captured measurements are their coincidence with a major flood (approximately 10 ARI) and the depth profiles of water quality captured around this event. In regard to flood magnitude and subsequent impacts on water quality, it is possible that this is a unique data set. Whilst there is a great deal of excellent and interesting analysis undertaken by Sanderson and Redden, references [2], [3] and [4] and not crucial to present concerns except for two aspects.

In [4], Sanderson analyses the seasonal behaviour of the freshwater inflows and salinities and finds very weak seasonality (Section 5.1, bullet point 2, 5.2, bullet point 6). Long-term climate fluctuations have been discerned in [4] and their impacts on variations in flow and salinity at many parts of the lower estuary. Also, during this present review, it was discovered that Sanderson (2007) refers to another report (Sanderson, 2005) which seems to have established a better model for characterising estuary salinity than was developed during the study reported in [1]. However, neither the studies undertaken for Hunter Water nor the report that is the subject of the present review refer to Sanderson (2005) so that does not affect this review. However, it is recommended that a copy of Sanderson (2005) be obtained for future reference.

One of the difficulties faced in estuarine systems is the determining a suitable coordinate system to define positions along the estuary. In this study, [1] computes distance upstream from the estuary mouth whilst BMT WBM (2009) measured distance downstream from Green Rocks. KH2010 do not seem to assume an estuary distance measurement system (although Figures 18 and 27 specify increases in intrusion distance into the estuary.) In this present review, it will assume distances along the North Arm of the estuary upstream from the estuary mouth and that the RAMSAR wetlands are located between 6 and 19 km from the mouth.

As [1] is the foundation of KH2010, it should be observed that:

1. From Figures 2 to 17 of [1], that the RAMSAR wetlands are the region in which the greatest vertical salinity stratification occurs in the Hunter estuary.
2. A depth-averaged salinity model in [1] was developed for four representative salinities and was most carefully verified within the RAMSAR wetland region (Figure 19 of [1]).
3. [1] clearly admits that antecedent flow conditions do have an influence on salinity but it is beyond the scope of [1] to incorporate this aspect of saline intrusion into the estuary (last paragraph of page 25 in [1]). This may have been addressed by Sanderson (2005).

With regard to the comments made by KH2010 on pages 34, 69, 77, the methodology described on page 34 assumes the depth-averaged model of [1] and, therefore, ignores antecedent flow effects. The particular reference salinity used as a reference should be clearly specified. Further, the report should clearly specify whether this increased intrusion occurs predominantly in the vicinity of the RAMSAR wetlands or further upstream. Detailed plots of the estimated daily position of reference salinity should be possible and would clarify these issues. At present, it is not clear whether their statements regarding increased salinity intrusion accurately characterise conditions in the vicinity of the RAMSAR wetlands.

The heading levels seem to be slightly disordered but I think the discussion on page 54 refers to the additional intrusion that would occur during the filling period of Tillegra Dam. It is stated that the average increase in salinity intrusion is 5km. On page 69, it appears that the operational period is being analysed and an average increased salinity intrusion of 11km is predicted, with significant inter-annual variation. It seems inconsistent that greater intrusion would occur during operational than the filling period but this may depend on the inflows assumed during these respective periods. Your reviewer of the hydrological aspects of this study may be able to provide more informed comment on this specific issue.

The discussion on page 77 occurs in the context of a wider discussion of ecological issues from page 73 to 78. Much of this is of an ecological character for which I am unqualified to comment.

Specific comments are made with regard to numerical modelling undertaken on behalf of Hunter Water (pages 74 and 75 in KH2010). My response to these is as follows:

p. 74: "The effects of any reductions in flows are reflected in changes in estuarine processes. Knowledge of fluvial interactions between freshwater and the marine ecosystems are poorly known or modelled.". For ecosystems this is true (Peirson *et al*. 2002) but as discussed in my previous review, the numerical modelling of unsteady salinity stratified estuarine systems is well established (Peirson, 2010, lines 66 to 72). [1] correctly describes the fundamental physics of these systems. Please note my previous remarks regarding the inability of this approach to include antecedent flow effects.

p. 74: "A coarse water balance approach was adopted in calculating how much of the estuary was made up of seawater and how much is freshwater flow…. This ignored the complex dynamism of freshwater and saltwater interactions and river flow and tidal cycles.". This statement is true. The nature of Australian estuarine systems means that averages need to be carefully interpreted as the fluctuations can be much greater than the average (Peirson, 2010, lines 21 to 30). From my discussions with my ecological colleagues, there is little doubt that this is also reflected in the feeding and spawning habits of Australian species.

p. 75: "The Environmental Assessment of the dynamics of the estuary were largely modelled with ELCOM ….There was no analysis of different periods of inflow during dry or wet periods and what effects these may have on the salinity." This issue was identified during the review (Peirson, 2010, lines 264-265) but has now been addressed by the proponents as discussed earlier in this present review.

In summary, [1] shows that the estuary is predominantly marine in character in the vicinity of the RAMSAR wetlands but with horizontal and vertical gradients in salinity. These are primarily associated with occasional flood periods when the estuary surface locally may become predominantly fresh ([1], Figures 2 to 17). If changes in the both the horizontal and vertical estuary saline structure in the vicinity of the RAMSAR wetlands are the specific criterion for determining the impact of Tillegra Dam, appropriately verified numerical modelling that incorporates these processes and antecedent effects must be completed (Peirson, 2010, lines 60-72). At present, the ecological advice provided by the proponents does not indicate that there are specific important considerations in this regard (Eco Logical, 2010). Detailed review of Eco Logical's work will require specialist ecological expertise.

One of the primary difficulties with these investigations has been that the potential interlinkages between changes in flow and ecological impact did not appear to be clearly defined at the outset. Kingsford and Hankin seem to have focussed on specific ecological impacts that they appear to have associated with salinity stratification in the lower estuary (Kingsford and Hankin, 2010, lower paragraph, p. 6 and upper paragraph p. 7). Both field measurements and numerical modelling confirm the conventional view that east Australian estuaries only become strongly stratified in their lower reaches during major flood events. Major flood events occur infrequently. The primary concerns expressed by ecologists with regard to flood conditions are changes to inundation patterns (therefore Peirson *et al*. 2002, Table 2, M/H5). I am not a professional ecologist and am unqualified to resolve such issues.

6. Can you please provide a professional opinion in your report as to the implications for the Hunter Estuary modelling from the underestimation of flows from the Williams River and resultant predicted changes in the hydrology and salinity modelling, with a specific focus on the area of the Ramsar wetlands.

It has been indicated that flows at Glen Martin have been underestimated by 14% for both existing and developed scenarios.

Responding to this issue is complicated in that the underestimated flows have been incorporated within the calibration and verification processes of the estuary models. However, it appears that the same error has been applied systematically to both the existing and developed conditions.

Given that the error is a modest portion of the Williams River flows, I would anticipate that correction of the error would not greatly change the study conclusions, provided that the error was incorporated systematically within both the existing and developed conditions.

However, in view of this error it would be appropriate to undertake a global budget of the freshwater inflows to the estuary to confirm that the consistency of the freshwater budget on a catchment scale between the different scenarios adopted. The construction of Tillegra Dam would be expected to increase the evaporative losses within the Williams catchment, particularly under drought conditions. The scenarios presented by BMT WBM predict increased low flows across Seaham Weir. A check on the overall budgeted diversions, enhanced evaporation and changes in the freshwater inflow to the Williams estuary would be relatively straightforward to undertake and provide an independent check on the catchment hydrology. The derived freshwater budgets should be able to be reconciled against Bewsher (2010) Table 2.

7. Are there any threshold flows or volumes associated with ecology for which an error of that magnitude (as reported in the understated flows in the Bewsher report) could make the assessment of impact difficult to discern?

My understanding is that this error has been in systematically incorporated within the numerical models during the calibration process and comparison of pre- and post-dam conditions. Determining critical thresholds relies on contrasting the pre- and post-dam conditions. Given the magnitude of error identified and the similarity in error bias in both the pre- and post-dam conditions, it is more likely to shift the identified location of any impact in the estuary slightly rather than fail to trigger identification of potential impact.

This is a very complicated question and my approach to answering the question reflects our present very poor understanding of Australian estuarine ecological response to freshwater flow.

8. Please provide a professional opinion on the relationship of flow and salinity as discussed by the Kingsford Report (and previously considered in Section 5) with reference to recent information provided by Hunter Water, Dr. Brian Sanderson and BMT WBM.

8a. Hunter Water Attachment - Section 3;

It is assumed that this reference is to the section entitled “3. SALINITY MODELLING” attached to an e-mail from Mr. Roland Bow to Ms. Anna Scott and dated 31 August 2010.

I agree with Mr. Bow’s introductory paragraph. We show note that the inflow data used was obtained on a daily time step (BMT WBM, 2010, p. 59). A daily time step is quite reasonable in my view.

Mr. Bow then restates seven extracts from Kingsford and Hankin (2010).

Mr. Bow’s comments are open to a number of interpretations. Kingsford and Hankin do seem to assume stratified flow behaviour occurs under a much wider range of conditions than observed. (See, for example, their comments in the lower paragraph on p. 6.) Certainly the model used by them is depth-averaged and cannot represent stratified processes.

Mr. Bow restates three extracts from Kingsford and Hankin (2010).

I support Mr. Bow’s comments in the paragraph commencing “This mechanism has been shown…”.

Mr. Bow restates three extracts from Dr. Sanderson’s e-mail.

I support Mr. Bow’s final comment in Section 3 that the modelling undertaken by BMT WBM (2010) is more sophisticated and clearly is capable of addressing a much wider range of conditions and processes than that undertaken by Kingsford and Hankin subject to the concerns I have summarised above.

8b. Email from Brian Sanderson to Hunter Water and Professor Kingsford;

I am in full agreement with Dr. Sanderson in his comments. However, I would add one note of caution. In my discussions with those less familiar with estuarine systems and their physical and chemical dynamics, the term “saline wedge” seems to be widely misunderstood. Some seem to apply it to the horizontal gradients that occur in estuarine systems. Dr. Sanderson understands the term correctly in its formal sense but it is not clear to me that some ecologists involved in estuarine and salt water wetlands assessment understand the complexities of salinity and temperature stratification in coastal waters. This may be a source of misunderstanding by Kingsford and Hankin.

8c. Letter from BMT WBM to Hunter Water dated 17 June 2010.

I have not reviewed the hydrology associated with these investigations in detail and review of the hydrological aspects of Dr. Haines's letter lie outside the scope of this review.

Dr. Haines's letter is extensive and I would endorse his comments except in three specific areas identified earlier in this report:

a. *Previous Modelling Assessments,* paragraph 2. It does not appear that the ELCOM 25% flow condition has been adequately characterised for the dam filling conditions. The dam filling conditions in general need to be addressed.

b. *Important Estuarine Processes*, paragraph 1. Salinity and low flow water levels in the lower estuary is not the only ecological considerations. Inundation during flood conditions need to be considered. (See also the final sentence of paragraph 5 of *Summary of Review*).

c. *Summary of Review*, paragraph 3. I do not think we are in a position to say that the Sanderson and Redden (2002) characterisation would overestimate saline intrusion into the estuary without formal analysis. In any case, the time-dependent TUFLOW-FV analysis has the necessary capability of considering antecedent conditions and is a superior analysis tool than use of Sanderson and Redden's simple characterisation (as used by Kingsford and Hankin) and subject to the limitations in the calibration of TUFLOW-FV discussed under issue A.

9. The Bewsher report has reviewed the dam filling time (refer to Section 3.4 of the Bewsher Report) and as the filling time is estimated to be longer than that predicted by the Proponent (most likely 12 years and up to 18 years under dry conditions) there is likely to be a reduction in high flows during that time, what would be the implications for the estuary modelling given the filling time is longer that what the Proponent estimated?

As stated in my *previous* review, the estuary modelling undertaken does not seem to have adequately addressed conditions during the filling of Tillegra Dam. This issue needs to be addressed, incorporating the comments made by Mr. Bewsher.

10. The Bewsher review looked at the issue of reporting findings using annual averages - are the estuary results such as salinity heavily dependent on the annual average flow estimates, rather than frequency and duration analysis?

The ELCOM modelling was undertaken using steady discharge conditions. The TUFLOW-FV model simulations were undertaken using average daily inflows (BMT WBM, 2010, p. 60).

On this basis, neither annual average flow estimates nor frequency-duration analyses are relevant to the estuary modelling except by providing a perspective on the magnitude of the inflows to the estuary models.

11. It has been suggested that HWC/BT WBM review the EC data being collected by MHL in the Hunter Tidal Pool, and use it (if appropriate) in terms of verifying the modelled salinity predictions. The EC data is recorded at Raymond Terrace, Green Rocks, Paterson at Hinton bridge, McKinns Corner and Paterson at Dunmore Bridge in the Hunter Tidal Pool on the NOW website and have been available for a few months.

In my previous review I noted that there appeared to be no systematic assembly of data collected within the Hunter estuary that is relevant to these investigations. Further, there has been no validation of the models in terms of salinity intrusion into the upper estuary.

If no salinity data has previously been gathered in the upper estuary this data could be of immense value. The validation benefit to the present project will depend on the data captured as it may not have recorded salinity intrusion to the upper estuary.

The models have been presently only been validated for the Sanderson and Redden (2002) data which extended 40km inland from the mouth.

Certainly, once a sufficient period of data has been captured, these stations will prove extremely useful reference data for model calibration, verification and discussion with irrigators in the Hunter tidal pool, particularly if Tillegra Dam is constructed.

Summary and Conclusions

The key conclusions of this review are as follows:

a. The influence of the dam during the filling period does not seem to have been subject to detailed assessment. This issue was raised in my previous review.
b. The revised documentation provided to this review has significantly improved the transparency of the numerical modelling undertaken and its relationship in terms of ecological impact.
c. Almost all of the previously identified issues with the modelling have been addressed by this better documentation. However, no models can be said to be valid in terms of predicting dry weather flows or salinity intrusion to the upper estuary. Both ELCOM and TUFLOW-FV have weaknesses in predicting salinity intrusion after flood events.
d. The impact of the dam on specific key ecological processes should now be able to be quantified by the proponents in terms of frequency of flood inundation and saline intrusion, whilst acknowledging the model limitations. I have provided examples of how this can be accomplished within my review.
e. There appears to be a significant issue associated with flood calibration for the Hunter River which should be addressed by the relevant government authorities. The proponents claim that present modelling is consistent with other flood modelling on the Hunter River. If this claim is verified by the relevant government authorities, further work on flood calibration as part of these present investigations would not be justified.
f. The total volumes of freshwater flowing into the Williams River and lost by evaporation should be checked carefully to confirm that no gross errors remain in the determined estuary inflows for pre- and post-dam assessment scenarios. These volumes can be reconciled against Bewsher (2010) Table 2.

References

BMT WBM (2010) Estuarine Impacts of the Proposed Tillegra Dam: A Collated Assessment. R.N1651.003.00 August 2010.

Bewsher (2010) Independent Review of the Tillegra Dam Hydrology. Draft Report. 24 August 2010

Eco Logical (2010) Tillegra Dam Ramsar Wetland Impact Assessment. Response to Independent Review. 23 August 2010.