



Investigation of Anglesea River estuary mouth dynamics : Review and recommendations for estuary management

AUTHOR(S)

Adam Pope

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Investigation of Anglesea River Estuary Mouth Dynamics

Review and Recommendations for Estuary Management

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Dr Adam Pope

School of Life and Environmental Sciences

Deakin University



1 BACKGROUND AND SCOPE

In December 2010 Water Technology (WT) completed a draft report investigating mouth dynamics of the Anglesea River estuary and associated hydrodynamic and ecological processes. The report was commissioned by Corangamite Catchment Management Authority (CCMA) with the following key objectives given in the brief:

- *‘To clarify the current opening procedure and management of the Anglesea River estuary*
- *Obtain and develop clear and informative mapping/diagrams/cross sections/pictorial representations to provide detail and technical clarity on any matters within the report*
- *Clear explanation of external processes delivering sand to the estuary*
- *Discussion of options, including diagrams, to deepen or alter the channel of Anglesea River*
- *Detail of likely system response to deeper openings*
- *Document the local catchment influences on water quality*
- *Identify and document future management challenges’*

Deliverables from the WT project were to *‘include sufficient detail for the work to be used as technical advice and to be replicated in the publication of the Anglesea River Estuary Management Plan’*. The content of the report was also to be guided by seven specific tasks detailed in the brief. (Appendix 1)

Deakin University was requested to review the draft WT report (Water Technology Pty Ltd, 2010) on behalf of CCMA in terms of:

- Outputs of the project in regards to objectives;
- Adequacy and accuracy of the outputs; and
- Suggesting additions or modifications relating to management of the estuary.

Seven specific tasks, with subtasks, were identified in the brief to WT. These tasks implicitly focus the outputs to particular aspects of the objectives and so were also taken into consideration in this review.

Statement of disclosure:

Adam Pope is currently involved in two non-related collaborative projects with Water Technology and is an Associate MSc Supervisor of James Rennie, one of the authors of the WT report being reviewed.

2 REVIEW OF OUTPUTS RELATIVE TO OBJECTIVES

Overall, the outputs reflected the guidance given in the tasks in the project brief (see Appendix) and the allocation of resources in the project. Not all objectives were fully met, possibly the result of a discrepancy between scope of the project and the time and/or resources available for the investigation.

Objective 1: *‘To clarify the current opening procedure and management of the Anglesea River estuary’*

Section 2 provides a concise summary of the legislative context of artificial estuary mouth openings in Victoria and identifies current operational permits, approvals and responsibilities in relation to that legislation. Whether this section of the report makes these arrangements clearer than other available documents is uncertain. Aside from recent dates of artificial openings and critical levels for flooding of infrastructure, no details of operational procedures, associated hydrologic conditions or critical processes are given. While this level of detail was not the primary focus of the WT investigation, a risk assessment of artificial opening of the Anglesea estuary should be included as part of the revision of the estuary management plan. Such an assessment should be based on measured estuarine conditions and assets at times when openings have been considered in the past. Wherever possible the Estuary Entrance Management Support System (EEMSS) (Arundel, 2006) should be used as a basis for recording relevant information and assessing risks of opening. Relevant conceptual models for such an assessment are contained in preliminary work for an ecological risk assessment of the estuary (EPA Victoria, 2005) in addition to several other previous studies including those referenced in the WT report.

Overall estuary management is not addressed in the WT report, it is assumed that the ‘management’ referred to in objective one relates solely to management of artificial openings.

Objective 2: *‘Obtain and develop clear and informative mapping/diagrams/cross sections/pictorial representations to provide detail and technical clarity on any matters within the report.’*

Figures provided in the report, including a reduced version of a poster summarizing potential vegetation impacts (Figure 3-4) were generally informative and clear and added significantly to the presentation of results. Fonts on some figures were too small to read (eg Figs 3-5 and 5-1). Figures illustrating salinity, particularly smaller ones such as Figure C-6, did not clearly illustrate salinity differences in the 0 to 8 psu range.

Objective 3: *‘Clear explanation of external processes delivering sand to the estuary.’*

Coastal processes delivering sand to the estuary were clearly and succinctly described. The description was consistent with that given by Nelson (1981) and with observations of mouth closures reported in Pope (2006).

Objective 4: *‘Discussion of options, including diagrams, to deepen or alter the channel of Anglesea River.’*

Clear descriptions of three options to deepen the entrance channel of Anglesea estuary were given in Section 3 and Appendix C. An additional engineering option of pumping

seawater into the estuary was also described. Details of channel widths and lengths associated with each of the first three options were not provided and a figure or table illustrating these would have been useful.

Objective 5: 'Detail of likely system response to deeper openings.'

Modelling results from each of the four scenarios were discussed in good detail, with a focus on aspects of the resulting hydrodynamic and salinity regimes with relevance to ecological responses.

The level of detail provided for modelled salinity distributions was substantially greater than that of resulting inundation patterns subsequently discussed in relation to potential impacts on existing EVCs. Assessments made for likely impact on existing EVCs based on salinity and inundation were of a level of detail appropriate for the resources available for the investigation. Ecological responses of fauna were not discussed in detail and some explicit consideration of the effect of a large change in the extent and character of available habitat in terms of both inundated areas and salinity distribution would have been appropriate for this objective.

The engineering options considered have no known precedent in Anglesea (deep openings at times of zero natural flow and seawater pumping). Despite this, documented system responses to previous deep openings (at times of higher flow) were not considered in the report but could have provided useful information on actual changes in inundation and associated ecological responses.

Objective 6: 'Document the local catchment influences on water quality.'

Discussion of water quality in the WT report was limited to a discussion of acid drainage, focusing solely on pH and the water balance model of the Upper Eastern View Formation aquifer used by Tutt (2008) to examine processes of acid generation and transport. This focus was presumably guided by Task 5 of the project brief. No discussion of transport of metals, nutrient inputs or the effects of catchment hydrology on the estuary was included.

Objective 7: 'Identify and document future management challenges.'

Discussion of future management challenges focused solely on predicted sea level rises and changes in storm surges (part a) of Task 6) and did not consider future changes in rainfall regime nor potential changes in entrance channel morphology under future hydrologic scenarios.

3 ADEQUACY AND ACCURACY OF OUTPUTS

Given the time available for the investigation, WT has provided a report that addresses the objectives reasonably well, with an emphasis on outputs from modelling, compared to a detailed assessment of historical information and empirical observations that would be required for any revision of the management plan for the estuary. Three models form the basis of the WT investigation:

- A wave model of Bass Strait
- A hydrodynamic model of the estuary
- A water balance analysis of the catchment from Tutt (2008).

Together, these models and the analysis of results from the scenarios assessed contribute substantially to the understanding and capacity required for effective management of the Anglesea River estuary. Application of the Bass Strait wave model to sediment dynamics of the coastal environment at the estuary entrance has added to the understanding of the processes driving closure of the estuary mouth. The hydrodynamic model of the estuary provides a tool not only for assessment of the scenarios examined in the report, but also to investigate a broader range of scenarios including projected changes in freshwater input and mouth dynamics and potential management approaches. Extension of Tutt's water balance analysis provides a degree of context for the recent acid event.

Relative to the stated objectives the adequacy of the WT investigation varies depending on the intended use of the outputs. The objectives are generally relevant to revision of the estuary management plan but the background to the project and specified tasks are focused on potential artificial opening (and pumping) scenarios at a time of minimal flow.

Recommendations for additional work to meet the objectives in context of the management plan revision are detailed in the next section of this review.

Objectives 1-4:

Aside from the comments in Section 2, the detail of the WT investigation was adequate for objectives 1 to 4. Descriptions of methodology for the assessment of shoreline movement from 1947 to 2008 are incomplete and it is unclear how the location of historical shorelines was determined (e.g. vegetation, strandlines, relief from stereo imagery). The relatively small number of times used in the comparison means that results may reflect natural variability on temporal scales less than 20 years or greater than 50 years. Similarly, conclusions drawn from these analyses about the effects of the 1975 weir are tenuous given the widely spaced dates of the photography used. Additional photography exists and is listed in Nelson (1981) whose analyses were not discussed in the report and is cited but not referenced.

Objective 5:

Objective 5 referred to 'system response', apparently incorporating both physico-chemical and ecological components of the Anglesea estuary. While this reviewer is not qualified to comment on the technical detail of the MIKE3 model and its adequacy for this assessment, the model package itself is current and widely used. Results from modeling of the scenarios were more than adequate to assess the nature of associated hydrodynamic and salinity changes although calibration of the model using existing empirical data would increase

confidence in the output of the model. Ocean boundary conditions did not include effects of overwash or of meteorological tidal components (storm surges), which have been measured at up to half the mean spring tidal height (i.e. increasing predicted tidal elevations by 50%), persisting in the order of days to weeks at nearby Barwon Heads (Nelson & Keats, 1978). The salinity of freshwater flows was not specified in the description of inputs of the model but it appears from Fig C-11 that a salinity close to zero was used. Freshwater inputs at times of low flow as per the scenarios have had measured salinities of ~3 PSU (Pope, 2006).

Ecological responses were assessed for one-off scenarios, rather than a new type of management response that may be repeated and so have cumulative effects. This was also the case for assessments of within-estuary sediment movements. Should these scenarios be contemplated as management responses that may be repeated over time, assessments of cumulative impacts should be made.

Physico-chemical system responses not considered in the report were the fate of metals that are typically present at times of acid flushes and any responses in terms of nutrient dynamics. The assumption that the degree of scour from a flood opening is less than that of a deep flush opening (and so would close faster post flood than after a deep opening) is incorrect, at least for the 0m AHD scenarios. A large flood in 2001 caused a degree of scour to a level lower than a measured water level of 0.17m AHD (Pope, 2006) which began an extended period when the estuary was tidal.

Discussion of likely ecological responses primarily focused on the response of vascular plant assemblages to changes in inundation and salinity regimes and this discussion was at a suitable level of detail for consideration of the entrance management scenarios. The assessment of relative risks could have taken greater account of the medium-term temporal variability of some components; the presence of *Typha* and *Triglochin* in an area previously mapped EVC952 Estuarine Reedbed may be a reflection of the relatively fresh conditions in the estuary associated with a prolonged dry period. Similarly, existing data analyses of the effect of similar openings on seagrass could have been used to inform assessments of impacts of deep openings. Relatively little detail was given regarding conclusions for other ecological components such as fish and birds. Other components of the estuarine ecosystem (not listed as assets in EEMSS) such as macroinvertebrates, macroalgae and planktonic communities were not mentioned.

Objective 6:

Catchment influences on estuarine water quality have been the focus of substantial research and a significant amount of information is available on this subject. Discussion of this topic in the WT report focused solely on acid generation, as guided by Tutt (2008). This focus is consistent with task 5 of the brief but does not fully address the objective, nor take into account the bulk of recent information on catchment hydrology and water chemistry. The water balance model also assumes that the water balance of the upper Eastern View formation aquifer is of primary importance in driving acid events which has not been demonstrated. Hydrogeological features of the catchment were not discussed in section 2 of the WT report. Aside from salinity outputs of modeled scenarios there was no consideration of estuarine water chemistry, including dynamics of mixing of acidic waters, buffering processes and generation of acids in soils surrounding the estuary.

Objective 7:

Output relating to this objective and the associated task was limited (see section 2 above). Use of LiDAR survey data and the assumption of an increase in berm height consistent with predicted sea level rise have accurately identified areas at risk. There was no discussion of uncertainties (for example continued sediment supply, degree of coastal recession) in this assumption of a directly proportional increase in berm height. As identified in the subtasks of task 6, effects of alterations in catchment hydrology need to be considered as part of any review of the estuary management plan.

4 RECOMMENDATIONS AND COMMENTS FOR REVIEW OF ESTUARY MANAGEMENT PLAN

The main task of this review was to assess the WT investigation against the objectives of the project brief. In the process of this assessment several points arose that should be considered in scoping the revision of the management plan for Anglesea estuary. The following recommendations should not be treated as comprehensive. Specific areas relating to the objectives and WT's investigation where further syntheses, analyses or studies would be of benefit are mentioned above and are not repeated below.

Essential to an effective estuary management plan, especially so for the Anglesea River estuary, is an understanding of dynamics between the catchment and the estuary. The hydrodynamic model of Anglesea estuary developed in this project could be a valuable tool in assessing potential management interventions in the estuary as well as comprising part of a key part of an overall model linking catchment hydrology with freshwater and estuarine water chemistry. Such a model would allow exploration of the consequences of future changes in weather patterns and anthropogenic alterations of the hydrology of the catchment and estuary, including artificial mouth openings.

An aspect of a linked catchment-estuary model that could provide useful information would be use of the model to simulate estuarine dynamics using flow and mouth conditions set in the range of previously recorded conditions at times of acidic flushes and baseflows from the catchment. This would provide the basis for an assessment of times of particular risk to estuarine environmental assets.

A quantitative comparison of predictive models for acid generation and flows would allow not only the prediction of periods of higher likelihood of acid flushes but would also allow incorporation of such a model with the existing estuarine hydrodynamic model to examine likely fates of acids and metals in the estuary. Monitoring of freshwater flow into the estuary along with data currently collected higher in the catchment would allow for a better understanding of the timing and nature of inputs and allow future improvement of predictive tools.

While acid flushes to the estuary are an obvious and dramatic feature of the estuary, other, less obvious processes such as increased sedimentation and nutrient supply may also be causing substantial changes in the estuary. In planning for future management of the

estuary it is important to consider all such processes in light of likely future changes to salinity regimes and inundation patterns. The Anglesea River estuary and its catchment are among the better studied systems in Victoria, with current and ongoing monitoring programs in place. The scale of the system, while making it variable also makes many management responses tractable. In the revision of the estuary management plan an opportunity exists to fill gaps and create links between our current understanding of the system and to effectively use this understanding to protect and improve the estuary.

5 REFERENCES

- Arundel, H. 2006. *EEMSS Background Report and User Manual: Estuary Entrance Management Decision Support System*, Deakin University, Warrnambool.
- EPA Victoria. 2005. *Interim report on the Risk-based Assessment of the Anglesea Estuary. Identifying the Values and Threats to the Anglesea Estuary to Assist with Targeted Management Actions*, Environment Protection Authority Victoria, Melbourne, Vic.
- Nelson, RC. 1981. *Anglesea Surfing Beach - Sand Movements and Restoration Strategies*, 1981, CE3/81, Deakin University, Waurn Ponds, Vic.
- Nelson, RC & Keats, AJ. 1978. *Abnormal Sea Levels on the Otway Coast - Their Nature, Cause and Effects*, CE 1/78, Deakin University, Geelong.
- Pope, AJ 2006, 'Freshwater Influences on Hydrology and Seagrass Dynamics of Intermittent Estuaries', PhD thesis, Deakin University.
- Tutt, T 2008, 'Acid drainage, limnology and bioremediation of western Victorian coal mine lakes', PhD thesis, Deakin University.
- Water Technology Pty Ltd. 2010. *Investigation of Anglesea River Estuary Mouth Dynamics*, December 2010 (V02, received by email 10 Jan 2011), Corangamite CMA, Notting Hill, Vic.

APPENDIX

TASK 1

Provide as much clarity as possible regarding the site and the current management arrangements, history of management and works and changes to estuary form.

- a. Acknowledge the site and its characteristics, including geographical position, geology, wind and wave patterns.
- b. Discuss current opening method as outlined within the DSE coastal management act consent and CCMA works on waterways permit. Use flow diagrams, or hierarchies to explain management relationships where suited.
- c. Consider historical information on the river regarding channel depth, tidal extent, excavation of channels on west bank (Coogoorah Park), and the various constructed features and works.
- d. Make use of historical photography where relevant (sources include Alcoa, War archives, Anglesea historical society, ANGAIR, Surf Coast Shire)

TASK 2

Be innovative in mapping and visually representing the estuary (and catchment if required) to inform decision making and planning.

- a. Using LiDAR, map the estuary area likely to be impacted by inundation via riverine flooding dry weather flooding tidal surge/sea incursion etc.

In doing so consider infrastructure, particularly on the west bank of the lower estuary, and identify critical water level for individual sites. Refer to this mapping in later sections when considering the impact of changes to opening regime and channel form.

- b. Show in cross section the differences in height between River at Coal mine Road and the estuary mouth on a “normal high tide. Use this to reflect later upon the impact of opening and what the tidal exchange impact will have. Also use to show altered saline intrusion.
- c. If possible, show the bathymetry of the system, particularly the estuary downstream of the Great Ocean Road bridge. Map this and show cross sections.

TASK 3

Develop a method to show processes of sand movement within the area proximal to Anglesea River estuary which can then be used to explain processes which limit management in the immediate and long term.

- a. What impact these may have in restricting the channel movement and sand accumulation? Consider also the position of the Great Ocean Road and the limits it creates on channel movement and depth.
- b. Analysis of whether man-made structures (shown in D2) should be removed, or retained and why?
- c. Identify the various system responses to a deeper opening or deeper channel with reference to (and anything else deemed important):
 - ecology,
 - channel form,
 - tidal exchange,
 - bank stability,
 - mixing of buried sediments
 - exposure to coastal/tidal surges

TASK 4

Consider “pros and cons” of a deeper opening for Anglesea River mouth, whether through a deeper excavated channel or dredging

- a. Design and detail methods for a deeper opening considering 3 different options:
 - slightly deeper excavation
 - significantly deeper excavation
 - dredging a deeper channel
- b. Include diagrams and indicated cost (where able) of such works.

TASK 5

Considering the acidic waters within the catchment

- a. Show the variability of pH within the system over time. Refer to Pope and Tutt, as well as the data provided by Alcoa. Also refer to EstuaryWatch data.
- b. Consider any known information about bore logs within the catchment and reflections of rainfall.
- c. Investigate the effect a deeper opening will have on acidic water within the system, including with upstream acid water and without upstream acid water ie can opening the estuary be used to manage the acidity of the estuary?
- d. Consider the impact of exposing previously excavated channels within the estuary at lower water levels.

TASK 6

Identify and document future management challenges

Consider impact of the following:

- a. Projected sea level increases referring to maps included earlier.
- b. Longer drier periods and changing in rainfall
- c. Resulting channel form under a reduced flow regime emphasising the current input of Alcoa

TASK 7

Final report complete and presentation to management agencies