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5th October, 2010

Coorong, Lower Lakes, Murray Mouth Project
Level 8 Chesser House
91-97 Grenfell Street
Adelaide SA 5000

Attention: Glynn Ricketts

Dear Glynn

RE: Coorong Model / South Lagoon Pumping Simulation Update

This letter provides an update to the Coorong 2-dimensional model simulations used to evaluate the South Lagoon Pumping Strategy (SLPS). It summarises recent additional work and provides an update to previous model output.

1 Introduction & Background

BMT WBM has undertaken a range of investigations into the Coorong on behalf of the South Australian Government. Clients included the South Australian Murray Darling Basin Natural Resource Management (SA MDB NRM) Board and the Department of Environment and Natural Resources (SA DENR) (previously Department of Environment and Heritage (DEH)).

A brief summary of previous investigations and outputs for this commission is given below:

BMT WBM (2009) "Coorong Model Upgrade and Simulations of Proposed Pumping from the Southern Lagoon", was delivered to the SA MDB NRM Board in December 2009. It covers details of:

- Improvements to model mesh and inclusion of new Parnka Point Survey into model DEM;
- Improved model calibration for 2008;
- Investigations into salinity relationships between electrical conductivity (EC - µS/cm) and salt concentration (kg/m^3 ~ ppt); and
- Three year scenario simulations (using 2008 boundary condition data) of South Lagoon pumping including: base case, pumping (at 250 ML/Day), pumping (at 250 ML/Day) and dredging (a 50 m channel with a minimum bed level of -0.8 mAHD through Hells Gate).

BMT WBM (2010a) "Six Year Coorong Model Simulations of Proposed Pumping from the Southern Lagoon", was delivered to the SA DEH in April 2010. It covers details of:

- The generation of model initial conditions based EC spatial survey data from the 16th December 2009;
- Simulation of base case model for six years (1/1/2010 – 1/1/2016) using new initial conditions;
- Six year simulations of the 250 ML/day pumping and the 250 ML/day pumping with dredged (~50m) channel models;
- Revising the dredged mesh to 100m width and re-running the dredge scenario for six years; and

- Re-run of the pumping simulation for six years using low UPSE flows (15GL/year in 2013-2016 instead of 60 GL/year).

BMT WBM (2010b), "Model Calibration to 2009 Data", was delivered to the SA DENR in August 2010. It covers details of:

- Updates to model mesh (South Lagoon and Goolwa Channel (between Goolwa Barrage and Murray Mouth)); and
- Model calibration for 2009/2010 (22nd April, 2009 to 1st April, 2010).

An email from BMT WBM to SA DEH on the 31st May, 2010 provided draft results of South Lagoon salinity for:

- A six year simulation using 2009 boundary conditions; and
- A six year simulation showing impact of moving pump off-take from Woods Well to Seagull Island.

An email from BMT WBM to SA DENR on the 27th September, 2010 provided draft results of South Lagoon salinity for:

- An update to the calibration due to a revision of South Lagoon bathymetry; and
- A six year simulation showing impact of revised bathymetry on the pumping simulation.

1.1 Outline of Letter Report

This letter provides a description of:

- Updates to South Lagoon bathymetry;
- Impact on calibration of updating South Lagoon bathymetry;
- Updates to six year simulation results using the most up-to-date model mesh and calibration parameters; and
- Presentation of results for a range of sensitivity tests In particular a comparison of:
    - Impact of bathymetry change on scenario simulations;
    - Use of 2008 or 2009 boundary conditions;
    - Impact of moving pump off-take location;
    - Impact of refining mesh resolution/bathymetry for scenario runs;
    - Impact of applying reduced (calibrated) evaporation for scenario runs;
    - Impact of low UPSE inflow for scenario runs.

2 Update South Lagoon Bathymetry

SA DENR commissioned the collection of additional bathymetry data in the Coorong South Lagoon. The location of the additional survey is shown in Figure 1. The black data points (Policeman Point area) were collected by HydroSurvey (Flinders Ports) on the 19th and 20th July, 2010, while the blue data points (end South Lagoon / Salt Creek area) were collected by SA Water Hydrographic Services on 1st September, 2010.

A 10 m resolution digital elevation model (DEM) of the survey data was provided by DENR and was used to update the model mesh elevations. Changes to the mesh bathymetry is shown in Figure 2, with blue area's indicating parts of the mesh which were deepened, while red areas show an increase in mesh elevation. Maximum decreases to bed elevation (blue areas) were in the order of -1 m while maximum increases to bed elevation (red areas) were in the order of +0.5m. Given that there were similar areas of increases and decreases to mesh elevation there was not a significant change to system volume.

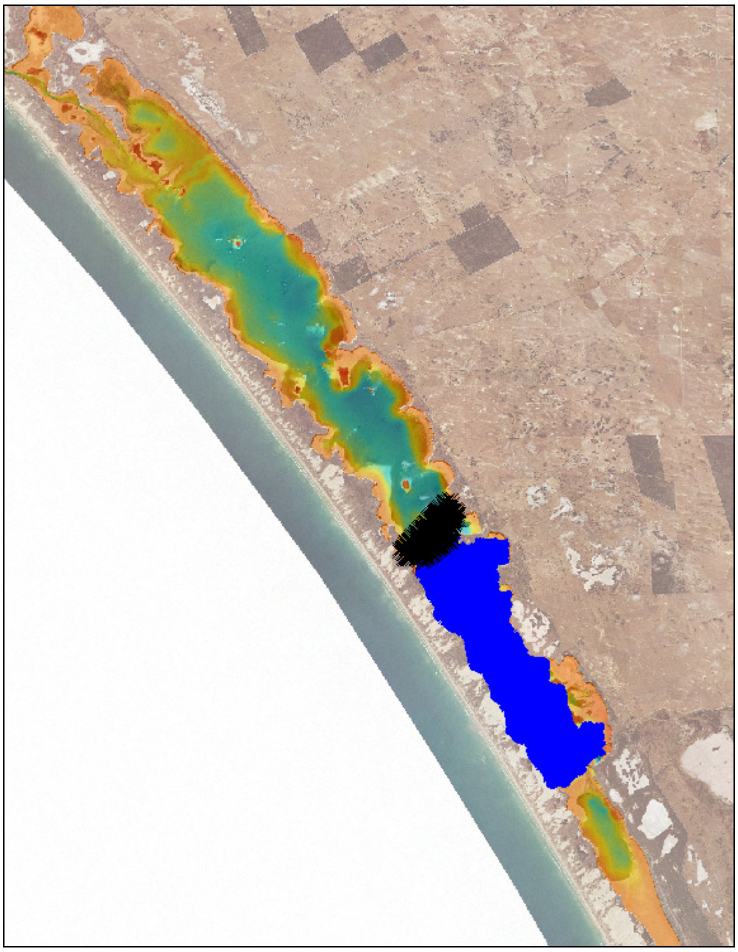

Figure 1 Additional Bathymetry Data (Blue & Black Areas) for Coorong South Lagoon

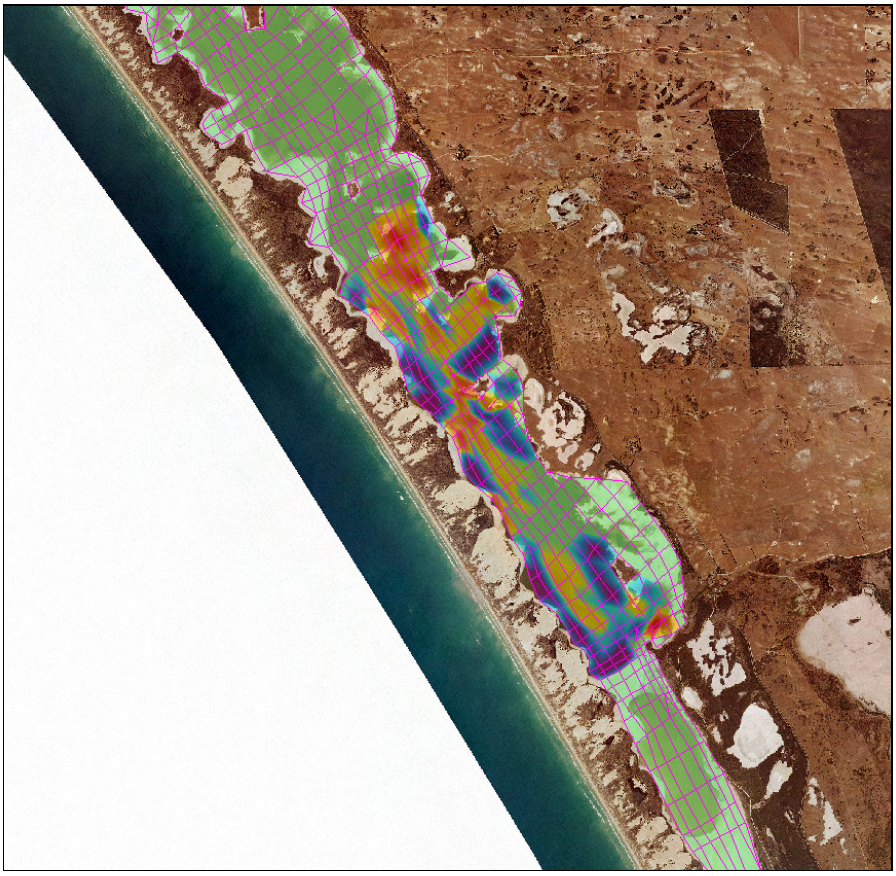

Figure 2 Changes to South Lagoon Model Mesh Bathymetry (Blue = Deeper, Red = Shallower)

3 Impact of Bathymetry Change on Model Calibration

The model extent, bathymetry and important locations are shown in Figure 3. The impact of updating the South Lagoon bathymetry (as described in Section 2) on model calibration is shown in Figure 4 and Figure 5. The bathymetry change resulted in salinity differences of only 1-2 ppt (i.e. less than 1% difference) in the South Lagoon and no change in the North Lagoon. The insignificant change is because there is only a minor variation in system volume based on the changes to model bathymetry. A full description of model calibration and model bathymetry is given in BMT WBM (2010b). The impact of the South Lagoon bathymetry update on the six year pumping scenario simulation is described in Section 5.1.

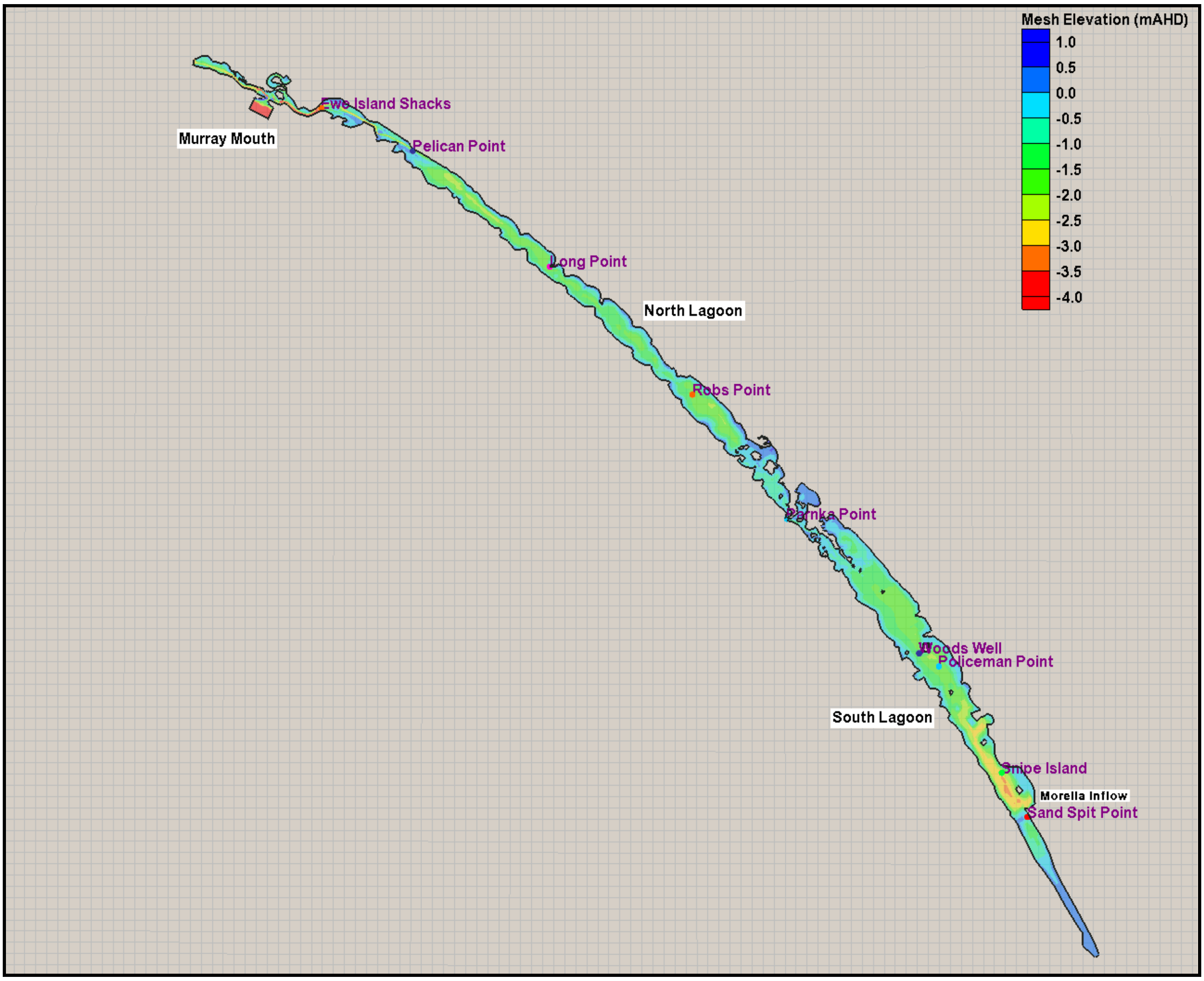

Figure 3 Model Extent, Bathymetry and Key Locations

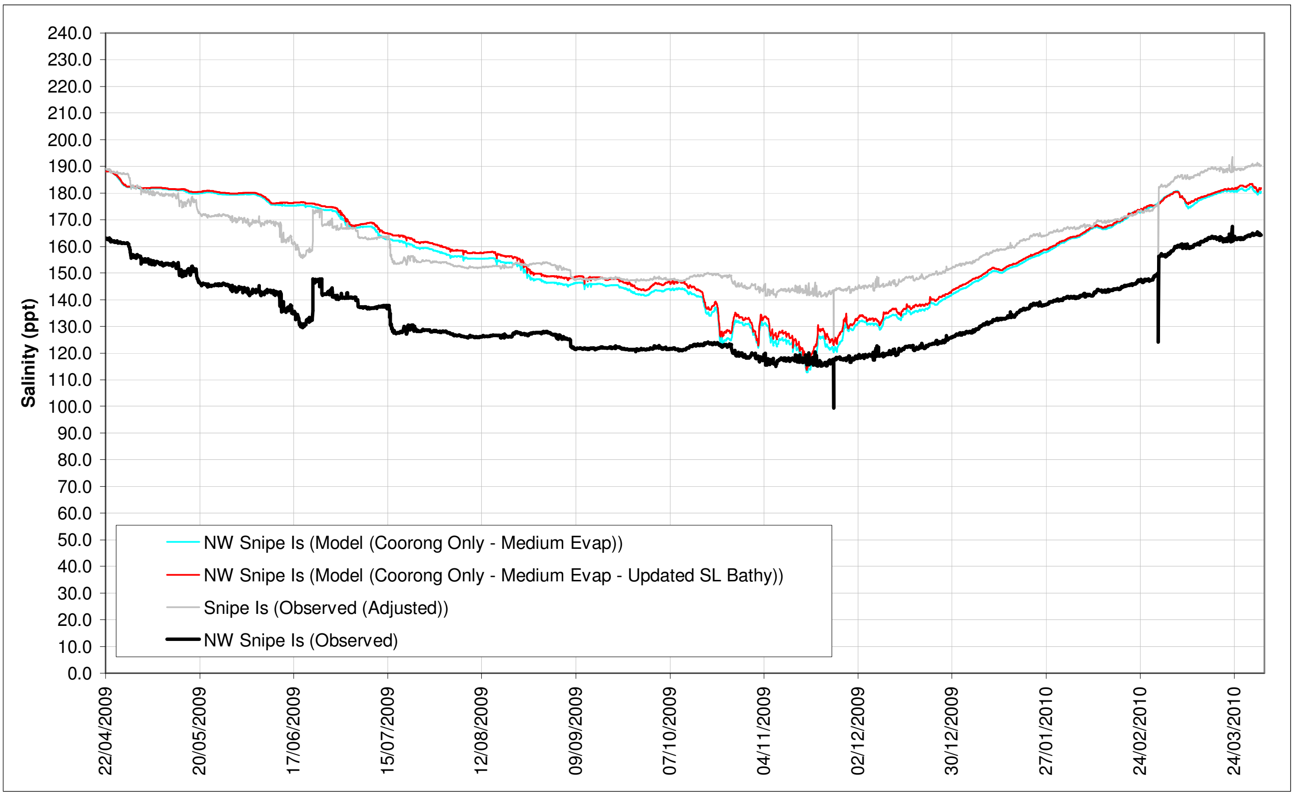

Figure 4 Observed and Modelled Salinity at Snipe Island (South Lagoon)

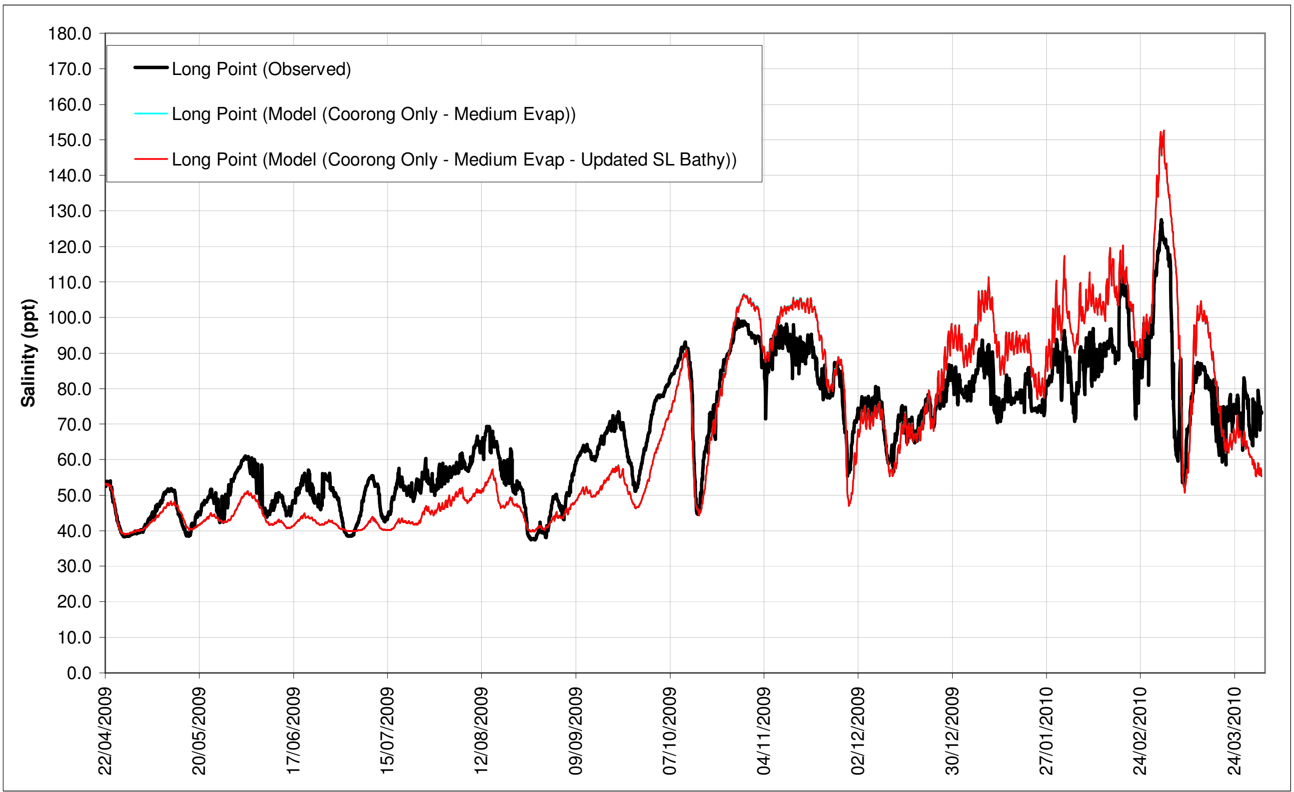

Figure 5 Observed and Modelled Salinity at Long Point (North Lagoon)

4 Update to Six Year Scenario Simulation using Latest Model

Since the original six year Coorong scenario simulations were presented in BMT WBM (2010a) there have been a number of model configuration changes. Key changes include:

- Use of 2009 instead of 2008 boundary conditions (including water level, wind and evaporation);
- Increasing model mesh resolution (and improving bathymetry representation) in the South Lagoon and Goolwa Channel (between Goolwa Barrage and Murray Mouth) as described in BMT WBM (2010b);
- Update of South Lagoon bathymetry using recent hydrosurvey (as described in Section 2);
- Relocation of the pump off-take from Woods Well to near Seagull Island;
- A 20% reduction in evaporation rate was applied to account for the impact of high salinity on reduced evaporation, based on the calibration exercise reported in BMT WBM (2010b); and
- Use of a realistic wind shear stress parameter instead of a higher than normal value that was required in the calibration presented in BMT WBM (2009).

Results are presented for the Base Case and Pumping (at 250 ML/Day from near Seagull Island). A description of the model setup and boundaries (excluding the above changes) is given in BMT WBM (2010a). Key boundary conditions include:

- Observed (2009) water levels at Victor Harbor applied at the mouth of the Murray;
- Observed (2009) Pelican Point winds;
- Pumping starts on 1/1/2011 and runs for three years at 250 ML/day until the 1/1/2014;
- UPSE discharges of 15, 10, 10, 60, 60, 60 GL/year for 2010 – 2016 (assumes UPSE connection in 2013);
- No barrage discharge is included in the model.

Figure 6 (Policeman Point in the South Lagoon) and Figure 7 (Robs Point in the North Lagoon) presents predicted salinities within the Coorong (using the scenario boundary conditions) and shows the effectiveness of the SLPS on reducing salinity within the Coorong. Figure 8 (Policeman Point in the South Lagoon) and Figure 9 (Robs Point in the North Lagoon) presents predicted water levels within the Coorong (using the scenario boundary conditions) and show that the pumping has negligible effect on North Lagoon water levels, though may reduce South Lagoon water levels by up to 0.2 m in Summer.

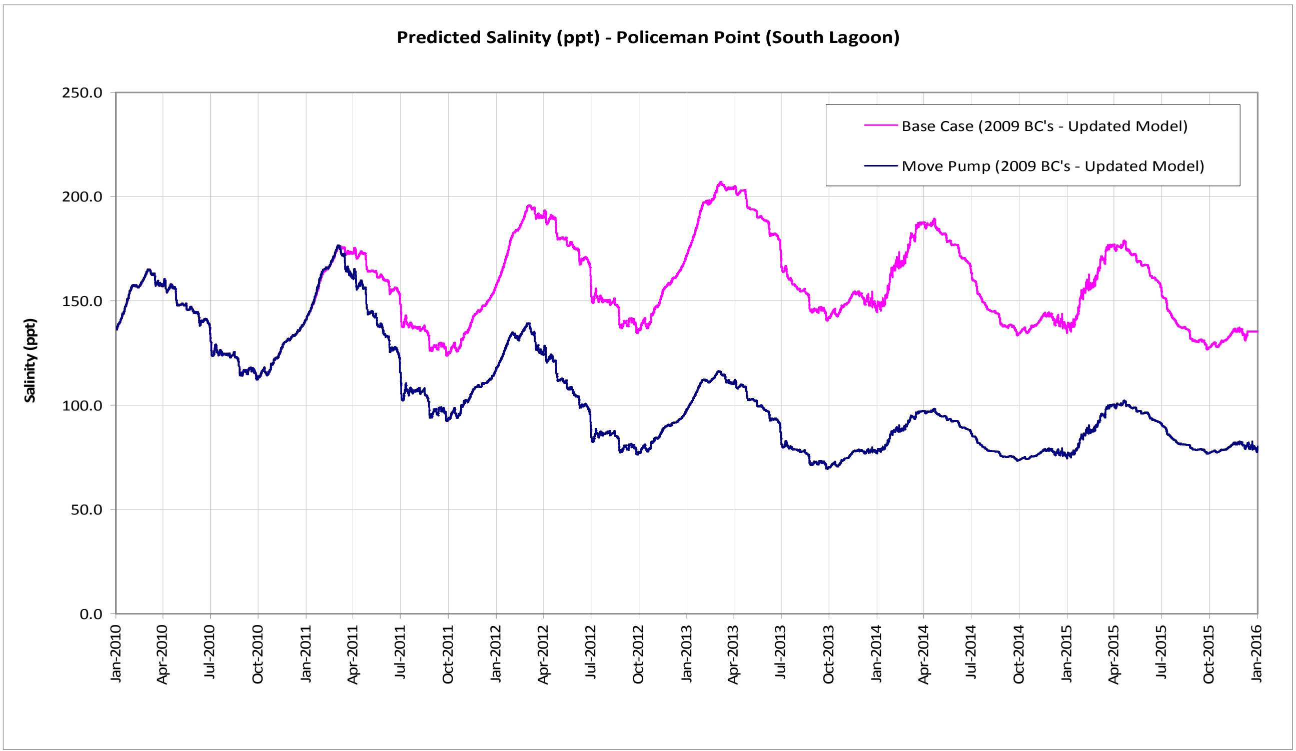

Figure 6 Predicted Salinity at Policeman Point (South Lagoon) for Base Case and 250 ML/Day Pumping

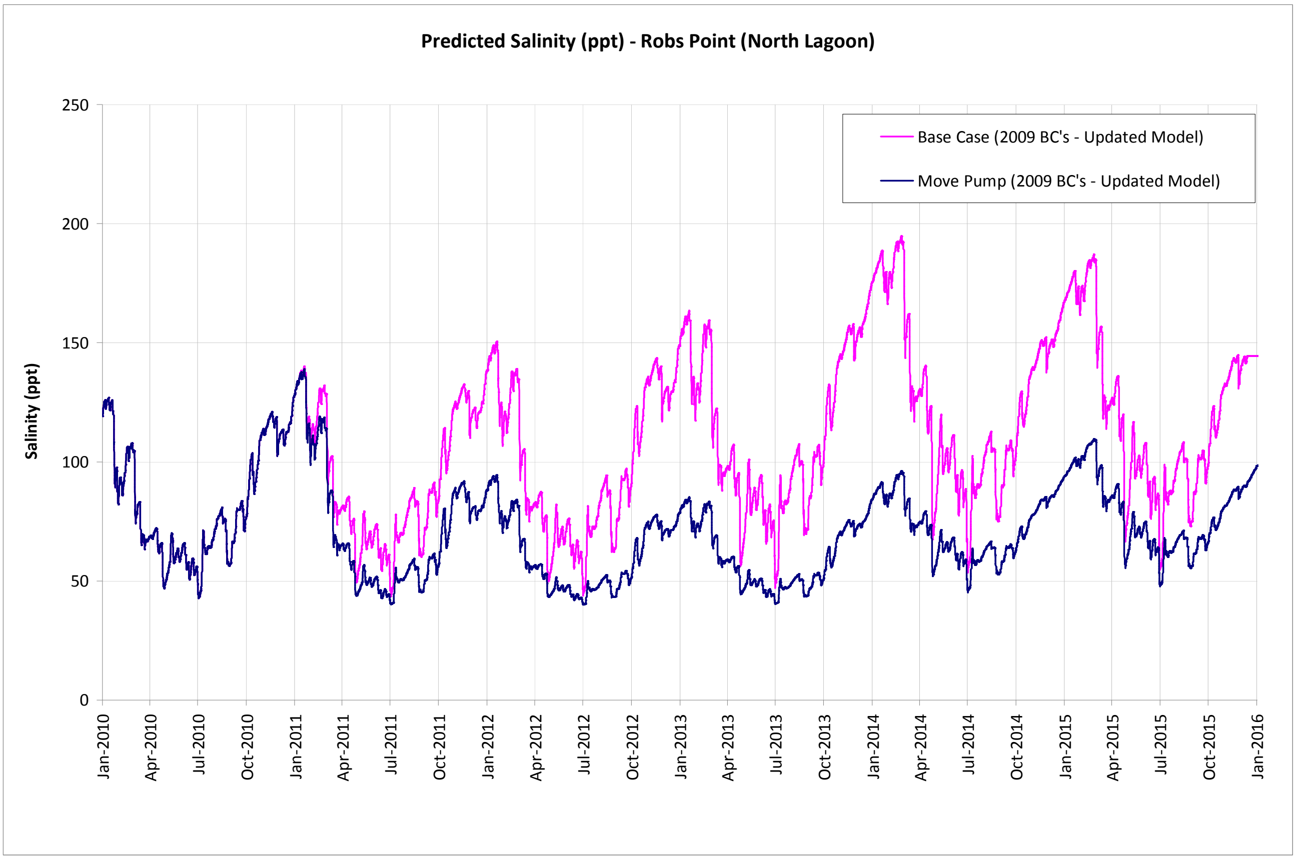

Figure 7 Predicted Salinity at Robs Point (North Lagoon) for Base Case and 250 ML/Day Pumping

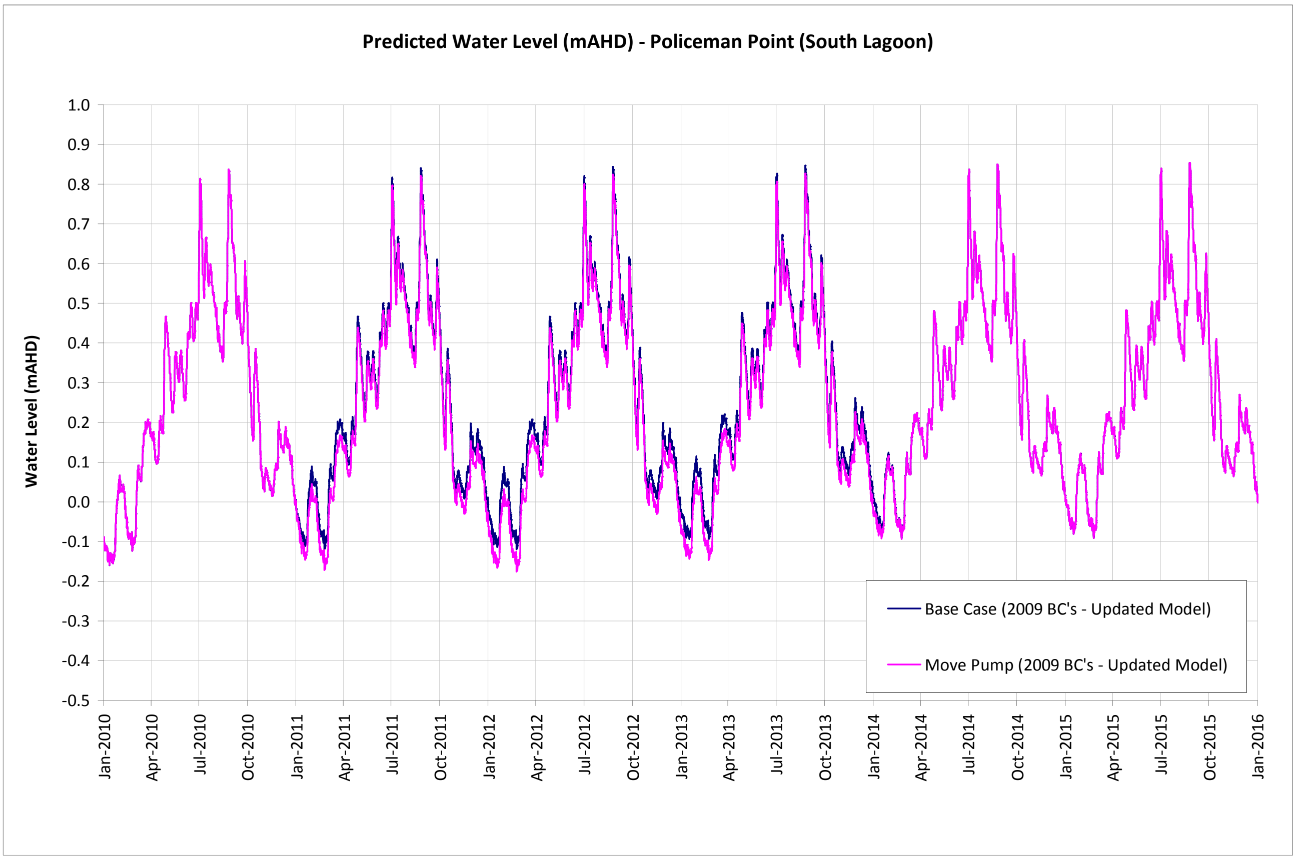

Figure 8 Predicted Water Level at Policeman Point (South Lagoon) for Base Case and 250 ML/Day Pumping

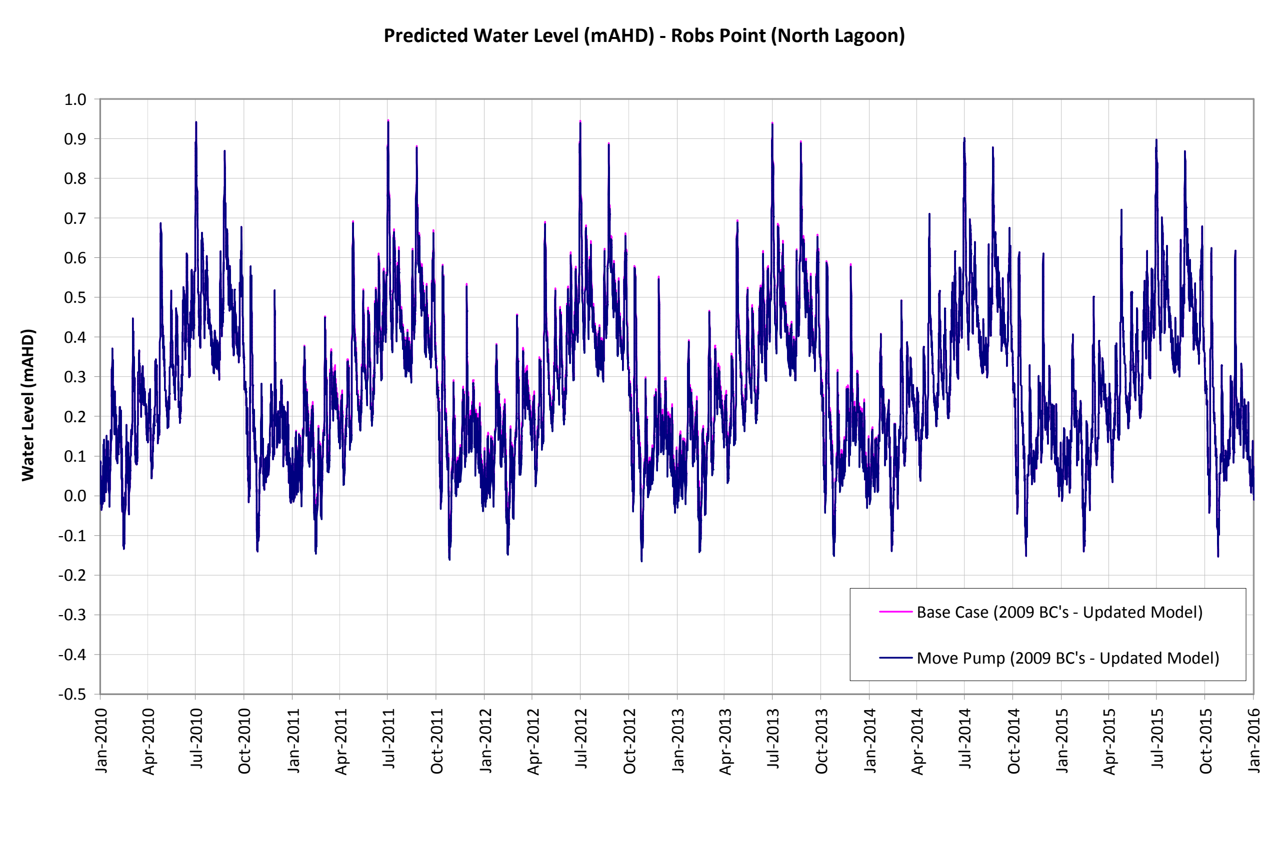

Figure 9 Predicted Water Level at Robs Point (North Lagoon) for Base Case and 250 ML/Day Pumping

5 Impact of Model Changes on Scenario Simulations

This section presents the results of a range of model sensitivity tests that show the impact of changing a range of different model configurations (including model boundary conditions, mesh resolution and bathymetry or model parameters (i.e. wind shear stress)). The results are presented to show relative change and are not necessarily presented against the most up-to-date model configuration.

5.1 Impact of Bathymetry Change on Scenario Simulations

The impact of updating the South Lagoon bathymetry (as described in Section 2) on model six year scenario runs is shown in Figure 10. The bathymetry change resulted in salinity differences of less than 2 ppt (i.e. less than 1-2%) in the South Lagoon and no change in the North Lagoon. The insignificant change is due to only a minor variation in system volume due to the changes to model bathymetry. Both model simulations utilise a refined model mesh, 2009 boundary conditions and high UPSE discharge. A full description of model scenario runs is given in BMT WBM (2010a). It should be noted that both below results use a conservative (i.e. high) estimate of model evaporation.

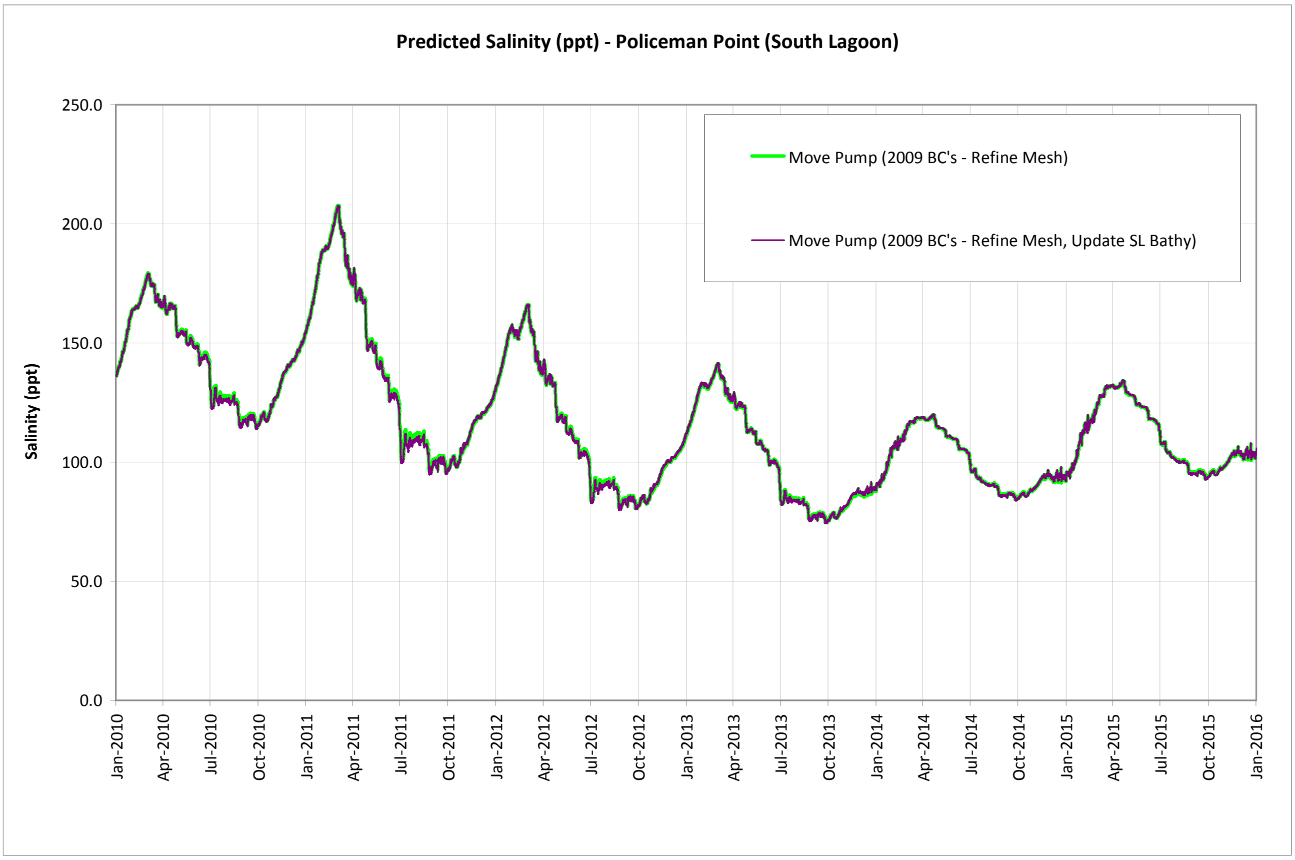

Figure 10 Predicted Salinity at Policeman Point (South Lagoon) – Impact of Bathymetry Change

5.2 Selection of 2008 or 2009 Boundary Conditions for Scenario Runs

The impact on South Lagoon salinity of using either 2008 or 2009 model boundary conditions (water level, wind and evaporation) is shown in Figure 11. The results show that for both the base case and pumping simulations, the use of 2008 boundary condition data results in higher peak salinities, while the overall salinity behaviour is comparable. The higher salinity peaks are likely to be primarily due to lower summer time South Lagoon water levels (see Figure 12) which are due to a number of strong wind events in 2008 which blow water into the North Lagoon. It should be noted that in addition to the different selection of boundary conditions, the models also differ in that; the 2008 model uses the unrefined mesh and older South Lagoon bathymetry.

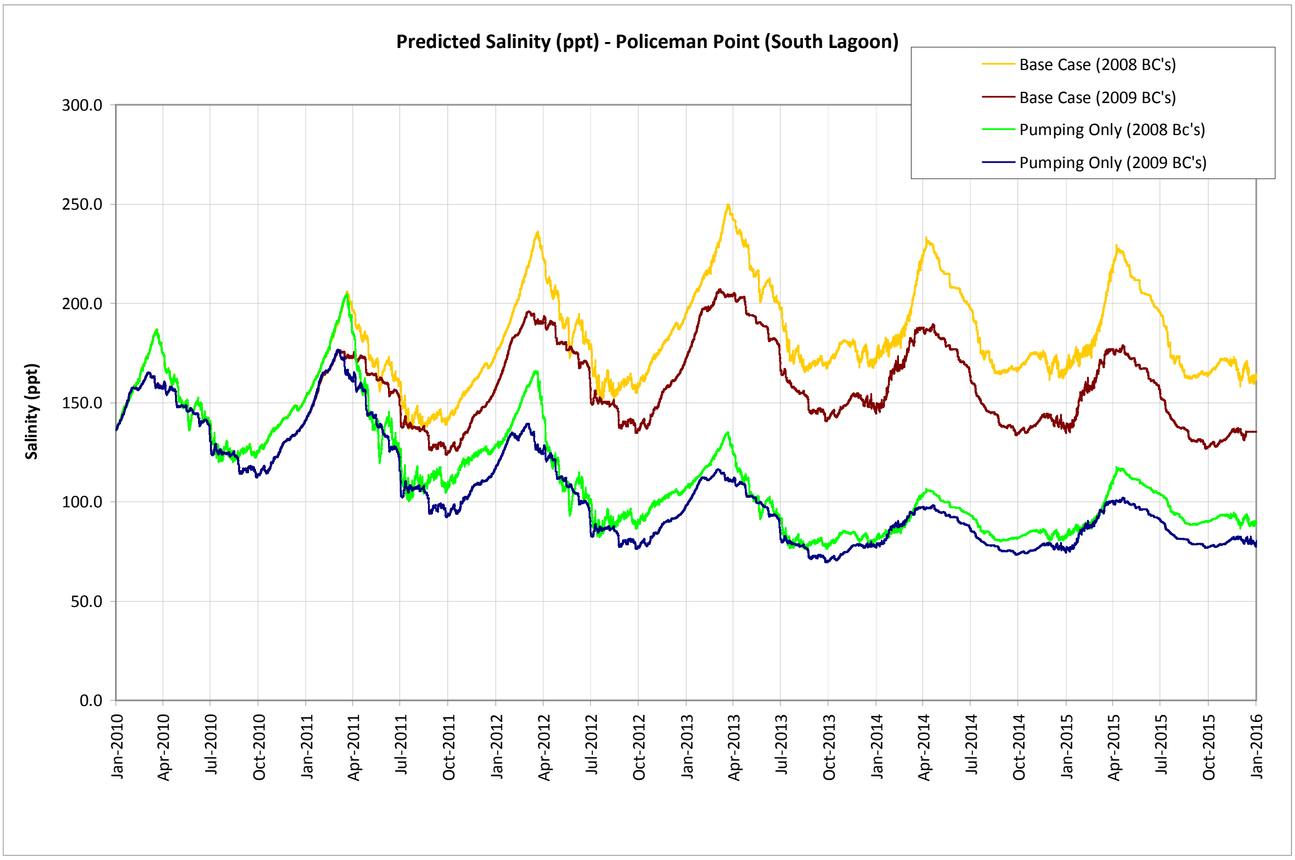

Figure 11 Predicted Salinity at Policeman Point (South Lagoon) – Selection of 2008 or 2009 BC's

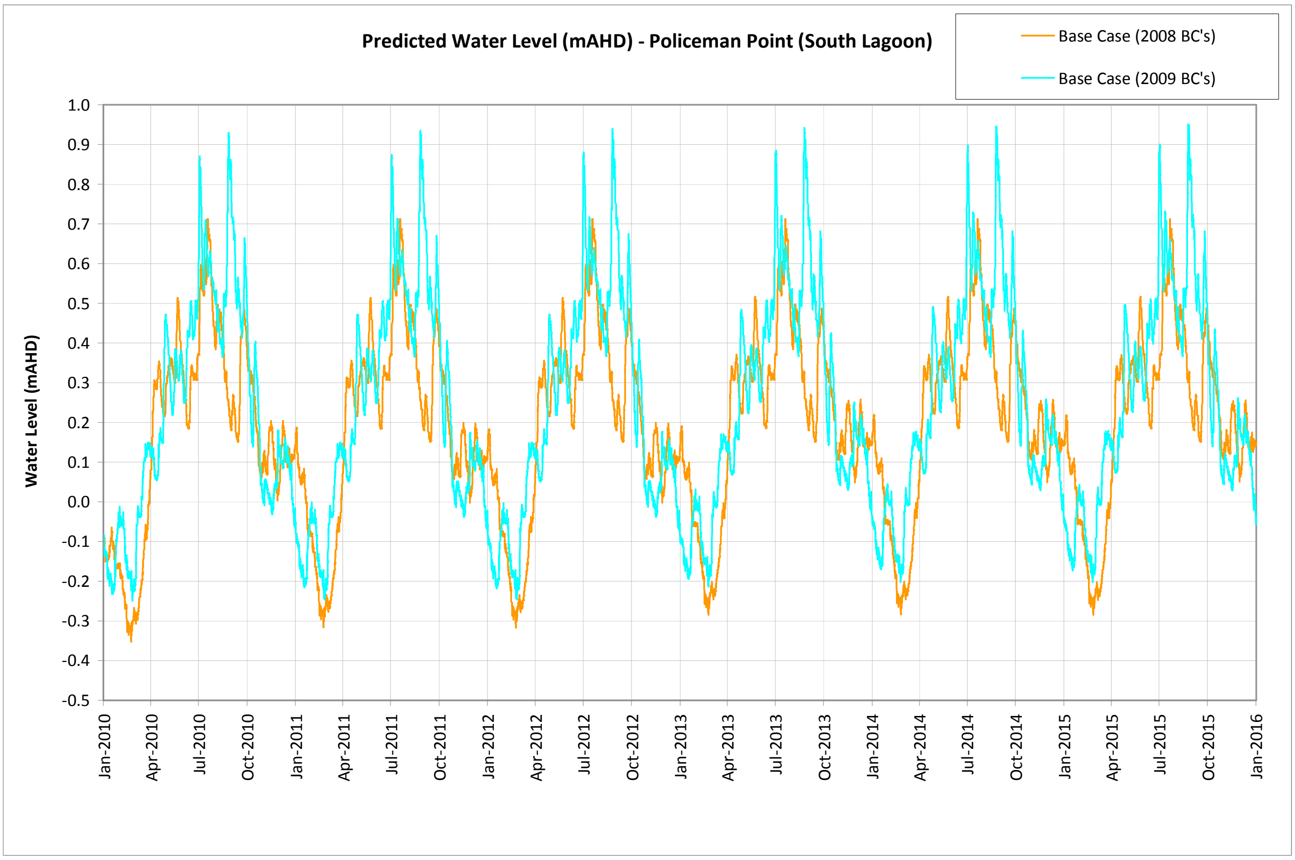

Figure 12 Predicted Water Level at Policeman Point (South Lagoon) – Selection of 2008 or 2009 BC's

5.3 Impact of Moving Pump Off-take Location

The impact on salinity within the South Lagoon of moving the location of the pump off-take from Woods Well (367670, 6012010) to Seagull Island (373680, 6004950) (see Figure 13) is shown in Figure 14. By moving the pump further south to near Seagull Island, fresher water from the North Lagoon is drawn past the location (Policeman Point) where results are presented. While differences of up to 10 ppt occur during the three years of pumping, by the end of the six year simulation the differences are negligible. It should be noted that both below results use a conservative (i.e. high) estimate of model evaporation.

Figure 13 Location of original (Woods Well) and moved (Seagull Island) Pump Off-takes

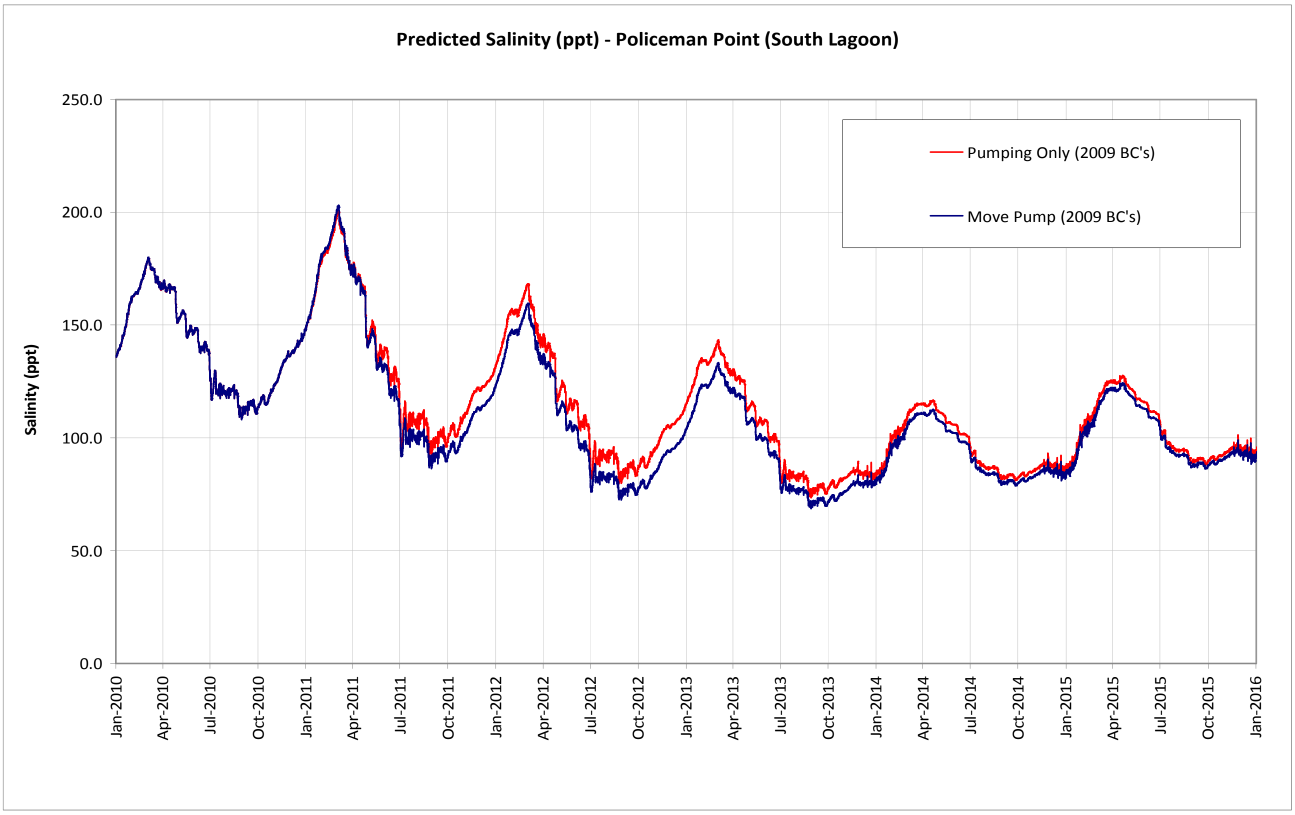

Figure 14 Predicted Salinity at Policeman Point (South Lagoon) – Impact of Moving Pump Off-take

5.4 Impact of Refining Mesh Resolution/Bathymetry for Scenario Runs

Considerable mesh refinement to both the South Lagoon and Goolwa Channel (between Goolwa Barrage and Murray Mouth) is described in BMT WBM (2010b). This included improving mesh bathymetry based on aerial photography and additional bathymetry data sets (excluding the July and September, 2010 ones (refer Section 2)). This resulted in changes to the model volume, surface area and conveyance of the South Lagoon. The impact on salinity within the South Lagoon of these changes is shown in Figure 15. The increase in salinity is likely to be due to the increased volume and surface area of the updated model mesh which results in a greater mass of salt at the start of the run and increased evaporation through the run. It should be noted that both simulations use a conservative (i.e. high) estimate of model evaporation.

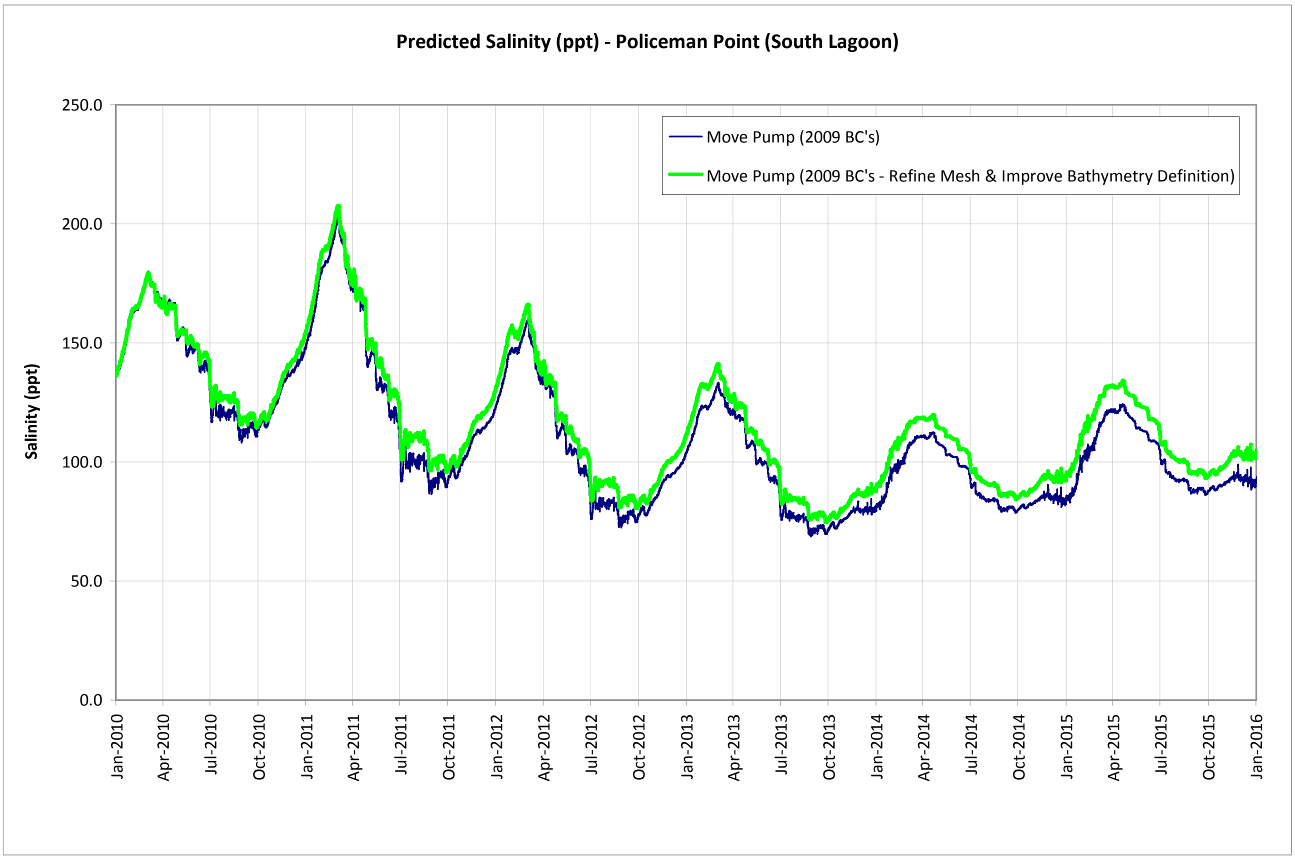

Figure 15 Predicted Salinity at Policeman Point (South Lagoon) – Impact of Mesh & Bathymetry Update

5.5 Impact of Applying Reduced (Calibrated) Evaporation for Scenario Runs

During the model calibration exercises presented in BMT WBM (2009) and BMT WBM (2010b), a reduction in applied evaporation (due to high salinity) was required to achieve a reasonable calibration. In BMT WBM (2008) observed evaporation rates were reduced by 15-30% (for 2008 calibration) while in BMT WBM (2010b) which calibrated the model against 2009 data, it was found that the observed evaporation rate should be reduced by between 20% and 30% to best match observed Coorong salinity values. A comparison of predicted South Lagoon salinity for both observed (unfactored) and 20% reduced (approx. calibrated) 2009 evaporation is shown in Figure 16 for both the Base Case and Pumping scenarios. The results show that for long term simulations the selection of an appropriate evaporation reduction factor has significant impact on model predictions, especially for the base case.

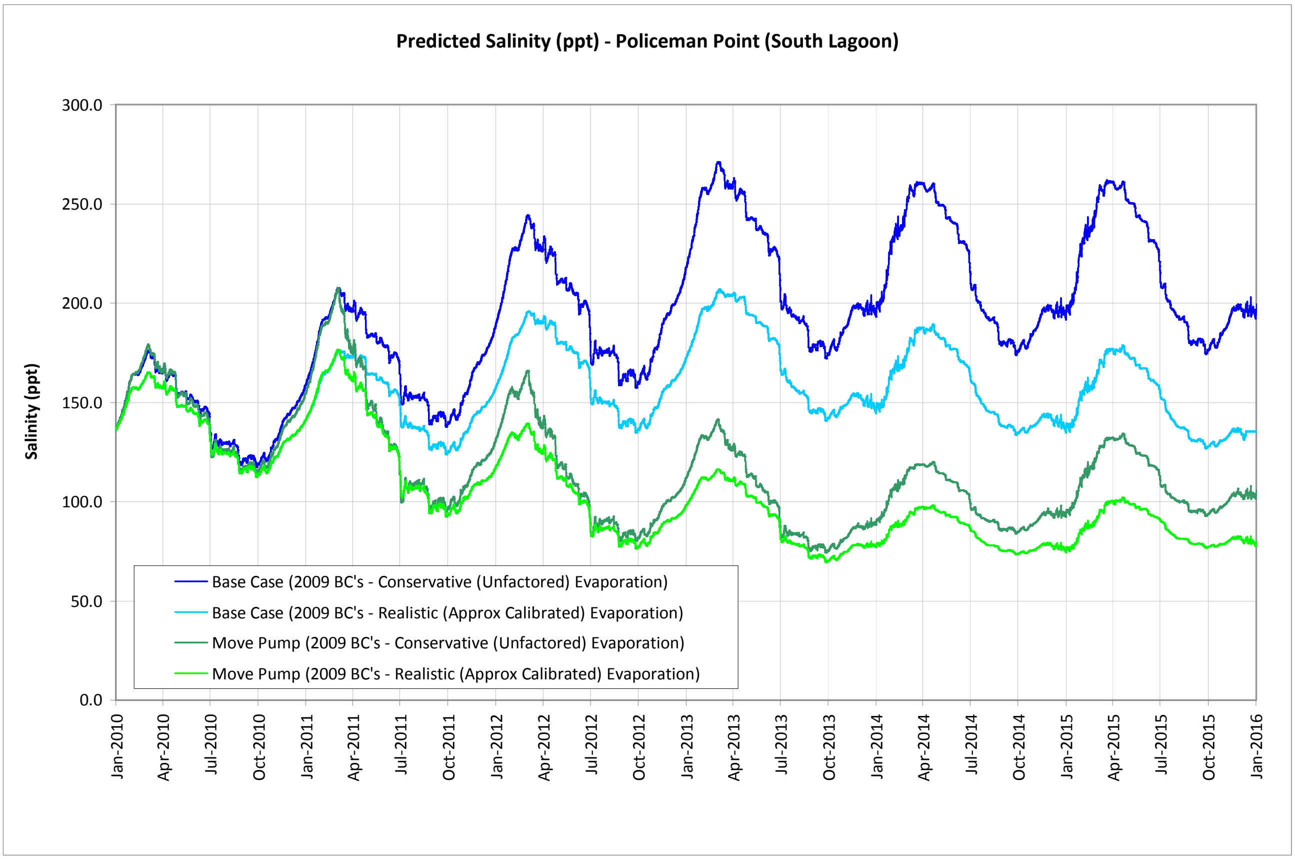

Figure 16 Predicted Salinity at Policeman Point (South Lagoon) – Impact of Adjusting Evaporation

5.6 Impact of Low UPSE Inflow for Scenario Runs

The impact on salinity within the South Lagoon of connecting the UPSE drainage scheme into the South Lagoon is shown in Figure 17. Without UPSE connection predicted Salt Creek / Morella Basin inflows are 15, 10, 10, 15, 15, 15, GL/year for 2010 – 2016, whereas if the UPSE drainage is connected in 2013, expected discharge is 15, 10, 10, 60, 60, 60 GL/year for 2010 – 2016. The results show that after the cessation of pumping in 2014, the higher freshwater inflows help reduce the relative increase in South Lagoon salinity. It should be noted that these simulation use 2008 BC's, the unrefined mesh and do not consider the impact of barrage discharge.

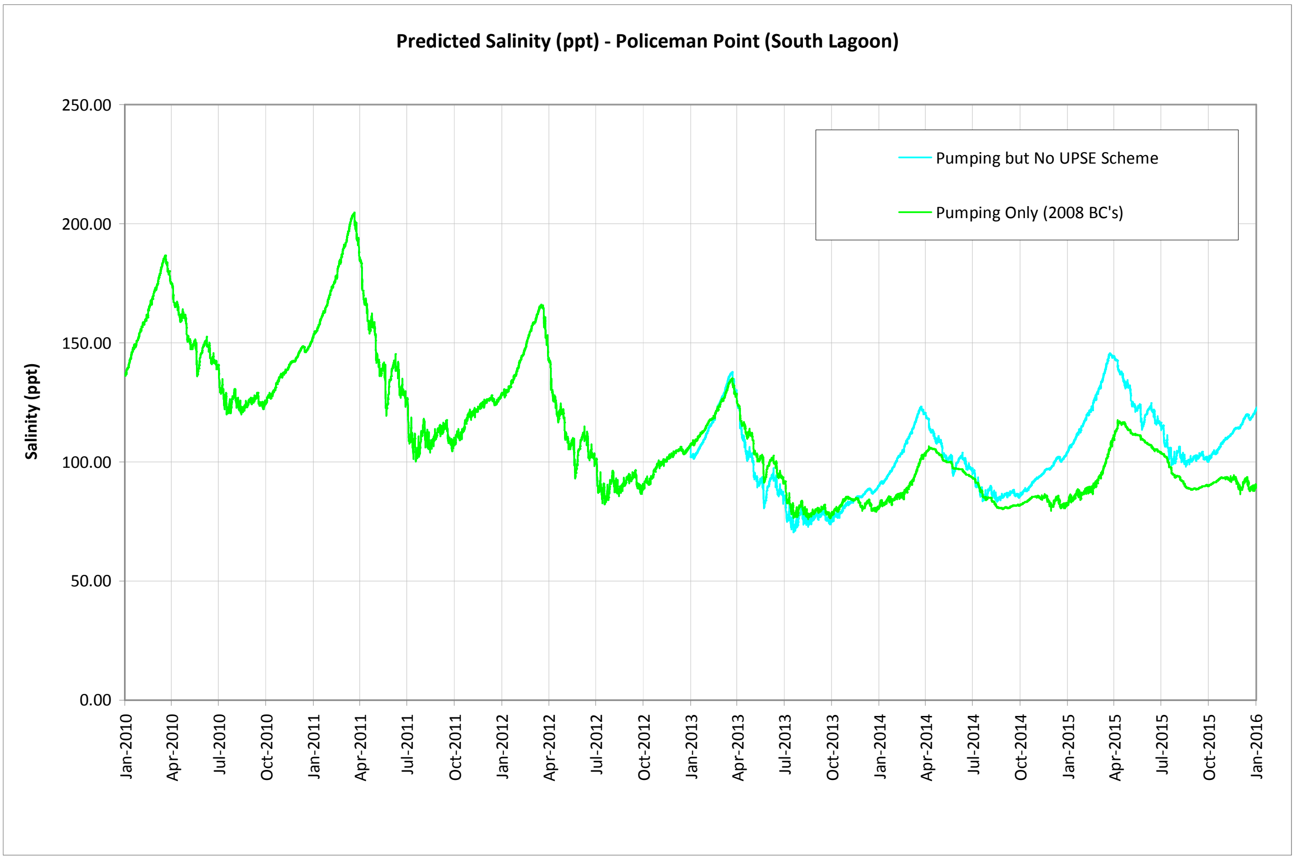

Figure 17 Predicted Salinity at Policeman Point (South Lagoon) – Impact of UPSE Connection

6 Discussion & Conclusions

This letter report has presented outputs using the most up-to-date model currently available. Section 5 describes a range of sensitivity testing undertaken to appreciate relative changes in model predictions. The investigation has found that the model predictions are quite sensitive to the applied boundary conditions (i.e. 2008 or 2009), the selection of reduced evaporation rate and changes to Salt Creek inflows (i.e. UPSE connection). The model is moderately sensitive to changes to the mesh/bathymetry which result in changes to the stage-area-volume characteristics of the South Lagoon. However, changes in bathymetry which do not significantly change overall system volumes, result in only small changes to model predictions. While moving the pump off-take location from Woods Well to south of Seagull Island does reduce salinity at Policeman Point during the period of pumping, by the end of the six year simulation there is only a minor difference in salinity.

While the existing investigations have covered a wide range of conditions an important variable they have not covered is the impact of barrage discharges on Coorong salinity. The large freshwater inputs to the Murray-Darling system since December 2009 have nearly filled the Lower Lakes and significant barrage releases are likely to occur from October 2010. Depending upon the magnitude of these releases, a significant change to the salinity regime of the Coorong is possible. The impact of barrage releases on the SLPS is yet to be investigated using the 2D model. While it is understood that some barrage release scenario's have been investigated using a CSIRO 1D model, there is yet to be a comparison between 1D and 2D model predictions using the same boundary conditions.

In addition to considering the impact of barrage releases, the 2D model could be used to help optimise the timing and rate of pumping for the SLPS. Given the high monetary cost and CO_2 emissions associated with pumping, optimisation of the pumping scheme is likely to be beneficial. Deliberate closure of the Murray Mouth during a large barrage release may result in enhanced salinity reduction in the Coorong and could be investigated using the existing 2D model. If releases occur during a period of low winds, vertical mixing cannot be assumed, so a 3D model (now a TUFLOW-FV capability) would be recommended.

7 References

BMT WBM (2009), "Coorong Model Upgrade and Simulations of Proposed Pumping from the Southern Lagoon", L.N1792.001_SouthLagoonPumpingSimulations_Final.pdf, Produced for: SA MDB NRM Board, December 2009

BMT WBM (2010a), "6 Year Coorong Model Simulations of Proposed Pumping from the Southern Lagoon", L.N1792.002_SouthLagoonPumping6yrSims_PreliminaryDraft.pdf, Produced for: SA DEH, April 2010.

BMT WBM (2010b), "Model Calibration to 2009 Data", L.N1792.003_SouthLagoon2009ModelCalibration_FinalDraft.pdf, Produced for: SA DEH, August 2010.

We trust that the above details meet the requirements of DENR. Should you require any further information, please contact the undersigned on (02) 4940 8882.

Yours Faithfully
BMT WBM Pty Ltd

Rohan Hudson
Senior Engineer