PERTH DESALINATION PLANT DISCHARGE MODELLING: MODEL VALIDATION

REPORT OF INDEPENDENT PEER REVIEW PANEL

Prepared for
WATER CORPORATION

Prepared by
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1. BACKGROUND

1.1 Introduction

The Water Corporation (WC) is undertaking investigations into the construction and operations of a second desalination plant in Kwinana, Perth Seawater Desalination Plant 2 (PSDP2). PSDP2 will be developed in two 25 GL stages (ultimate production capacity 50GL/annum) and operated independently of the existing Perth Desalination Plant (PSDP1).

The WC has undertaken a comprehensive programme to assess the feasibility of a potential second desalination plant. The first stage included the development of a hydrodynamic and water quality model for Cockburn Sound. Once calibrated the model was subsequently used to accurately depict the discharge of brine from both the existing PSDP1 and the potential new PSDP2 into Cockburn Sound; its subsequent dilution, advection and dispersion as well as its influence on dissolved oxygen concentrations within Cockburn Sound. The model can also be used to optimise the location and design of marine infrastructure needed for a new seawater desalination plant

BMT was engaged to develop the model.

The Water Corporation engaged the independent Peer Review Panel (PRP) to review the development of this model. The peer review panel (PRP) included:

- Prof. Chari Pattiaratchi, University of Western Australia
- Dr Nick D'Adamo, Intergovernmental Oceanographic Commission (IOC) of UNESCO
- Dr Jason Antenucci. DHI Water and Environment
- Dr Des Lord (Chair) DA Lord and Associates

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The PRP undertook a review of the following report;

- Perth Desalination Plant Discharge Modelling: Model Validation (R.B22253.002.05.ModelValidation.docx))

The PRP was specifically requested to provide commentary on:

- Whether the model developed is fit for purpose as the basis for the EPA decision making.
- The appropriateness of the approach, methodology and data used to develop the model in light of current practices and knowledge
- The ability of the model to appropriately simulate the desalination discharge into Cockburn Sound

Following the review of the validation report the PRP also provided comment on;

- Perth Desalination Plant Discharge Modelling: Model Scenarios (R.B22253.004.03.ReferralScenarios.docx)

The terms of reference for the review of the scenario report was as follows;

- Whether the model developed was appropriate to simulate the discharge scenarios selected.

The PRP was not requested to provide comment on the individual scenarios selected for modelling however was requested to provide comment on the outputs from the modelling results. The PRP also had no role in providing impact assessment commentary.

This document describes the review process undertaken and presents a summary of the main conclusions and recommendations made by the PRP.

1.2 Structure of the PRP process

The peer review process was undertaken in a rigorous and comprehensive manner. It commenced in February 2018 when the PRP was requested to review the first draft of the calibration report. The recommendations from this first review were incorporated into the model development by BMT and the second draft was provided to the PRP for final comment and sign off in October 2018.

The review of the Scenario Modelling report was completed in February 2019.

Throughout the iterative review process the PRP, the WC and BMT exchanged information, and resolved issues through a well-structured process of report reviews, workshops and written communication. This meant all technical issues raised were discussed and considered in detail, which resulted in the relevant modification/enhancements of the final reports.

The PRP is of the view that this interactive process enhanced the structure and capacity of the model that was developed for this application as well as the analysis and interpretation of model results generated.

The WC retains the extensive record of all commentary and correspondence of the detailed review process.

2. PEER REVIEW - MODEL VALIDATION REPORT

2.1 Model Selection

BMT selected and utilised a suite of numerical models and procedures for the simulation of the hydrodynamics and water quality (DO only) of the coastal area including Cockburn Sound and the brine discharge from the existing PSDP.

These models are:

- Computational Fluid Dynamics (CFD) for the simulation of nearfield (NF) processes specifically the representation of the brine discharge from the diffuser at the existing PSDP
- Hydrodynamic model TUFLOW Finite Volume (FV) model for the representation of the hydrodynamics of the far-field (FF) and wider coastal area including Cockburn Sound
- Water quality model (AED2) for the representation of dissolved oxygen dynamics and concentration. This was coupled to the TUFLOW (FV) hydrodynamic model.

In addition, the modelling programme required

- the application of appropriate techniques for the linking of the NF and FF models, and
- the application of an appropriate Turbulence Closure Scheme using the GOTM model coupled with the TUFLOW FV model to simulate vertical mixing processes

Conclusion and Recommendation

1. An appropriate suite of models has been selected for use, where processes that require a high level of resolution (such as brine discharge) over a relatively small area are linked with those occurring at far larger spatial and time scales. The ability of the modelling system to realistically represent DO concentrations in the water column is of intrinsic importance.

2. The models used are all recognised to be current state of the art and have been effectively applied in similar environments elsewhere

2.2 Model Calibration

The review of the first validation draft report identified the following matters requiring further consideration.

- Representation of local wind field
- Model resolution close to the sea floor
- Sensitivity analysis of model parameters to better represent horizontal momentum transfer
- Clarification of selection of values used for sediment oxygen demand (SOD)
- Analysis of information relating to existing brine discharge from PSDP1 to assist model validation

In response, BMT undertook a series of modelling runs to assess the sensitivity of various model parameters on model results. Model results were compared with water level predictions at Mangles Bay and current velocity conditions at the Spoil Grounds and Northern Basin.

Model parameters assessed for sensitivity were:

- The representation of the local wind field across Cockburn Sound, by comparing the use of the CFS2 generated wind field with the use of BOM Garden Island measured wind data.
- Effects of bottom roughness in the range from 0.02 m to 0.0002 m.
- In addition the model was adjusted to include
    - Increase in model vertical resolution to 0.5 m between -3.0 and -22.0 m AHD
    - Update of model bathymetry using the average of DEM values within each model (horizontal) cell.

Model results showed that the use of the measured and more localised BOM Garden Island wind field rather than the inferred/computed CSF2 wind field improved the correlation between measured and modelled results. The PRP noted BMTs comments that this modified wind field also improved the representation of the vertical transfer of wind derived momentum at the Spoil Ground site producing higher bottom velocities correlating closely with measured values. In addition it was noted that the model is not substantially sensitive to bottom roughness at the locations modelled.

Based on these observations BMT has proposed that the most suitable model for representation of the hydrodynamics of the Cockburn Sound area are best represented by a revised CFS model, termed the G1 model, with the incorporation of the wind field derived from the Garden Island BOM site. No changes in the representation of bottom roughness are proposed.

In addition the G1 model included higher vertical resolution and updated bathymetry.

The model and modelling also adequately simulated the existing desalination discharge and related plume dynamics in the near-field (port/jet mixing) and mid-field zones. The dynamics of the near-mid field mixed desalination discharge water along the Calista/Stirling channels en-route to the deeper basin were well resolved by the model.

At this stage the significantly diluted plume is subjected to movement principally under

I. its own density difference for propagation away as a gravity current(s) and/or
II. by wind driven currents (when the wind driven processes dominate over gravity current dynamics); and that
III. once the plume enters the wider (deeper) Cockburn Sound region the dynamics are more complex and more difficult to both characterise and model to the same level of confidence as in the near-mid field plume regions; and hence
IV. Under the addition of increased discharge via PSDP2, it is recommended that further characterisation be undertaken to resolve the dynamical interaction between the discharge and receiving environment of Cockburn Sound, through field and associated modelling studies.

Conclusion and Recommendations

1. The PRP advises that the G1 model as described is fit for purpose for the task assigned, which is to represent the hydrodynamic and water quality features and processes occurring within Cockburn Sound and subsequently for use to represent the dilution, advection and dispersion of an additional brine discharge, as well as the levels of dissolved oxygen particularly in bottom waters.

3. PEER REVIEW - SCENARIO MODELING REPORT

Conclusion and Recommendations

1. The PRP advises that the suit of models, the results of simulations and their interpretation will provide a reliable and effective tool for the understanding of any increase of brine discharge to the Sound and to assess the impacts of an increased discharge.

2. The PRP notes that field measurements collected over a number of years have not shown a measurable association between the current desalination discharge and the incidence of stratification and oxygen depletion in the deeper waters of CS which have been well simulated by the model.

3. Simulations show that as desalination capacity is increased, there is an expected increase in penetration of higher salinity water from the discharge into the deeper basin albeit at a moderately elevated level. It is recommended that the WC address this potential manifestation to the salinity and density structure of the Sound through an appropriate measurement program.