

Angus Place and Springvale Mine Extension Projects

SPRINGVALE COAL PTY LTD

Additional Simulations of the Regional Water Quality Impact Assessment Model

IA059800 | 002c

26 March 2015

Document history and status

Revision	Date	Description	By	Review	Approved
A	08/03/2015	Preliminary Draft for Discussion	Dr Justin Bell	n/a	n/a
B	13/03/2015	Draft Report for Review	Dr Justin Bell	n/a	n/a
C	26/03/2015	Final Report	Dr Justin Bell	RC	RC

Distribution of copies

Revision	Issue approved	Date issued	Issued to	Comments
A	08/03/2015	08/03/2015	Client	Preliminary Draft for Discussion
B	13/03/2015	13/03/2015	Client	Draft Report for Review
C	26/03/2015	26/03/2015	Client	Final Report

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Project no: IA059800
Document title: Additional Simulations of the Regional Water Quality Impact Assessment Model
Document no: IA059800
Revision: 002c
Date: 26 March 2015
Client name: Springvale Coal Pty Ltd
Client no:
Project manager: Project Manager
Author: Dr Justin Bell
File name: I:\ENVR\Projects\IA059800\Deliverables\Reports\002c.docx

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Executive Summary

Centennial's Regional Water Quality Impact Assessment Model (RWQIAM) for the Coxs River and Wollondilly River catchments has been updated. The model update comprised refinement of model calibration, new sensitivity analysis conditions, updated model predictions following calibration, uncertainty analyses as well as a range of End of Pipe targets and Treatment Option simulations.

Details as to assumptions underpinning the calculations presented below are contained within the report.

An evaluation of a range of End of Pipe targets is presented from 350 μ S/cm to 900 μ S/cm. Modelling indicates that an End of Pipe target of 900 μ S/cm will lead to a water quality in Lake Lyell that is consistent with historical observation, whereas an End of Pipe target of 350 μ S/cm will lead to a water quality in Lake Lyell that is well below that experienced in the last 15 years.

Model calculation of volumetric treatment requirement under a potential 350 μ S/cm End of Pipe Target is up to 34.5ML/d in 2023, considering concurrent implementation of extension to Angus Place Colliery and Springvale Mine. If considering sequential implementation of Springvale Mine and then Angus Place Colliery, modelled treatment requirement is up to 25.9ML/d in 2023. This level of treatment is prohibitively expensive and impracticable due to the magnitude of pre-treatment that would be required. Model calculation of treatment requirement under a potential End of Pipe target of 900 μ S/cm is up to 12.1ML/d (concurrent implementation) or 9.1ML/d (sequential implementation).

Modelling indicates an End of Pipe Target of 900 μ S/cm (equivalent to 603mg/L assuming a conversion factor of 0.67) leads to a predicted salinity in Lake Lyell that is less than 450mg/L (670 μ S/cm) and is well below historical maximum of 634mg/L (950 μ S/cm). The equivalent maximum for an End of Pipe target of 350 μ S/cm is 366mg/L (550 μ S/cm).

There are several potential options that could be applied to mine water treatment in the Upper Coxs River catchment. Two potential Treatment Options have been assessed and include translocation of mine water discharge at Clarence Colliery from the Wollangambe River to the Coxs River at Springvale, and continuous treatment at a fixed rate of 6ML/d.

Modelling indicates that simulation of mine water discharge from Clarence, combined with continuous treatment at a fixed rate of 6ML/d, leads to a predicted salinity in Lake Lyell of less than 460mg/L (685 μ S/cm). This is essentially equivalent to the End of Pipe target of 900 μ S/cm. It is highlighted, however, that volumetric discharge to the Coxs River will be higher under this scenario, with discharge from Clarence increasing from 13.7ML/d currently to 19ML/d in 2024 and maintained at that level through to end of simulation.

Updated predicted increase in salinity in Lake Burragorang due to the Proposal, without treatment, is an increase from modelled median of 98mg/L in the null case to 104mg/L (concurrent implementation) or 103mg/L (sequential implementation) under median rainfall conditions. This is equivalent to an increase of 6% and 5% respectively and accordingly is considered to have neutral impact to water quality since the predicted increase in salinity is minimal.

Predicted increase in salinity in Lake Burragorang in a simulation of mine water discharge from Clarence, combined with continuous treatment at a fixed rate of 6ML/d, is an increase from modelled median salinity of 98mg/L in the null case to 104mg/L (consecutive implementation) and 103mg/L (sequential implementation). This is equivalent to the without treatment case and is due to the magnitude of discharge at Clarence (up to 19ML/d) when combined with proposed discharge from Angus Place Colliery and Springvale Mine, compared to the assumed salinity of runoff from each sub-catchment. The predicted increase in salinity under this scenario is an increase of 6% and 5% respectively and accordingly is again considered to have neutral impact to water quality since the predicted increase in salinity is minimal.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to undertake and report on additional simulations of the Regional Water Quality Impact Assessment Model that is being used to assess potential impacts to flow and quality (salinity) in the Cocks River catchment of various water management strategy options in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

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1. Introduction

1.1 Purpose of Report

Jacobs Group (Australia) Pty Ltd has prepared this report for Springvale Coal Pty Ltd (Springvale) and Centennial Angus Place Pty Ltd (Angus Place).

The objective of this report is to present the outcomes of additional simulations of Centennial's Regional Water Quality Impact Assessment Model (RWQIAM) (RPS, 2014a). These additional simulations consider predicted salinity in Lake Lyell, and downstream to Lake Burragorang, under a range of 'End of Pipe' treatment options. The impact of potential supply from Centennial Clarence Colliery (Clarence) to the Coxs River is also presented.

In addition, an update to the model calibration is presented, along with outcomes of sensitivity analysis. Accordingly, updated prediction results are presented as well as updated uncertainty analyses. These refinements were undertaken in response to comments received from the NSW Office of Environment and Heritage and Sydney Catchment Authority on Centennial's Response to Submissions in regard to their Environmental Impact Statements (EISs) for Angus Place Colliery and Springvale Mine Extension Projects. Advice prepared by Jacobs to Centennial on these issues is presented in Jacobs (2014).

1.2 Layout of the Report

This report should be read in conjunction with Centennial's response to comments received from the NSW Office of Environment and Heritage (NSW EPA, 2014) and Sydney Catchment Authority (SCA, 2014) on the RWQIAM (including Jacobs, 2014), the original RWQIAM report (RPS, 2014a) and the Surface Water Impact Assessment prepared for the Angus Place Mine Extension Project (RPS, 2014b) and Springvale Mine Extension Project (RPS, 2014c).

- Chapter 1 – presents an introduction as to the purpose of this report
- Chapter 2 – presents relevant details of the Clarence option. Detailed description of the surface water environment in the Coxs River is presented in the Surface Water Impact Assessment and original RWQIAM report and is not repeated
- Chapter 3 – presents the modification to the water quality model, as relevant, as well as the updated calibration, the sensitivity analysis, updated predictions including potential treatment options, and updated uncertainty analysis
- Chapter 4 – presents a summary of model outcomes
- Chapter 5 – presents relevant references.

2. Background

2.1 Study Area and Surface Water Environment

The water quality model encompasses all catchments contributing to Lake Burragorang, including the Coxs River catchment, which lies to the north of Lake Burragorang and is the uppermost catchment.

The Coxs River catchment comprises mixed land-uses including natural vegetation, dryland farming / cleared pasture, urban areas and heavy industry.

2.2 Clarence Colliery

Clarence Colliery lies within the Colo River Management Zone of the Water Sharing Plan of the Greater Metropolitan Region Unregulated River Water Sources 2011 and currently is approved and licenced, following treatment, to discharge mine water make to the Wollangambe River via its Environmental Protection Licence (EPL) No. 726, at Licensed Discharge Point, LDP002. The Wollangambe River lies within the Hawkesbury and Lower Nepean River Extraction Management Unit and as such is outside of the Sydney Drinking Water Catchment (Water NSW Act 2014).

Water quality of mine water make at Clarence is fresh, with salinity, as Electrical Conductivity (EC), of approximately 400 μ S/cm (268mg/L as TDS, if conversion between EC and TDS is assumed to be 0.67). pH of this water is near neutral.

Figure 2.1 presents the modelled time-series change in mine water make at Clarence between 1 July 2014 and 31 December 2032, being the period of the prediction simulation. It is noted that mining at Clarence continues beyond 31 December 2032.

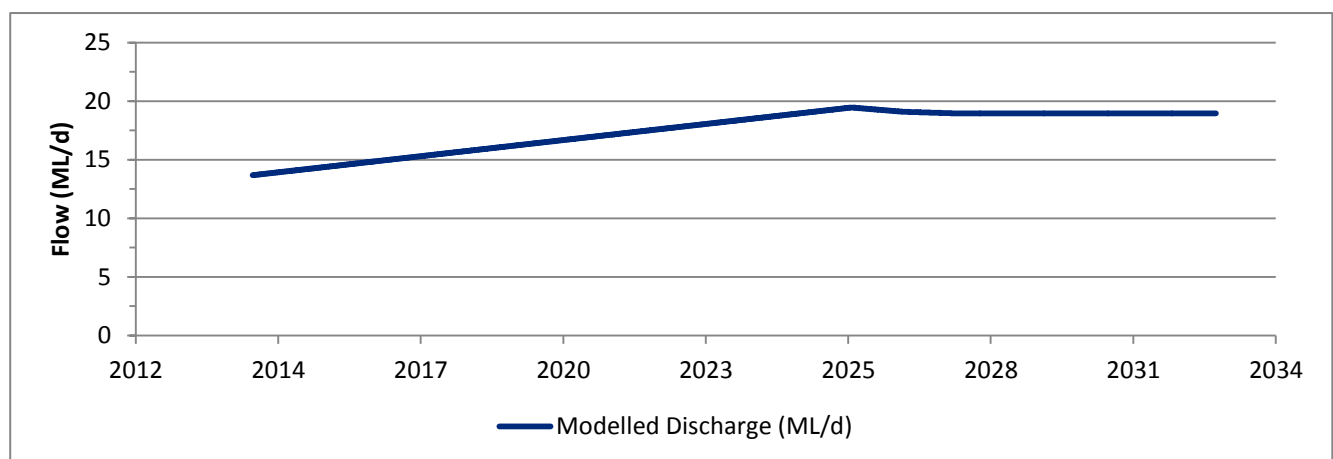


Figure 2.1 : Modelled Mine Water Make at Clarence during the Model Prediction Period (ML/d)

It is highlighted that there is currently treatment of Fe and Mn at Clarence, prior to disposal. The RWQIAM is a salt mass balance model and as such, the treatment requirement for Fe and Mn, should mine water make at Clarence be supplied to the Coxs River, is presented elsewhere, in the treatment option assessment report.

3. Modelling

3.1 Model Setup

3.1.1 Model Approach

The water quality model presented herein is based on the rainfall-runoff model Australian Water Balance Model (AWBM) by Walter Boughton (Boughton, 2010), coupled to simple mass flux to allow calculation of concentration (salinity as TDS, mg/L) in a spatially and temporally distributed manner. The AWBM is a rainfall excess model and has been used extensively in Australia to model surface runoff, interflow and baseflow in surface water courses. The structure of the AWBM is presented in RPS (2014a) and is repeated below in Figure 3.1 for the purpose of reference. Further detail on the AWBM is presented in RPS (2014a).

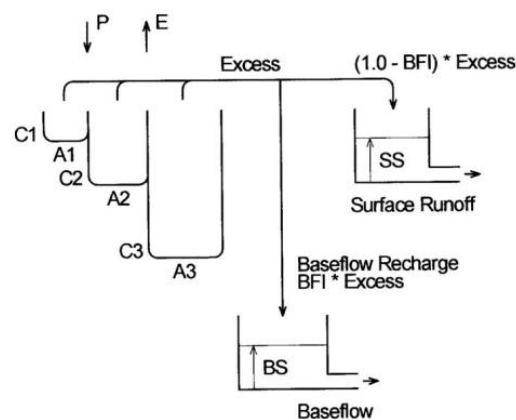


Figure 3.1 : Structure of the AWBM (after Boughton, 2010)

3.1.2 Overview of Changes

During update of the RWQIAM, the following refinements were undertaken. Details of each of these refinements are presented below.

- Rainfall
 - Update from manual patching method of daily rainfall to an in-house automated processing based approach, validated against and supplemented by SILO data, where required
- Evaporation
 - Resolved discrepancy in selected evaporation station and upgraded to spatially distributed evaporation
 - Update from monthly mean daily rainfall to historical daily and daily predicted from climatic records, again based on an in-house automated processing approach, validated against and supplemented by SILO data, where required
- Model Geometry
 - Resolved unintended activation of release from and recirculation to Thompsons Creek Reservoir
 - Amended approach to minimum flow from assumed concentration of 50mg/L, if flow was zero, to minimum flow being 0.001ML/d
- Model Calibration

- Updated calibration parameters with respect to assumed land-use salinities, baseflow index and average surface soil storage capacities
- Sensitivity Analysis
 - Undertook sensitivity analysis (three scenarios)
- Model Predictions
 - Evaluated impact of Sequential Implementation of Springvale and Angus Place projects
 - Evaluated Clarence as a potential water supply to the Cocks River
 - Evaluated potential 'End of Pipe' targets for the various water management strategies
 - Evaluated impact of RO treatment at a fixed capacity of 6ML/d
 - Combinations of the above options, as relevant.
- Uncertainty Analysis
 - Undertook additional uncertainty analysis simulations (four scenarios)

3.1.2.1 Rainfall

The rainfall stations used in the RWQIAM are presented in Table 3.1 of RPS (2014a). The spatial distribution of rainfall stations was not altered in the update to the model.

Historic daily rainfall used in the RWQIAM has been processed by a suite of in-house programs developed by Jacobs (formerly Sinclair Knight Merz, SKM) to generate a continuous time-series. The historic input data to this processing is the Bureau of Meteorology (BOM) Australian Rainfall and produced by the National Climate Centre, Melbourne. Processing is achieved through disaggregation of accumulated data and infilling of missing data, both through relationships developed with neighbouring gauges.

3.1.2.2 Evaporation

The evaporation data used in the water quality model was updated from monthly mean daily from BOM Station No. 061089 (Scone SCS) to a spatially distributed historical daily record. Table 3.1 presents the evaporation stations used in the updated model. It is noted that the use of the BOM Station at Scone was an error in the previous version of the RWQIAM. The BOM Station at Bathurst was intended to have been used.

Historic daily evaporation used in the RWQIAM has been processed by a suite of in-house programs to generate a continuous time-series. The historic input data to this processing is the BOM Rainfall record. Processing is achieved through disaggregation of accumulated data and infilling of missing data, both through relationships developed with neighbouring gauges.

This time-series was supplemented from the SILO dataset where required. The SILO dataset is disaggregated and infilled via a gridded approach, where necessary, and adopts long-term averages where no data is available and extrapolation from adjacent sites is infeasible.

Table 3.1 : Evaporation Stations in the Water Quality Model

BOM ID	Station Name	BOM ID	Station Name
63036	OBERON (JENOLAN CAVES)	68045	MOSS VALE (HOSKINS STREET)
63048	LITTLE HARTLEY (SHEEPCOMBE)	68051	PENROSE (PANORAMA)
63224	LITHGOW (BIRDWOOD ST)	70080	TARALGA POST OFFICE
63227	WENTWORTH FALLS COUNTRY CLUB	70263	GOULBURN TAFE
68044	MITTAGONG (ALFRED STREET)	70313	TARAGO (WOODLAWN MINES)

3.1.2.3 Assumed Concentration When Flow is Zero

As presented in Section 3.1.1 of RPS (2014a), salt concentration (mg/L) was calculated by dividing mass flux (kg/d) by water flow (ML/d). So as to avoid a 'division-by-zero' error, in the previous version of the model, concentration was set to 50mg/L when water flow was 0ML/d. The assumption is not relevant to modelled salinity within reservoirs and only refers to handling of concentration calculation where baseflow store reduces to zero. The purpose of the statement was for documentation of an internal assumption for a future user of the model and was not intended to hold particular significance. To resolve potential ambiguity, the approach to dealing with the 'division-by-zero' error was amended.

Salt concentration is calculated in the water quality model by mass flux divided by water flow. When water flow is 0ML/d, reflecting complete dissipation of the baseflow store in the relevant sub-catchment AWBM module, flow is instead set at 0.001ML/d, equivalent to 0.01L/s. Accordingly, salt concentration can now be calculated as per the normal method, without requiring the previous assumption of 50mg/L.

3.1.2.4 Release from and Recirculation to Thompsons Creek Reservoir

As indicated in the comments by NSW Office of Environment and Heritage (NSW EPA, 2014) on the original RWQIAM, there was a disparity in median flows as measured at NSW Office of Water Station No. 212054. The cause of the disparity has been resolved and, as stated in Centennial's response to NSW Office of Environment and Heritage (including Jacobs, 2014), the issue was active in both the prediction simulation and prediction null case and therefore did not invalidate predicted impacts.

The disparity was mostly due to an unintended activation of release from and recirculation to Thompsons Creek Reservoir. The objective of the programmed logic was to emulate balancing of stored volumes in each reservoir; however, the approach did not function as intended and created a 'circular loop' type error. As stated, the consequence of this issue on predicted impacts was not significant since the issue was active in both the prediction simulation and prediction null case simulations. Additional changes to the model assisted in refining the calibration and included update to rainfall and evaporation datasets as presented above. A refinement of AWBM rainfall-runoff parameters was also undertaken and is discussed below.

3.1.2.5 Energy Australia LDP004

During refinement of model calibration, there was a minor change to the location of the Cooling Tower discharge from Wallerawang Power Station in the water quality model. In the previous version of the model, this discharge was applied to Node #172, which is located below the NSW Office of Water Station No. 212008. Review of model output at this location, when compared to the flow gauge station, implied that discharge is occurring upstream of the gauge, therefore the LDP004 discharge was reassigned to Node #032, which corresponds to the location of the gauging station in the model.

The record of discharge from LDP004 was available from January 2006 through to June 2014. Unit 8 at Wallerawang Power Station closed in April 2014. For the period 1979 through to 2005, discharge to LDP004 was synthesised by sampling the available historical record, whilst applying a linearly increasing scaling factor, ranging from 0.02 to 0.60, to attempt to account for typical variability in discharge and presumably lower discharge in the past. The assumed value of linear factors was refined during model calibration.

Similarly, there was only a limited record, in particular during the early period of the calibration simulation, of salinity of discharge at LDP004. The salinity of this discharge was therefore assumed where no data existed and applied in a time-varying manner.

Figure 3.2 presents the assumed discharge and salinity from EnergyAustralia LDP004.

As indicated in Section 2.3 of RPS (2014a), Cooling Tower blowdown at Wallerawang Power Station was discharged to Lake Wallace (EnergyAustralia LDP001 and LDP021) but the majority was discharged below Lake Wallace (EnergyAustralia LDP004). At Node #086, upstream of Lake Wallace, there was discharge from

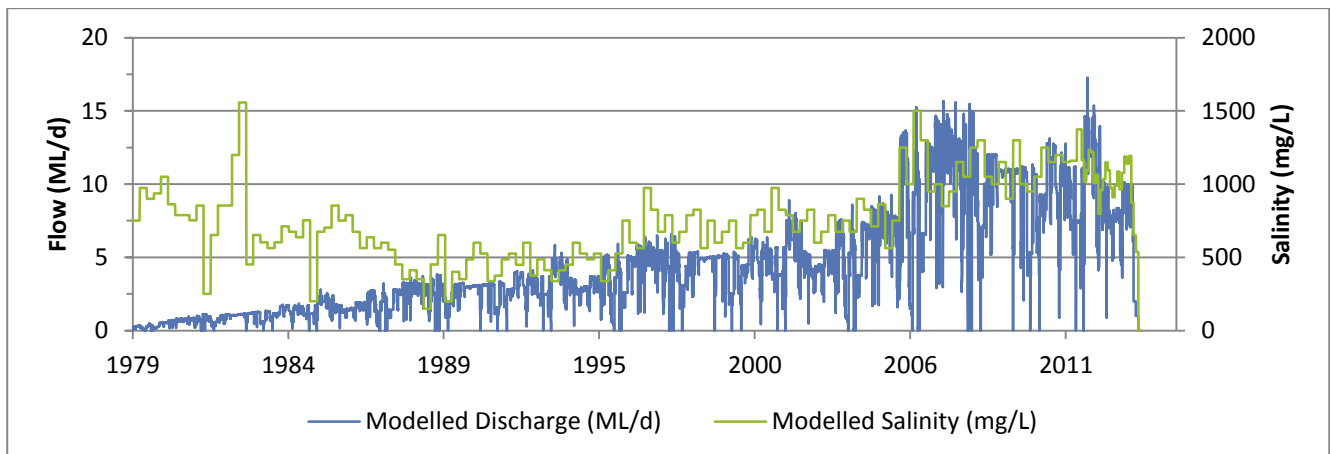


Figure 3.2 : Assumed Discharge and Salinity of EnergyAustralia LDP004 in the Water Quality Model

EnergyAustralia LDP001, based on available record and was extrapolated as required. EnergyAustralia LDP001 was included in the previous model and was not changed in the current model. EnergyAustralia LDP021 is an emergency discharge location and was not included in the model. The available record indicates flow ranging from 0ML/d up to 15ML/d on a sporadic basis, with salinity of ~1000mg/L. This may partially account for observed under-prediction of salinity in Lake Wallace in the water quality model.

3.1.2.6 Historical Discharge from Angus Place LDP001

Continuous flow gauging of Angus Place LDP001 was available from September 2010 onward. In the previous version of the water quality model, there was a simplified assumption as to historical discharge, namely:

- 2ML/d in January 1979, linearly increasing to 5ML/d in June 2007
- 2ML/d in July 2007, linearly increasing to 3ML/d in September 2010.

With respect to salinity, it was assumed in the previous model that salt was 250mg/L in January 1979 and increased linearly to 804mg/L in September 2010.

The previous assumption has been refined and now is based on re-sampling of available record, with a linearly increasing scaling factor. A similar approach was adopted for the assumed salinity.

Figure 3.3 presents the assumed discharge and salinity at Angus Place LDP001. As will be presented below, these amendments improved the fit of modelled salinity against observed salinity in the Coxs River, at Node #056; however, the model is still quite conservative in the 1980s. This suggests that the assumed flow and salinity of historical discharge at Angus Place LDP001 could be refined further.

3.1.2.7 Historical Discharge from Springvale LDP009

It is noted that discharge at EnergyAustralia LDP020 and Springvale LDP009 was not updated from the previous version of the model. These discharge locations refer to discharge to Sawyers Swamp Creek when mine water from the Springvale Delta Water Transfer Scheme (SDWTS) was not required at Wallerawang Power Station. Discharge data was reconstructed from historical records, as available, from 2006.

3.1.2.8 Assumed Seepage at Mt Piper Power Station

As presented in Section 3.2.3 of RPS (2014), an assumed seepage to Wangcol Creek was applied adjacent the Brine-Conditioned Ash Placement Facility at Mt Piper Power Station. The rate of seepage in the previous version of the water quality model was set at 5% of modelled water demand at Mt Piper Power Station. In an

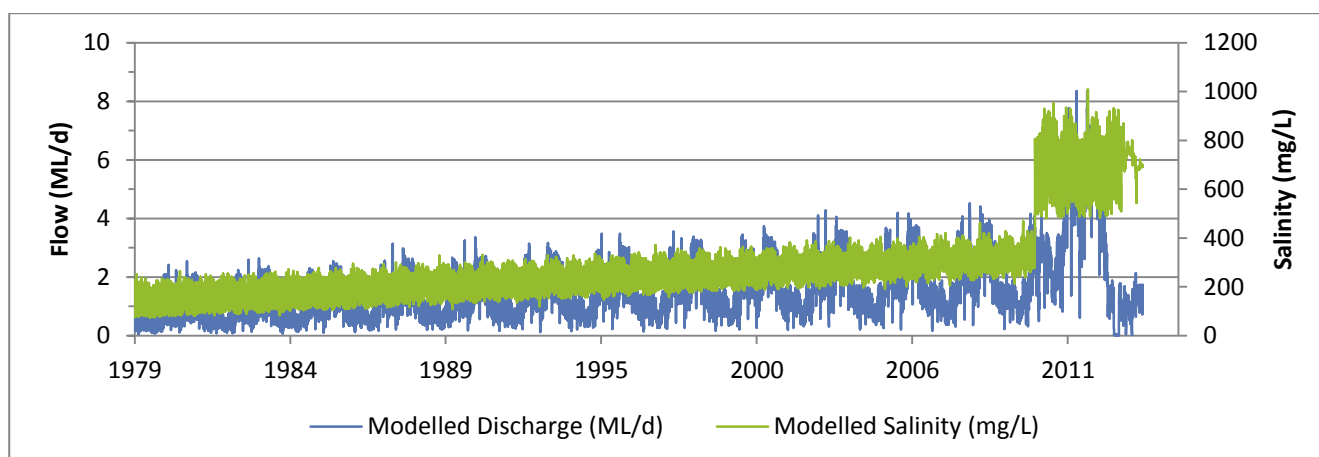


Figure 3.3 : Assumed Discharge and Salinity of Angus Place LDP001 in the Water Quality Model

interim version of the water quality model, this assumption was disabled in order to improve the fit to flow gauge data at NSW Office of Water Station No. 212055; however, this change led to a decrease in the quality of fit to observed salinity data. The assumed seepage rate and concentration was therefore retained in the current version of the water quality model, although it appears that the seepage rate may be overestimated. The impact of this assumption is not significant with respect to predicted salinity in Lake Wallace and Lake Lyell due to the proposed mine extensions and may be refined at a later stage. The large increase in salinity in 2014 was not replicated by either version of the model and is suggested to be due to activity other than usual rainfall-runoff processes.

3.1.2.9 Surge Tank

A minor amendment was made to the operation of the Surge Tank in the RWQIAM. In the previous version, the Surge Tank, which is understood to have a capacity of 95ML/d, it was assumed that the full pump capacity would be directed to either Lake Wallace or the Valve House below Thompsons Creek Reservoir. In the updated model, this was amended so that the pump was either on or off to Lake Wallace, with an assumed 'capacity' of 40ML/d; and the pump was either on or off to the Valve House, with an assumed 'capacity' of 55ML/d. Prior to 1990, pump capacity to Lake Wallace was set to be on or off at 95ML/d. There was no difference in intent of this pumping apparatus in the model; however, it operated more smoothly in the refined approach. It is noted that the updated configuration was also retained for the prediction simulation, where Wallerawang Power Station was offline, such that the full storage volume of Lake Wallace was maintained.

3.2 Model Calibration

3.2.1 Calibration Parameters

In addition to the changes identified in Section 3.1 above, there was amendment to assumed land-use salinities, baseflow separation index in AWBM and average surface storage capacity in AWBM during refinement of model calibration. There was no change to model geometry in regard to assignment of land-use type to various model sub-catchments. Changes to climatic data inputs are presented in Section 3.1.

Table 3.2 presents the updated values of the calibration parameters.

Table 3.2 : Calibrated AWBM and Water Quality Parameters

Land-Use	C1 (mm)	C2 (mm)	C3 (mm)	Cave ¹ (mm)	BFI ²	Kb ²	Ks ²	Concn ³ (mg/L)
Natural	12.5	128.0	256.0	168	0.25	0.98	0.3	50
Pasture	14.3	146.3	292.7	192	0.25	0.98	0.3	150
Urban	2.0	20.6	41.2	27	0.25	0.98	0.6	400
Disturbed	5.6	60.2	120.4	79	0.25	0.98	0.3	600
Channel	2.0	20.6	41.2	27	0.25	0.98	0.6	325

1. Assumed pattern of distribution of partial areas is A1 = 0.134, A2 = 0.433, A3 = 0.433 for all land-use classes; 2. BFI is Baseflow Index, Kb is daily baseflow recession constant and Ks is daily surface recession constant; 3. Concn is assumed runoff salinity from each land-use class.

It is highlighted that the assumed land-use salinities are higher for Pasture, Urban, Disturbed and Channel than the previous version of the RWQIAM. The assumed salinity for Natural land-use was not changed. As will be presented below, model calibration suggests these higher salinity values are satisfactory with respect to matching the observed salinity record in the Coxs River and Lake Lyell. A sensitivity analysis scenario with respect to salinity was undertaken to test the veracity of this statement.

The changes from previous values of the AWBM pertain to improved fit to flow monitoring data at Node #047, corresponding to NSW Office of Water Station No. 212054, and other gauging stations listed in Table 3.3 of RPS (2014a). In general, baseflow index has been set at 0.25 for all land-use classes. It was previously set to 0.0 for non-Natural land-use. This meant that there was no partitioning to baseflow store. The baseflow storage recession constant was set to 0.98 for all land-uses from 0.981 for Natural, and 1.0 for other land-uses. Due to there being no partitioning to baseflow store, the previously adopted values for non-Natural baseflow storage recession constants were arbitrary. The surface storage recession constant was set at 0.3, except for Urban and Channel land-use, which were set at 0.6 instead.

It is noted that an initial condition was also applied to the baseflow store of 10% of the average surface storage capacity. An initial condition was also applied to the three surface storages, being 50% of the average surface storage capacity, distributed according to assumed partial areas. The initial conditions adopted for prediction simulations were the baseflow store and three surface storage values at the end of the calibration simulation for each AWBM module.

3.2.2 Calibration Approach

The observation dataset for salinity, in particular in the early part of the calibration simulation, was not as extensive as that available with respect to flow. The calibration approach therefore focussed on matching historical salinity in Lake Lyell, as a first priority, and then secondarily at gauging stations and Lake Wallace.

Figure 3.4 presents the configuration of the GoldSIM model at Node #047, for the purpose of illustration. Node #047, which is typical, also corresponds with the location of NSW Office of Water Station No. 212054.

From Figure 3.4, runoff (mm/d) is calculated in the AWBM module (cloned, based on land-use and rainfall) and used to calculate flow in ML/d by multiplying by sub-catchment area, 'Area'. A minimum flow of 0.001ML/d is applied to 'Water' in expression 'Water1'. Mass flux, 'Mass', is calculated by multiplying assumed land-use catchment salinity (which is stated in the AWBM module as simple data) by flow, represented by 'Water1'. Concentration, 'Concn', is mass flux, 'Mass' divided by flow, 'Water1'.

These calculations are then compared to observation at this location via a chart.

It is noted that comments received from NSW Office of Environment and Heritage and Sydney Catchment

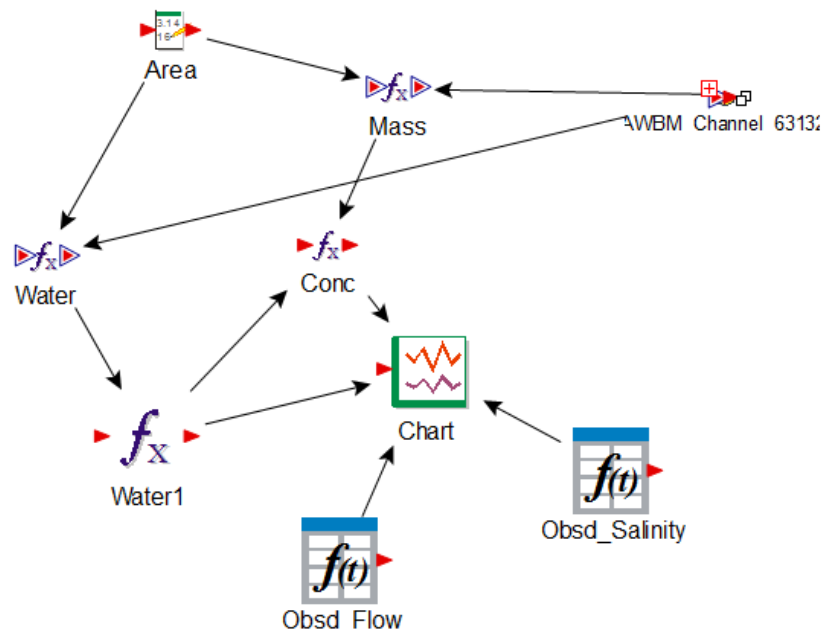


Figure 3.4 : Typical Configuration of the GoldSIM model (Node #047)

Authority in regard to presentation of calibration results have been taken into account, as well as with respect to the outcomes of prediction simulations.

3.2.3 Calibration Results

The model control file pertaining to the updated calibration simulation is:

- 002a_CAL-Jun14_04aa.gsm

Kangaroo Creek and Coxs River above Wangcol Creek / Blue Lagoon

Figure 3.5 presents the calibration time-series model output at Node #011, which corresponds with Angus Place monitoring station, Kangaroo Creek Downstream. As noted in RPS (2014a), water quality upstream of point of discharge in Kangaroo Creek is assumed to be 50mg/L. There is a short monitoring record of salinity at Node #011, with 69 observations. A direct comparison between observed and modelled salinity was prepared and is presented in Figure 3.6 as a distribution plot. Table 3.3 presents a summary of that comparison.

From Figure 3.5, there is reasonable fit between modelled and available observation data and the distribution plot in Figure 3.6 indicates the model is slightly under-predicting the median salinity, with 500mg/L from the model compared to 612mg/L from the observation record. The shape of the distribution presented in Figure 3.6 is appropriately captured by the model.

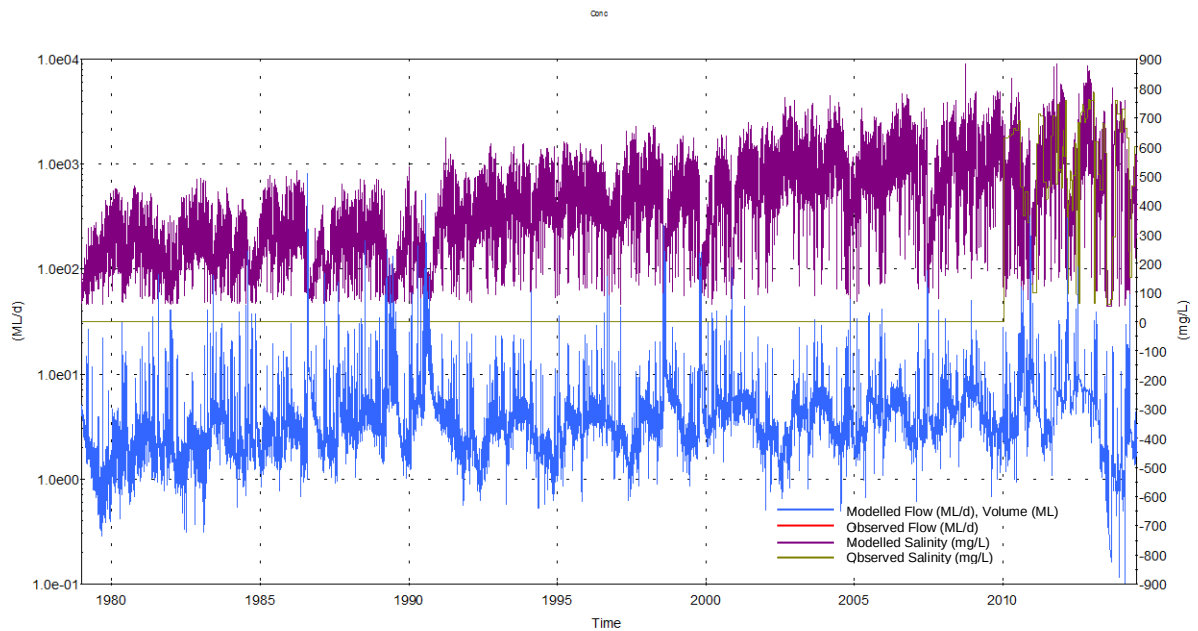


Figure 3.5 : Calibration Time-Series Chart at #011 (Kangaroo Creek, downstream of Angus Place LDP001)

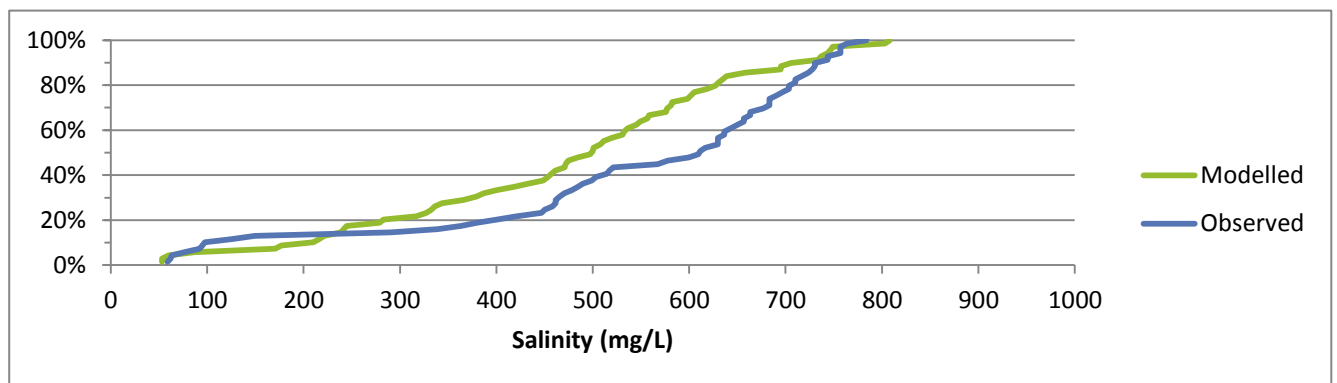


Figure 3.6 : Calibration Distribution Plot at #011 (Kangaroo Creek, downstream of Angus Place LDP001)

Table 3.3 : Calibration Daily Statistics at #011 (Kangaroo Creek, downstream of Angus Place LDP001)

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	n/a	n/a	59	53
5%	n/a	n/a	83	120
10%	n/a	n/a	120	215
20%	n/a	n/a	413	303
50%	n/a	n/a	612	500
80%	n/a	n/a	706	629
90%	n/a	n/a	733	711
95%	n/a	n/a	757	746
Maximum	n/a	n/a	784 (n=69)	808 (n=69)

Figure 3.7 presents time-series output at Node #056, which is located on the Coxs River above Wangcol Creek. This location corresponds with Angus Place monitoring location, AP_COXS_DOWNSTREAM. Figure 3.8 presents the distribution plot of modelled and observed salinity.

As indicated above, the distribution plot was prepared by direct comparison of model results and observations on equivalent days. The distribution plot is summarised in Table 3.4.

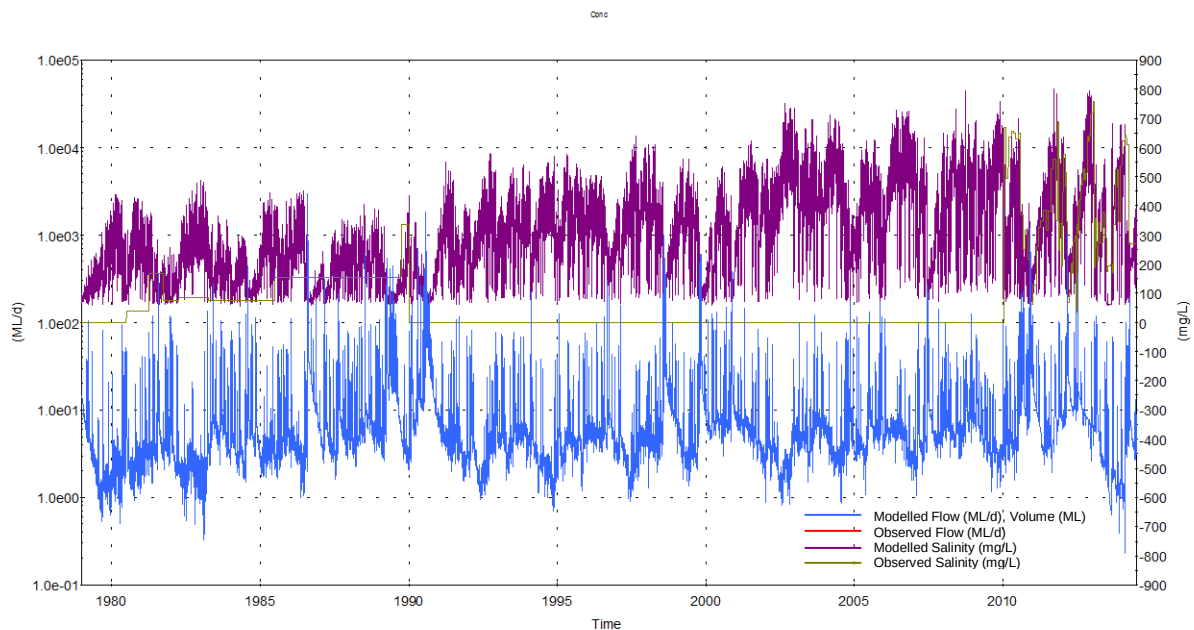


Figure 3.7 : Calibration Time-Series Chart at #056 (Coxs River above Wangcol Creek / Blue Lagoon)

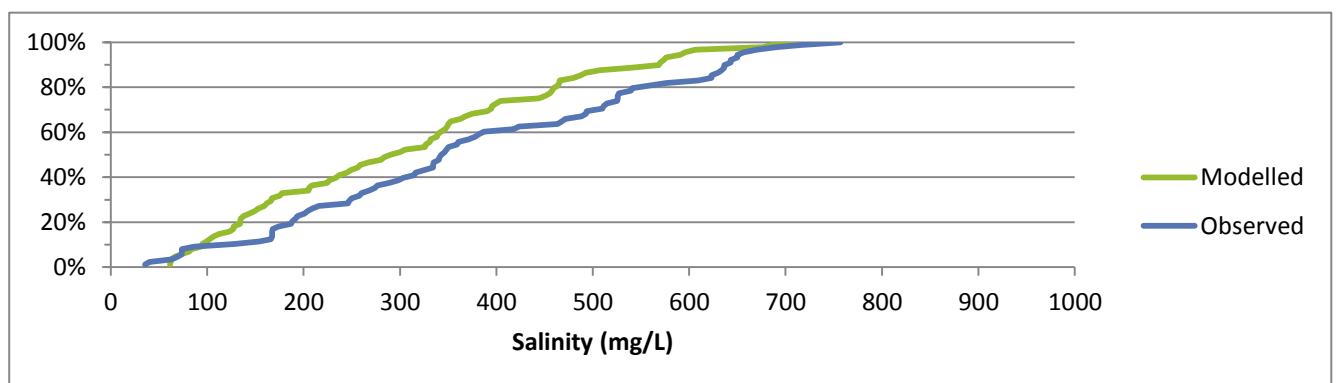


Figure 3.8 : Calibration Distribution Plot at #056 (Coxs River above Wangcol Creek / Blue Lagoon)

Table 3.4 : Calibration Daily Statistics at #056 (Coxs River above Wangcol Creek / Blue Lagoon)

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	n/a	n/a	36	62
5%	n/a	n/a	74	76
10%	n/a	n/a	146	98
20%	n/a	n/a	190	134
50%	n/a	n/a	345	295
80%	n/a	n/a	552	462
90%	n/a	n/a	639	569
95%	n/a	n/a	654	594
Maximum	n/a	n/a	757 (n=88)	736 (n=88)

From Figure 3.7, there is reasonable agreement between modelled and observed salinity with respect to the period 2010 to 2014, when the majority of observations are available. Figure 3.7 suggests the assumed salinity of discharge at Angus Place LDP001 in the 1980s is still too high. From Table 3.4, median modelled salinity is 295mg/L, compared to the median of available observations of 345mg/L.

Wangcol Creek

There a monitoring gauge at Node #105, NSW Office of Water Station No. 212055. Figure 3.9 presents the time-series calibration model results at this location. The distribution plot is presented in Figure 3.10 and is summarised in Table 3.5.

As discussed in Section 3.1 above, there is an assumed seepage from the Brine Conditioned Ash Placement

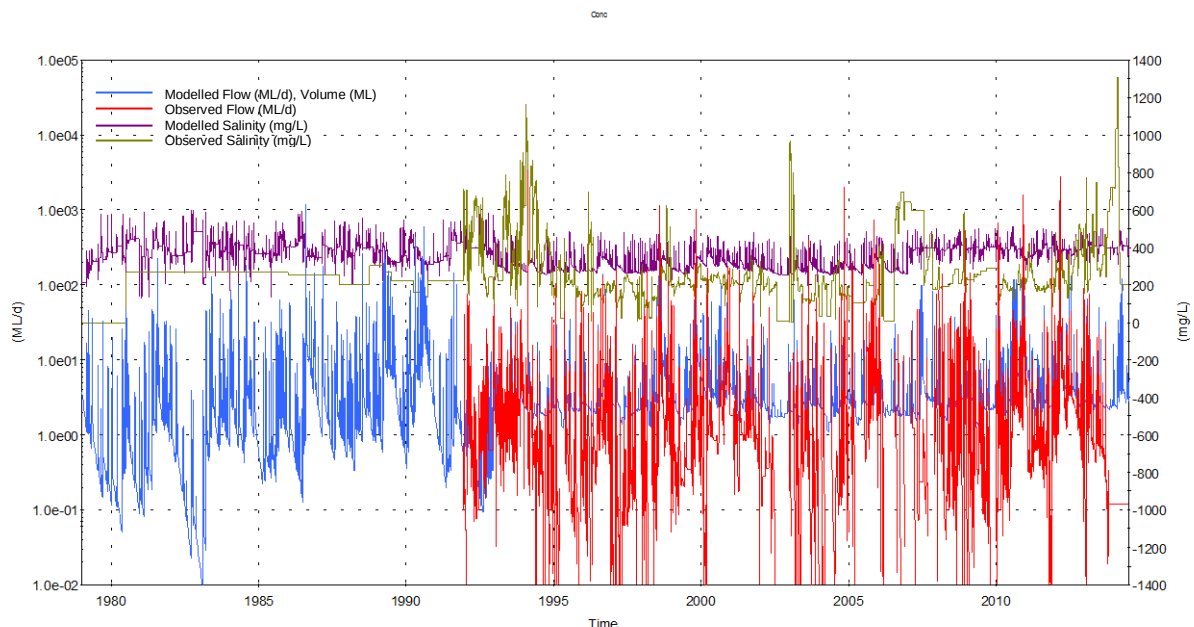


Figure 3.9 : Calibration Time-Series Chart at #105 (Wangcol Creek above Western Coal Services, Gauge No. 212055)

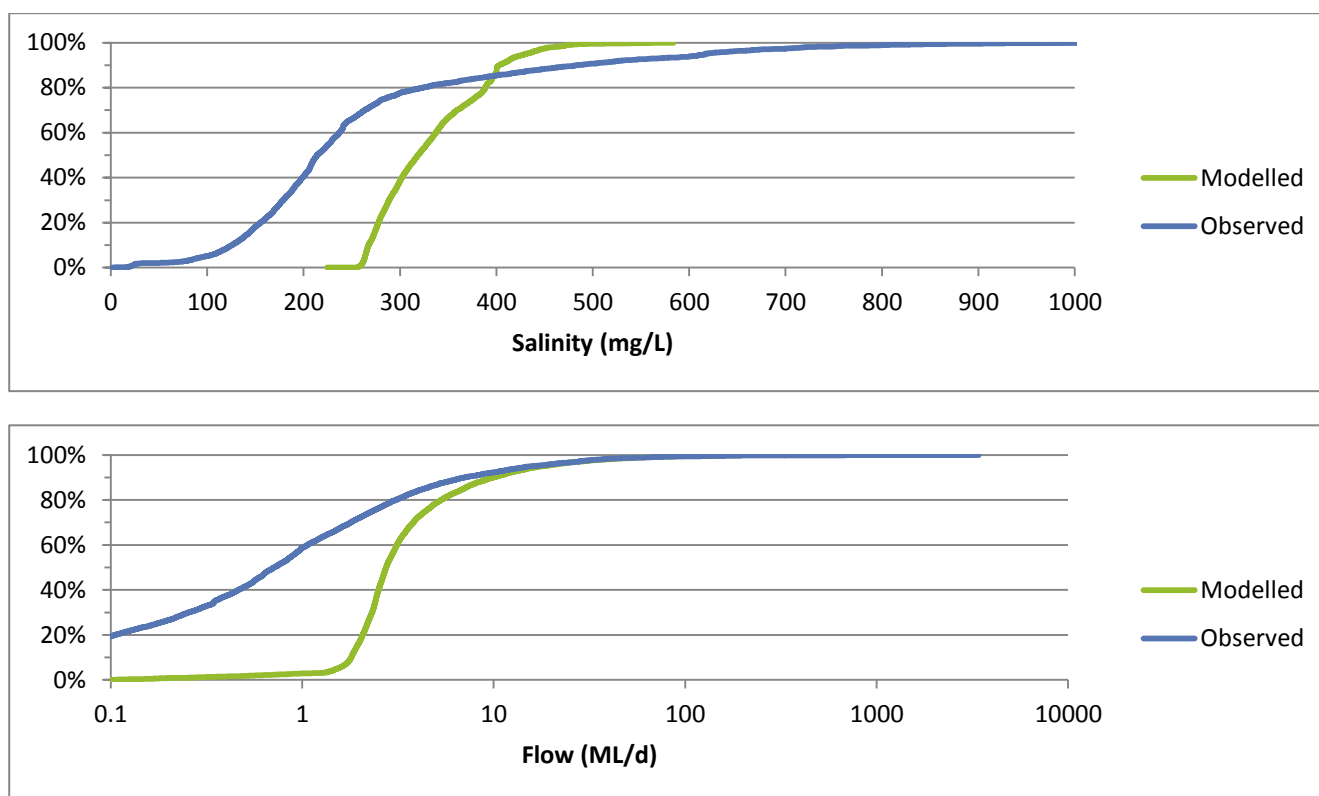


Figure 3.10 : Calibration Distribution Plot at #105 (Wangcol Creek above Western Coal Services, Gauge No. 212055)

Table 3.5 : Calibration Daily Statistics at #105 (Wangcol Creek above Western Coal Services)

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	0.0	0.1	2	224
5%	0.0	1.5	98	264
10%	0.0	1.8	126	268
20%	0.1	2.1	155	278
50%	0.7	2.7	214	319
80%	3.1	5.3	324	389
90%	7.1	10.0	484	403
95%	15.9	18.0	616	431
Maximum	3,416 (n=6,984)	469 (n=6,984)	1,307 (n=4,656)	584 (n=4,656)

Facility to Wangcol Creek. Review of Figure 3.9 and Figure 3.10 suggests the seepage rate may be overestimated; however, comparison of modelled and observed salinity is reasonable.

To investigate the sensitivity of model output to the assumed seepage, results from an interim version of the water quality model are presented in Figure 3.11 and Figure 3.12. The model control file of this interim simulation is 002a_CAL-Jun14_05a.gsm.

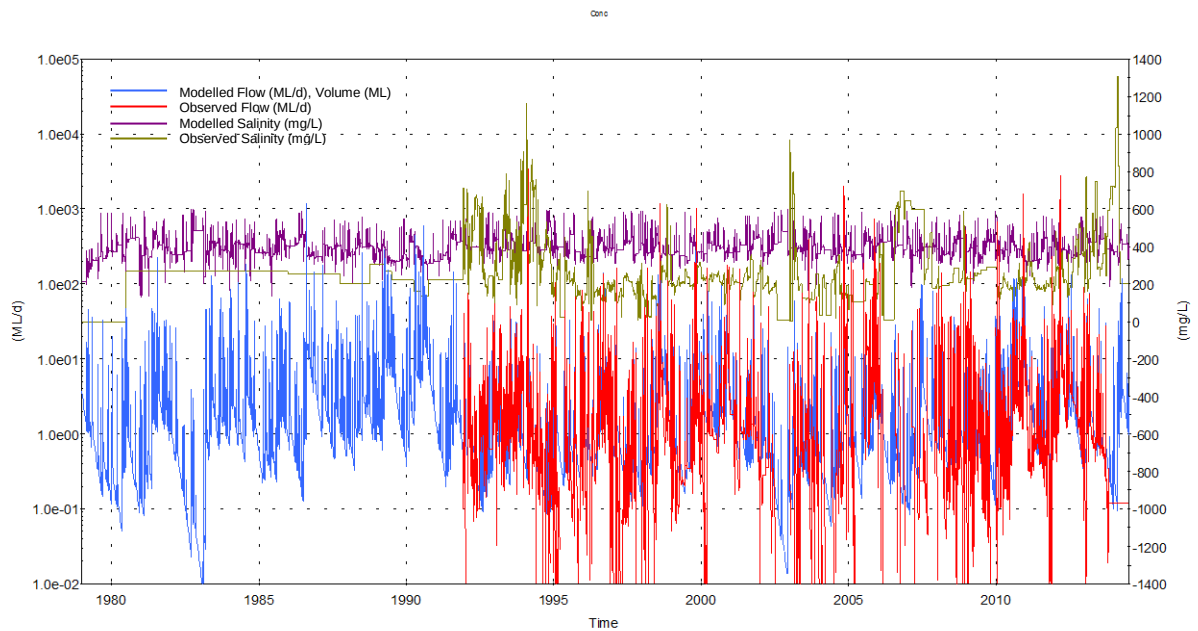


Figure 3.11 : Calibration Time-Series Chart at #105 (Wangcol Creek above Western Coal Services, Gauge No. 212055) – Interim

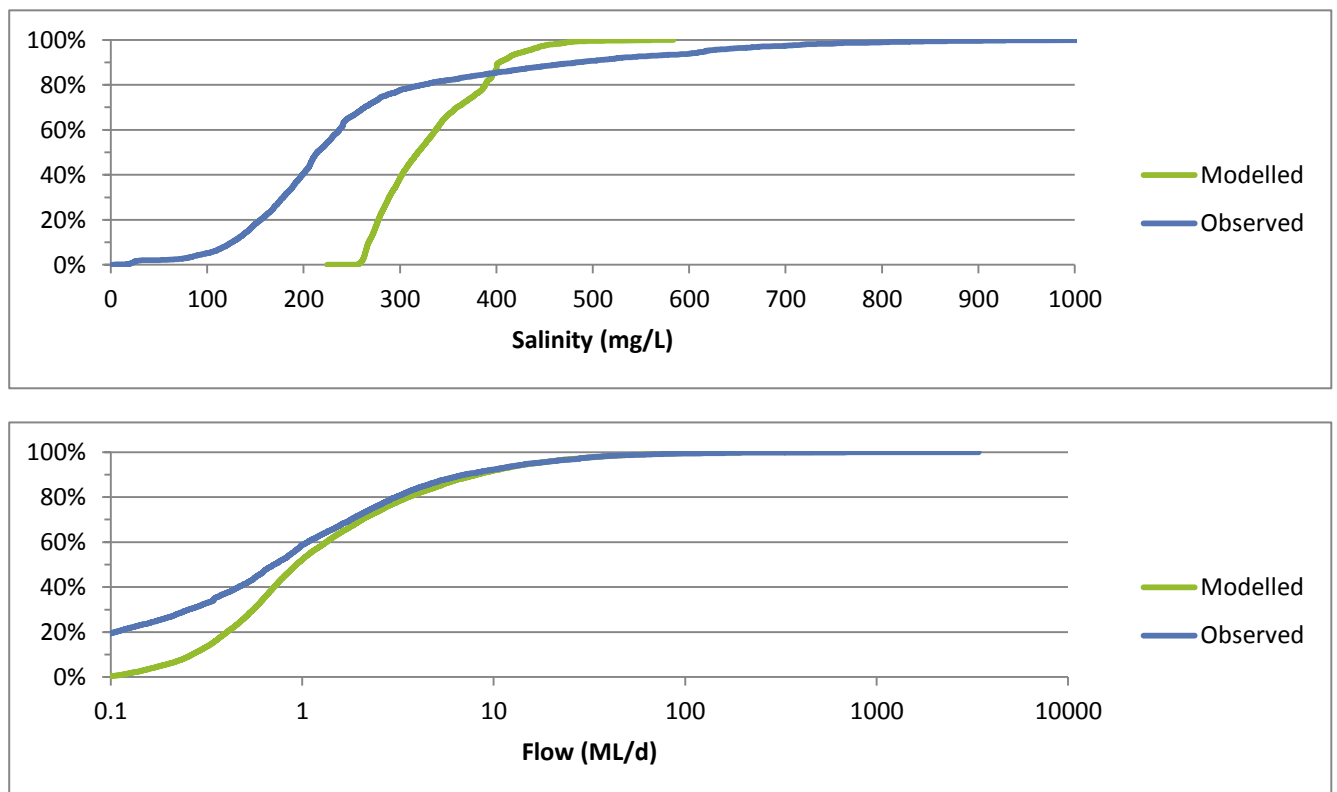


Figure 3.12 : Calibration Distribution Plot at #105 (Wangcol Creek above Western Coal Services, Gauge No. 212055) – Interim

Table 3.6 : Calibration Daily Statistics at #105 (Wangcol Creek above Western Coal Services) – Interim Simulation

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	0.0	0.0	2	203
5%	0.0	0.2	98	325
10%	0.0	0.3	126	337
20%	0.1	0.4	155	357
50%	0.7	0.9	214	387
80%	3.1	3.6	324	430
90%	7.1	8.2	484	458
95%	15.9	16.3	616	484
Maximum	3,416 (n=6,984)	467 (n=6,984)	1,307 (n=4,656)	595 (n=4,656)

From Figure 3.11, the modelled fit to observed flow is improved by disabling the assumed seepage; however, the fit to observed salinity deteriorates.

Sawyers Swamp Creek

Mine water discharge from Springvale LDP009 is currently occurring to Sawyers Swamp Creek. Node #166 is understood to correspond with Centennial monitoring location WCS_LDP003_DOWNSTREAM and is located on Sawyers Swamp Creek immediately above the Coxs River.

As per RPS (2014a), modelled salinity at this location is higher than observation. Figure 3.13 presents the updated time-series chart and Figure 3.14 presents the distribution plot, with summary in Table 3.7.

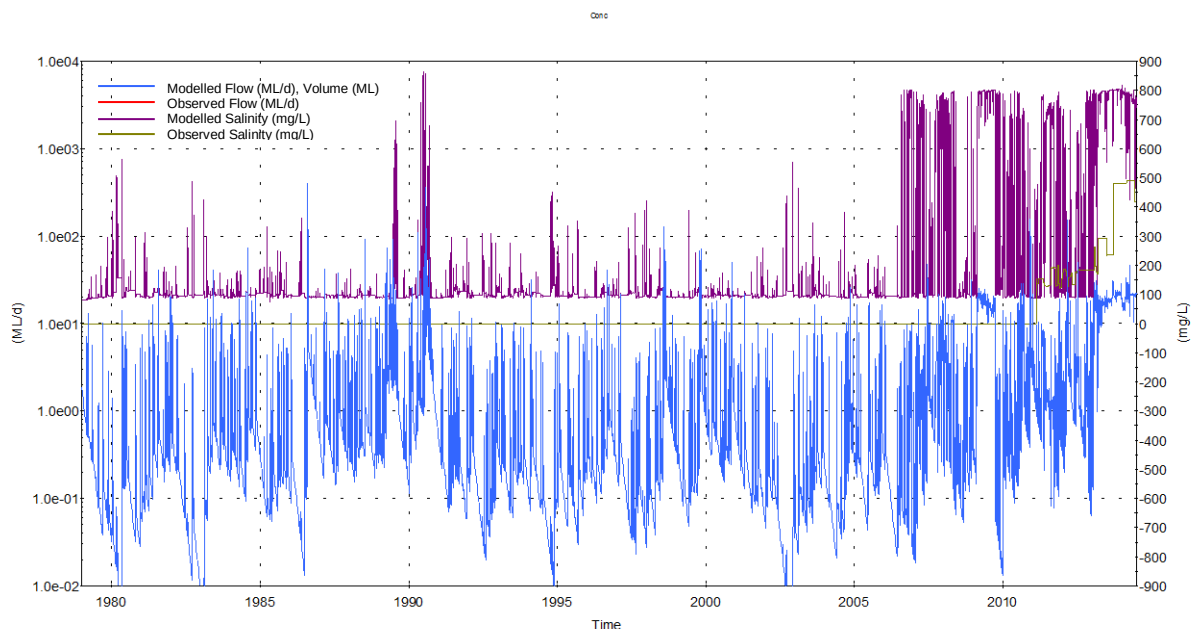


Figure 3.13 : Calibration Time-Series Chart at #166 (Sawyers Swamp Creek above Coxs River)

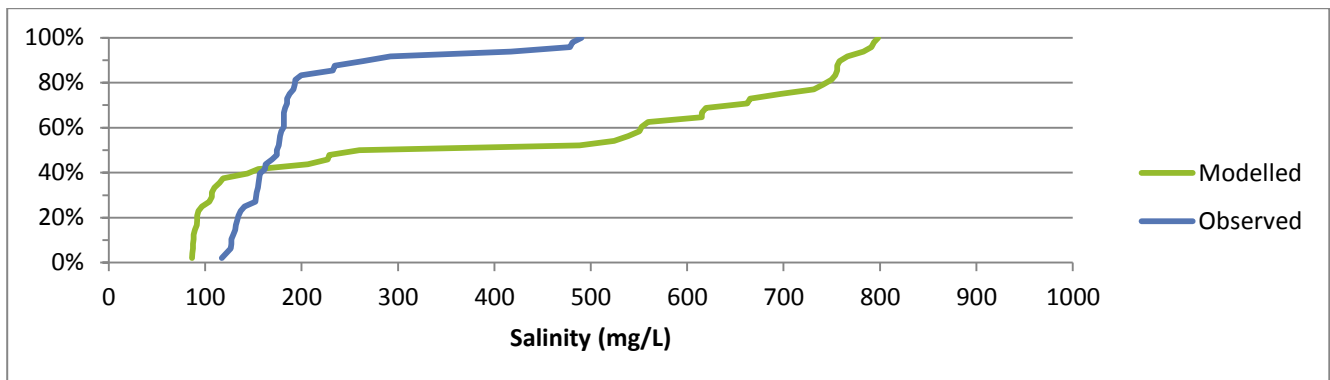


Figure 3.14 : Calibration Distribution Plot at #166 (Sawyers Swamp Creek above Coxs River)

Table 3.7 : Calibration Daily Statistics at #166 (Sawyers Swamp Creek above Coxs River)

Percentile	OBSD Volume (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	n/a	n/a	117	86
5%	n/a	n/a	127	87
10%	n/a	n/a	129	88
20%	n/a	n/a	135	92
50%	n/a	n/a	175	374
80%	n/a	n/a	193	746
90%	n/a	n/a	272	761
95%	n/a	n/a	457	788
Maximum	n/a	n/a	490 (n=48)	798 (n=48)

From Figure 3.14, the water quality model does not encapsulate observed distribution of salinity particularly well. The cause of this discrepancy is not known at this stage and is considered may be due to the assumed location of the Centennial monitoring station.

Lake Wallace

Figure 3.15 presents the time-series modelled flow and salinity at Node #047. Figure 3.16 presents a distribution of that data and is summarised in Table 3.8. This location corresponds with NSW Office of Water Station No. 212054 and is situated on the Coxs River immediately upstream of Lake Wallace.

From Figure 3.15 there is reasonable agreement between observed and modelled salinity and flow, although direct comparison of observed and modelled salinity in Figure 3.16 indicates under-prediction by 100mg/L. The shape of the distribution plot, however, is appropriately matched.

From Table 3.8, modelled median flow is 13.0ML/d compared to 13.1ML/d from observation record, indicating a satisfactory match.

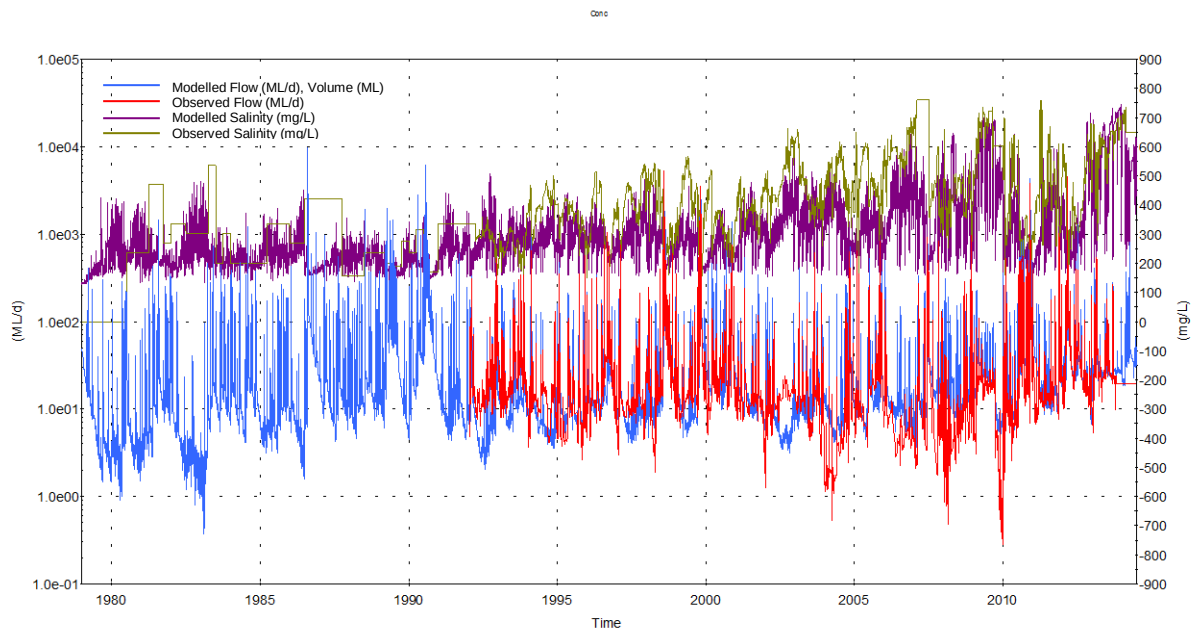


Figure 3.15 : Calibration Time-Series Chart at #047 (Coxs River above Lake Wallace, Gauge No. 212054)

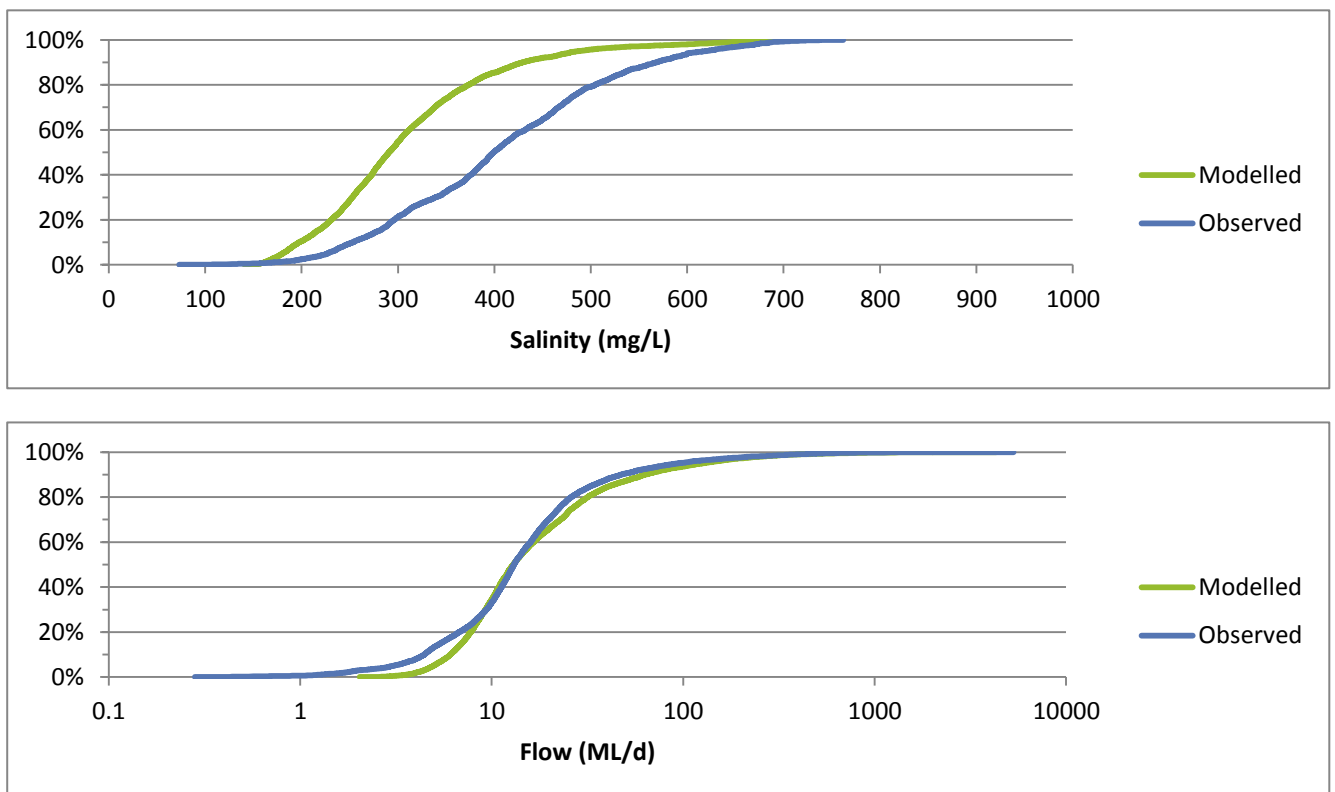


Figure 3.16 : Calibration Distribution Plot at #047 (Coxs River above Lake Wallace, Gauge No. 212054)

Table 3.8 : Calibration Daily Statistics at #047 (Coxs River above Lake Wallace)

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	0.3	2.0	73	141
5%	3.1	5.0	227	180
10%	4.5	6.1	253	198
20%	6.8	7.8	296	231
50%	13.1	13.0	399	291
80%	26.1	31.8	504	373
90%	47.7	63.1	568	429
95%	94.7	126.4	620	487
Maximum	5,321 (n=7,906)	4,318 (n=7,906)	762 (n=5,280)	733 (n=5,280)

Figure 3.17 presents the observed versus modelled salinity and modelled volume in Lake Wallace. Figure 3.18 presents a distribution plot of observed versus modelled salinity, with a summary in Table 3.9.

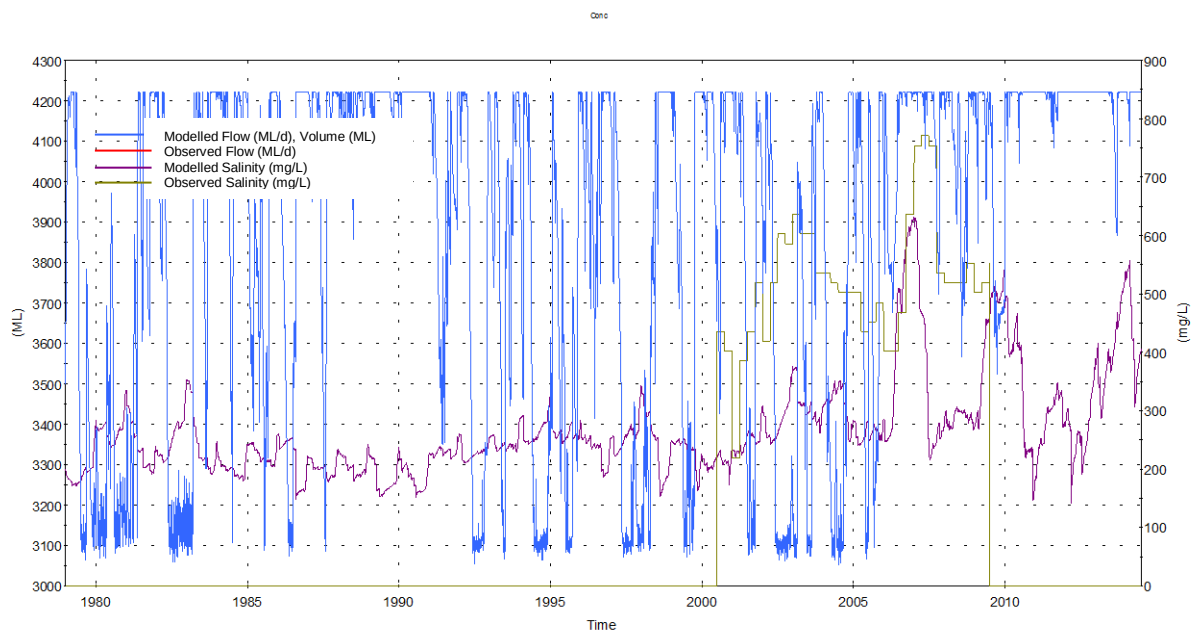


Figure 3.17 : Calibration Time-Series Chart at #074 (Lake Wallace)

From Figure 3.17, the modelled fit to observed salinity in Lake Wallace has deteriorated in the current version of the water quality model compared to the previous version; however, as shall be shown below, the modelled fit is improved in Lake Lyell further downstream.

As noted in Section 3.1.2.5, there is an assumption with respect to emergency discharge via EnergyAustralia LDP021 that may partially account for under-prediction of salinity in Lake Wallace.

From Figure 3.18, the shape of the distribution plot is reasonably matched; however, the magnitude of mass of salt stored in Lake Wallace appears under-estimated.

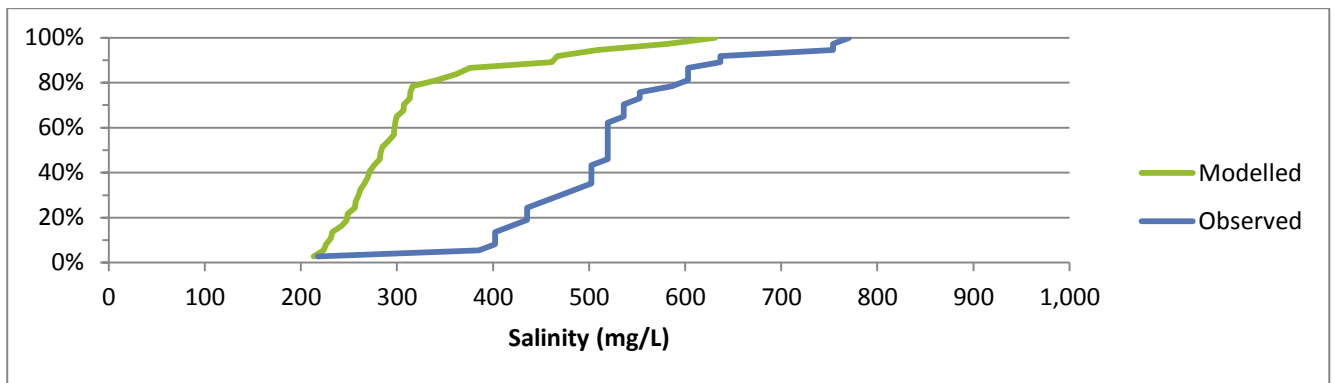


Figure 3.18 : Calibration Distribution Plot at #074 (Lake Wallace)

Table 3.9 : Calibration Daily Statistics at #074 (Lake Wallace)

Percentile	OBSD Volume (ML)	CAL Volume (ML)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	n/a	n/a	218	213
5%	n/a	n/a	398	230
10%	n/a	n/a	402	237
20%	n/a	n/a	436	256
50%	n/a	n/a	519	288
80%	n/a	n/a	603	341
90%	n/a	n/a	637	464
95%	n/a	n/a	754	527
Maximum	n/a	n/a	771 (n=37)	631 (n=37)

Lake Lyell

There is a flow gauging station located downstream of Lake Wallace at Node #32, NSW Office of Water Station No. 212008. There is also a reasonably extensive water quality observation record at this node. Figure 3.19 presents the time-series output from the calibration model at this location and Figure 3.20 presents the distribution plot with respect to salinity and flow. Table 3.10 presents a summary of the distribution plot.

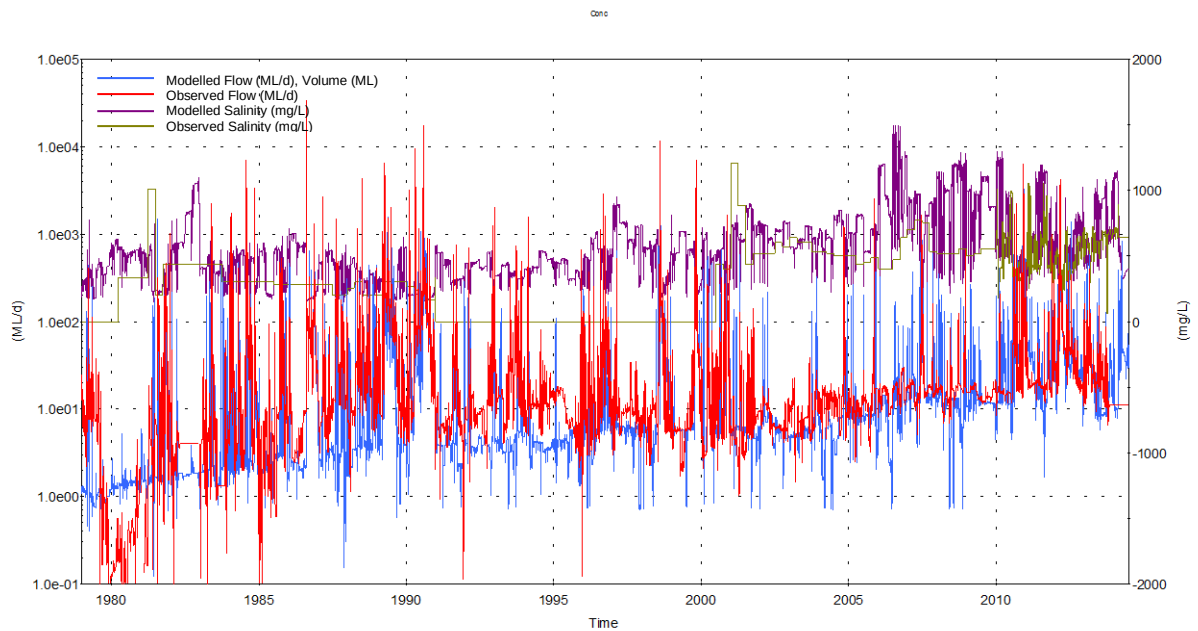


Figure 3.19 : Calibration Time-Series Chart at #032 (Coxs River below Lake Wallace, Gauge No. 212008)

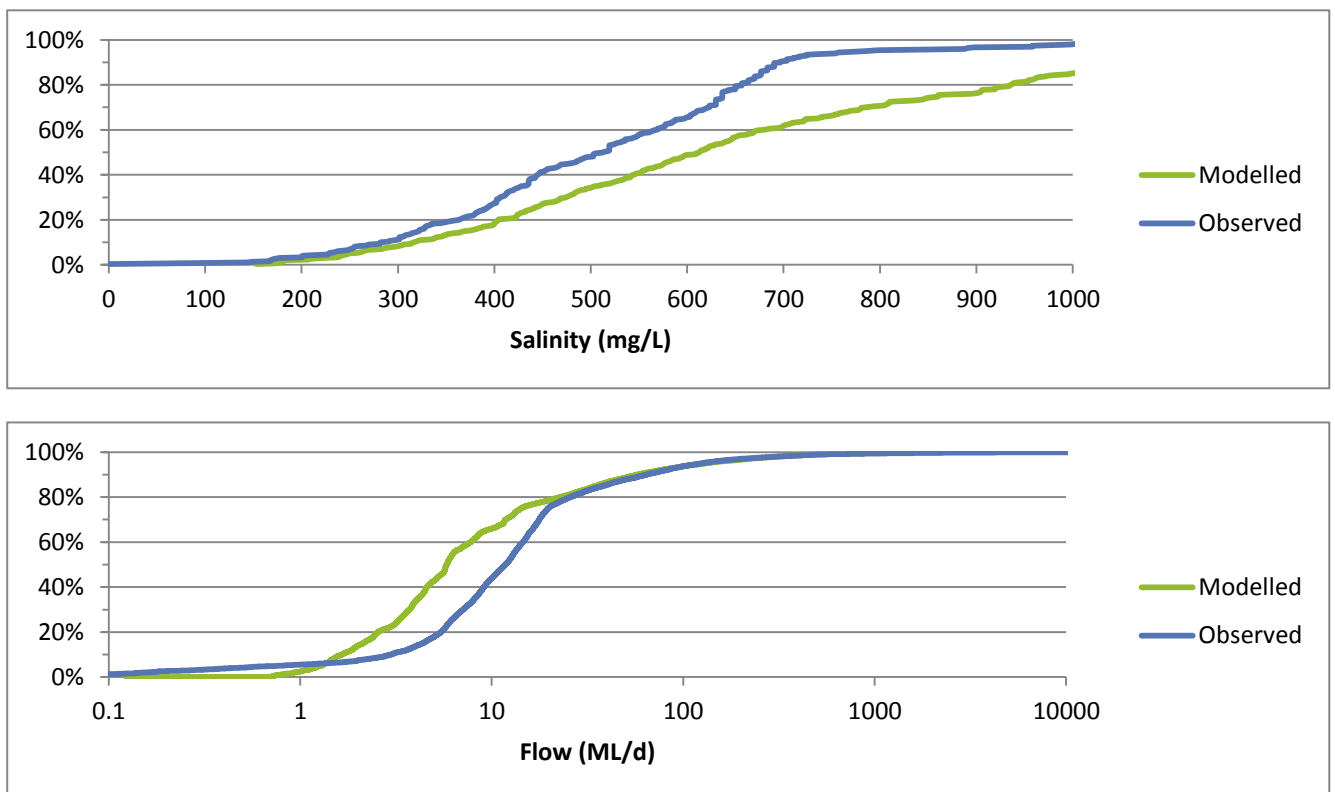


Figure 3.20 : Calibration Distribution Plot at #032 (Coxs River below Lake Wallace, Gauge No. 212008)

Table 3.10 : Calibration Daily Statistics at #032 (Coxs River below Lake Wallace, Gauge No. 212008)

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	0.0	0.1	0	153
5%	0.8	1.3	229	257
10%	3.0	1.7	289	319
20%	5.4	2.5	366	405
50%	11.8	5.8	516	613
80%	25.8	22.7	657	936
90%	64.5	57.8	697	1,099
95%	124.9	130.4	785	1,144
Maximum	33,729 (n=12,340)	10,870 (n=12,340)	1,206 (n=301)	1,407 (n=301)

From Figure 3.19 and Figure 3.20, there is reasonable agreement between modelled and observed salinity and flow. Median modelled salinity is 613mg/L compared to 516mg/L from the observation record, at equivalent times.

Node #154 on the Coxs River corresponds with NSW Office of Water Station No. 212058. Figure 3.21 presents the time-series model output at this location, together a distribution plot with respect to flow. Summary data is presented in Table 3.11, however, only with respect to flow.

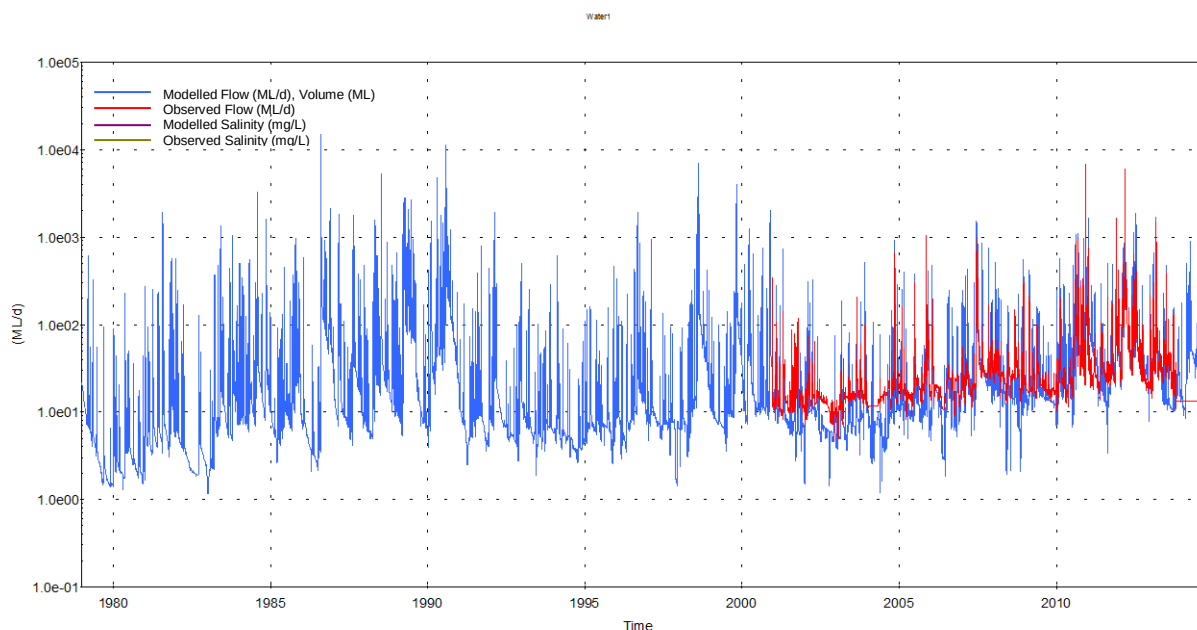


Figure 3.21 : Calibration Time-Series Chart at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

From Figure 3.21 and Figure 3.22, the update to AWBM parameters has improved the fit to observed flows; however, a small discrepancy in flow is starting to become apparent, in particular in the shape of the distribution of flows, although is not significant with respect to the use of the water quality mode for the purpose of impact assessment.

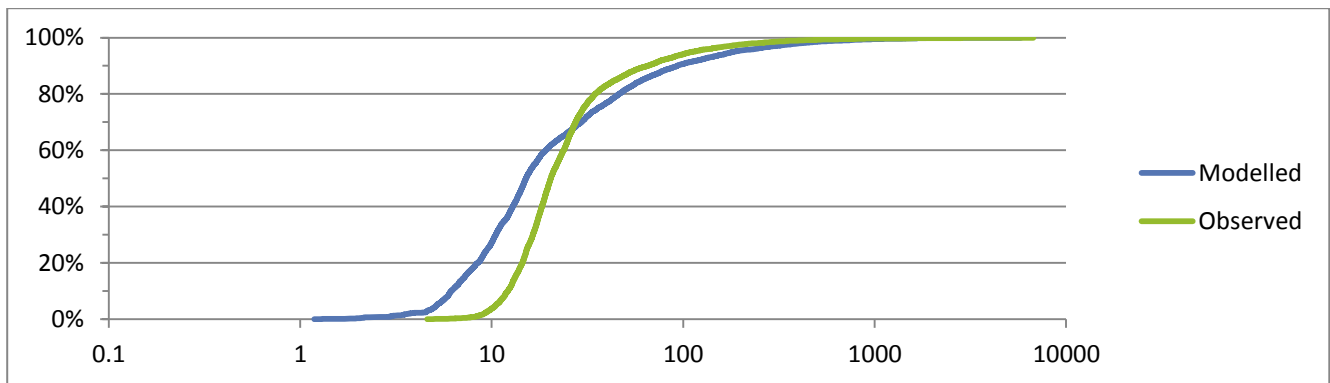


Figure 3.22 : Calibration Distribution Plot at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

Table 3.11 : Calibration Daily Statistics at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	4.6	1.2	n/a	n/a
5%	10.5	5.2	n/a	n/a
10%	12.1	6.2	n/a	n/a
20%	14.5	8.5	n/a	n/a
50%	20.4	15.1	n/a	n/a
80%	34.7	46.2	n/a	n/a
90%	65.4	93.1	n/a	n/a
95%	112.1	182.6	n/a	n/a
Maximum	6,750 (n=4,563)	5,809 (n=4,563)	n/a	n/a

Node #174 corresponds with Lake Lyell and Figure 3.23 presents the time-series modelled salinity (mg/L) and volume (ML). A distribution plot is presented in Figure 3.24 and is summarised in Table 3.12.

From Figure 3.23, there is reasonable agreement between time-series modelled salinity and observation. Observed median salinity is 295mg/L in Table 3.12 and modelled median salinity, at equivalent times, is 292mg/L. This is particularly the case for the period post 2005, where, in general, higher quality input data was available. Peak observed salinity is 634mg/L in Table 3.12. It is noted that additional observation data is presented in Figure 3.23 compared to that presented in RPS (2014a). This additional data was received from EnergyAustralia.

It is apparent from Figure 3.23 that there is a significant correlation between stored volume and modelled salinity, with a large drop in salinity in June 2007 coincident with a significant rise in stored volume. A similar observation is made with respect to August 2010.

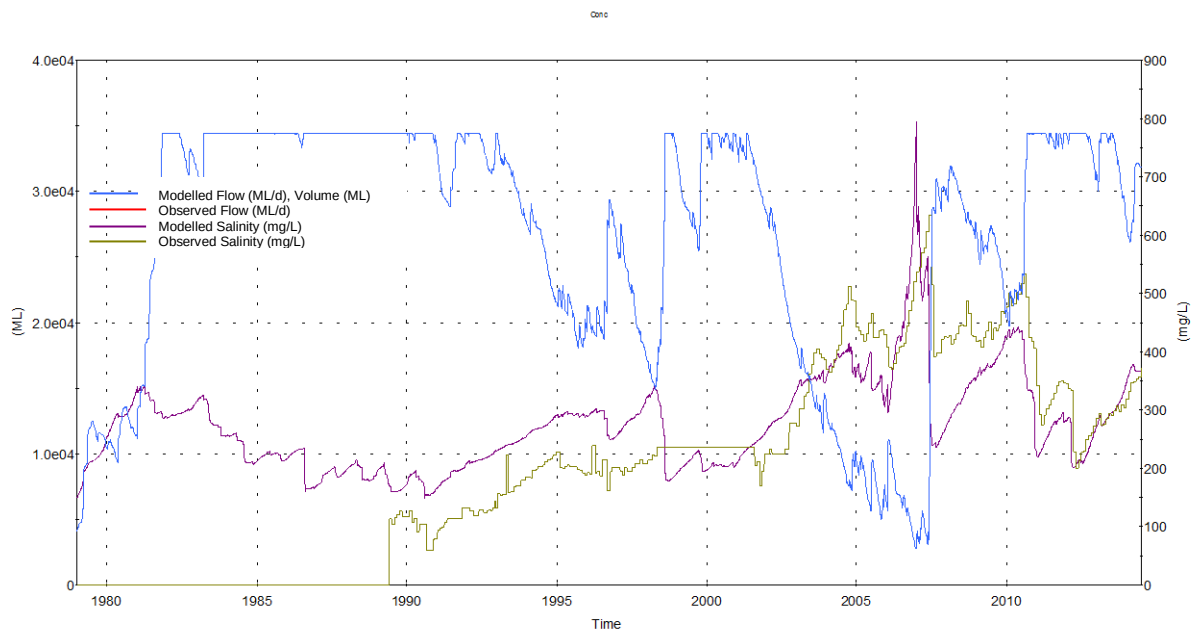


Figure 3.23 : Calibration Time-Series Chart at #174 (Lake Lyell)

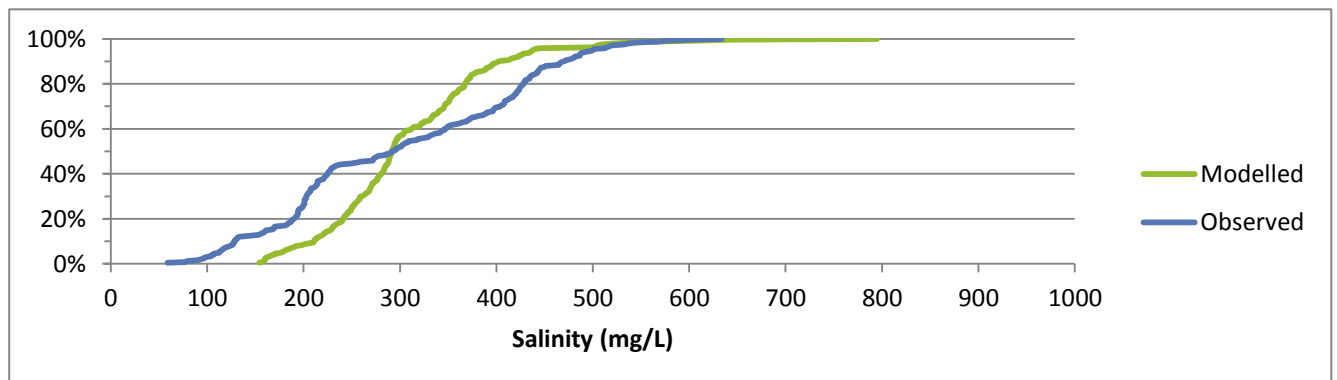


Figure 3.24 : Calibration Distribution Plot at #174 (Lake Lyell)

Table 3.12 : Calibration Daily Statistics at #174 (Lake Lyell)

Percentile	OBSD Volume (ML)	CAL Volume (ML)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	n/a	n/a	59	154
5%	n/a	n/a	114	180
10%	n/a	n/a	129	211
20%	n/a	n/a	192	242
50%	n/a	n/a	295	292
80%	n/a	n/a	428	368
90%	n/a	n/a	471	403
95%	n/a	n/a	500	438
Maximum	n/a	n/a	634 (n=242)	795 (n=242)

Thompson Creek Reservoir

Figure 3.25 presents the calibration simulation in Thompsons Creek Reservoir. Thompsons Creek Reservoir corresponds with Node #272 in the model. A distribution plot for Thompsons Creek Reservoir is presented in Figure 3.26 and is summarised in Table 3.13.

From Figure 3.25 and Figure 3.26, there is a reasonable fit of modelled salinity in Thompsons Creek Reservoir to the observation record.

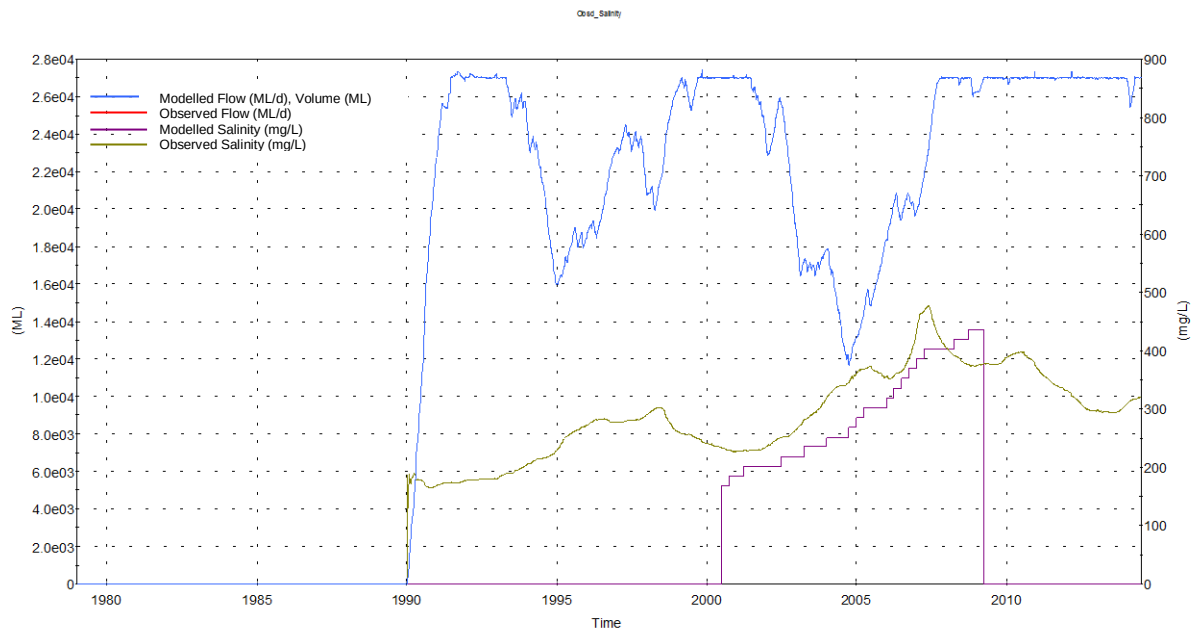


Figure 3.25 : Calibration Time-Series Chart at #272 (Thompsons Creek Reservoir)

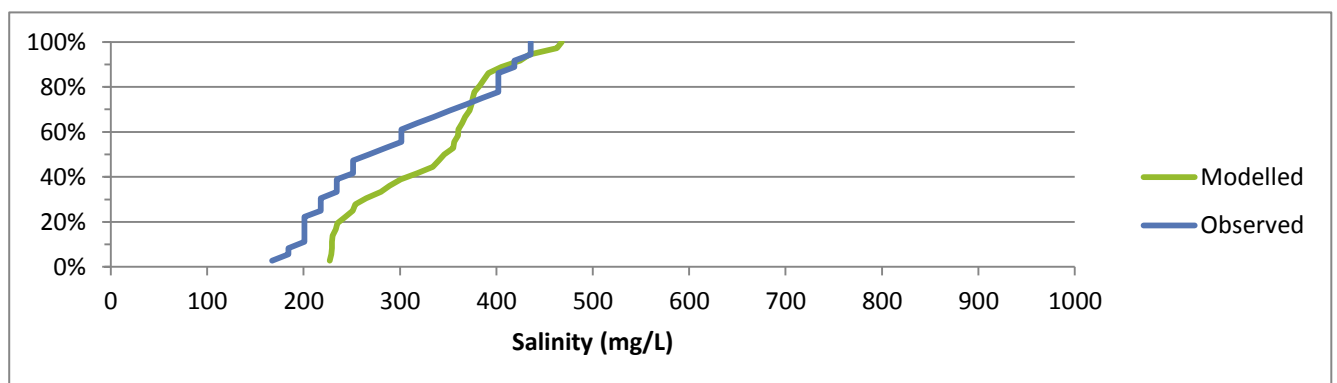


Figure 3.26 : Calibration Distribution Plot at #272 (Thompsons Creek Reservoir)

Table 3.13 : Calibration Daily Statistics at #272 (Thompsons Creek Reservoir)

Percentile	OBSD Volume (ML)	CAL Volume (ML)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	n/a	n/a	184	227
5%	n/a	n/a	196	229
10%	n/a	n/a	201	230
20%	n/a	n/a	214	250
50%	n/a	n/a	285	355
80%	n/a	n/a	402	384
90%	n/a	n/a	419	417
95%	n/a	n/a	436	443
Maximum	n/a	n/a	436 (n=36)	468 (n=36)

Lake Burragorang

As per the original RWQIAM report, there are three observation locations between Lake Lyell and Lake Burragorang, as well as Lake Burragorang itself:

- Coxs River below Lake Lyell (Node #209, corresponding with NSW Office of Water Station No. 212008)
- Coxs River above Little River (Node #221, corresponding with NSW Office of Water Station No. 212045)
- Coxs River above Lake Burragorang (Node #225)
- Lake Burragorang (Node #280, no observation data but useful to present modelled salinity and volume).

Figure 3.27 presents the time-series calibration model at Node #209, below Lake Lyell. Figure 3.28 presents

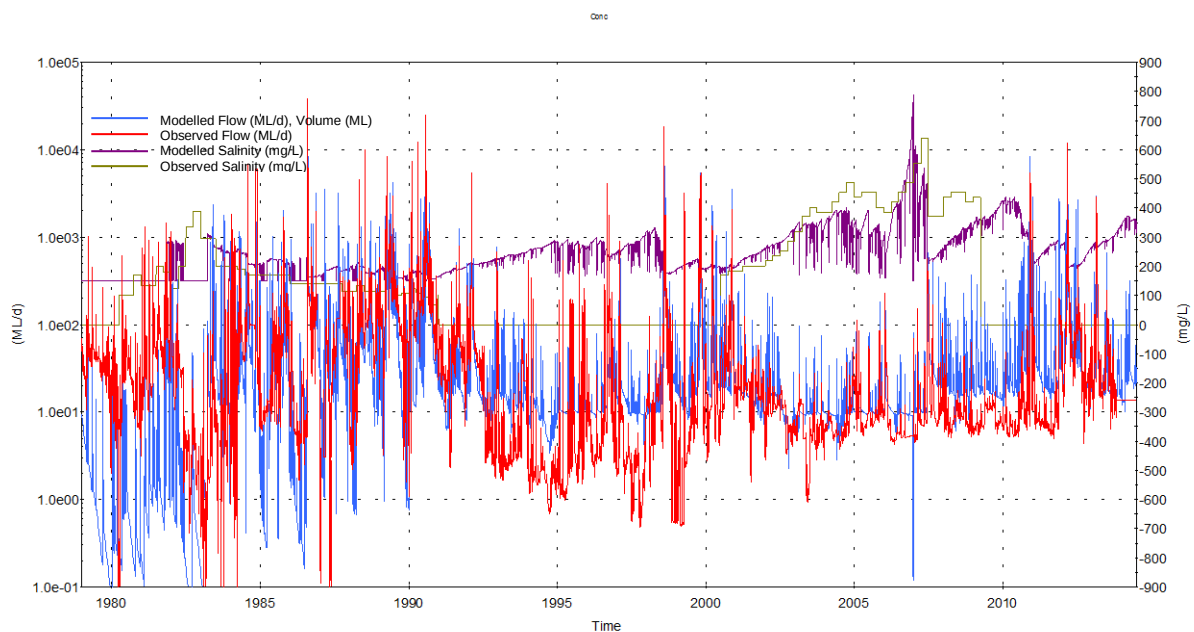


Figure 3.27 : Calibration Time-Series Chart at #209 (Coxs River below Lake Lyell, Gauge No. 212011)

the distribution plot, which is summarised in Table 3.14.

From Figure 3.27, there is good agreement between modelled salinity and observation with respect to Node #209. There is also a good fit to flow gauge data (Station No. 212011). This is also demonstrated in Figure 3.28.

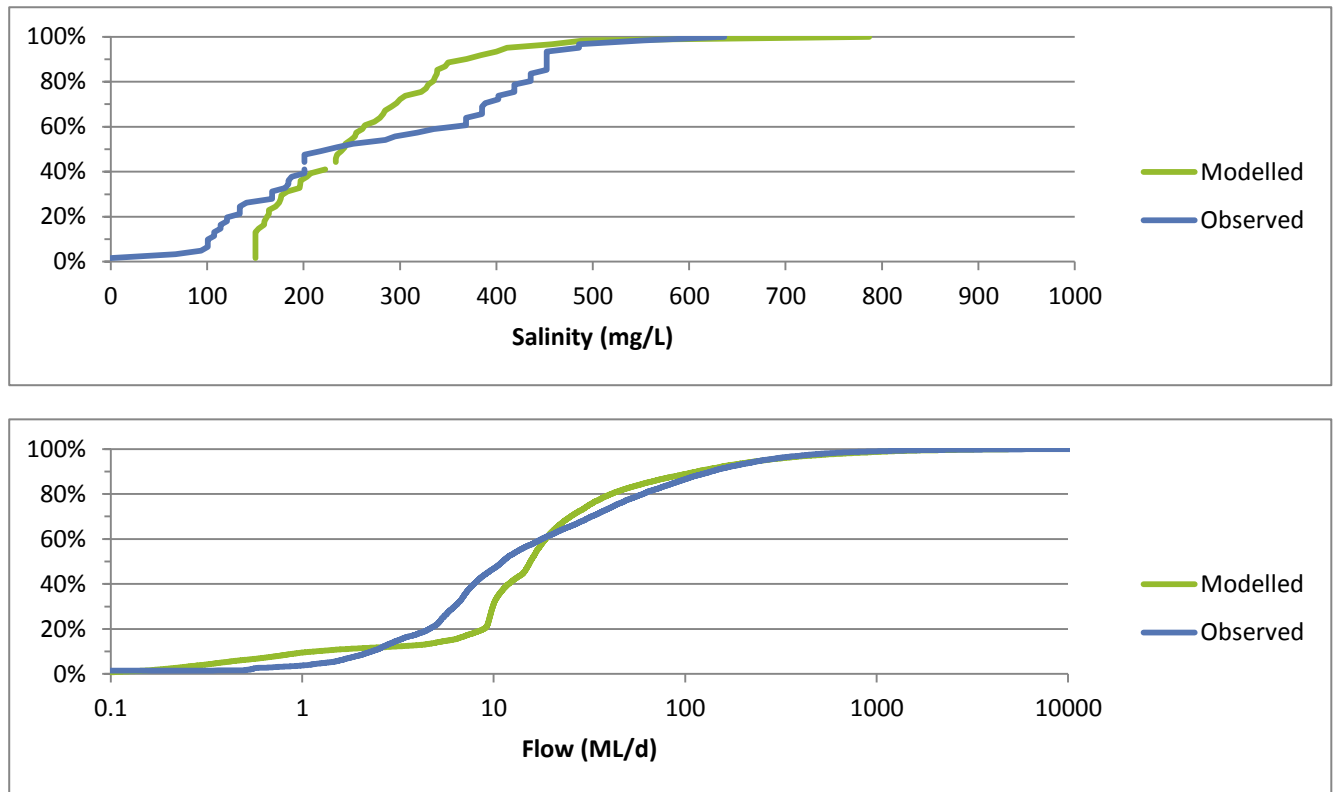


Figure 3.28 : Calibration Distribution Plot at #209 (Coxs River below Lake Lyell, Gauge No. 212011)

Table 3.14 : Calibration Daily Statistics at #209 (Coxs River below Lake Lyell)

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	0.0	0.0	67	150
5%	1.3	0.4	101	150
10%	2.3	1.2	113	150
20%	4.6	8.9	134	168
50%	11.2	15.6	251	243
80%	60.1	41.1	436	335
90%	136.9	115.5	452	372
95%	256.1	260.5	486	416
Maximum	38,188 (n=12,394)	23,835 (n=12,394)	637 (n=60)	787 (n=60)

Figure 3.29 presents the time-series chart for Node #221, which is the next downstream reporting location. The distribution plot is presented in Figure 3.30, and summarised in Table 3.15.

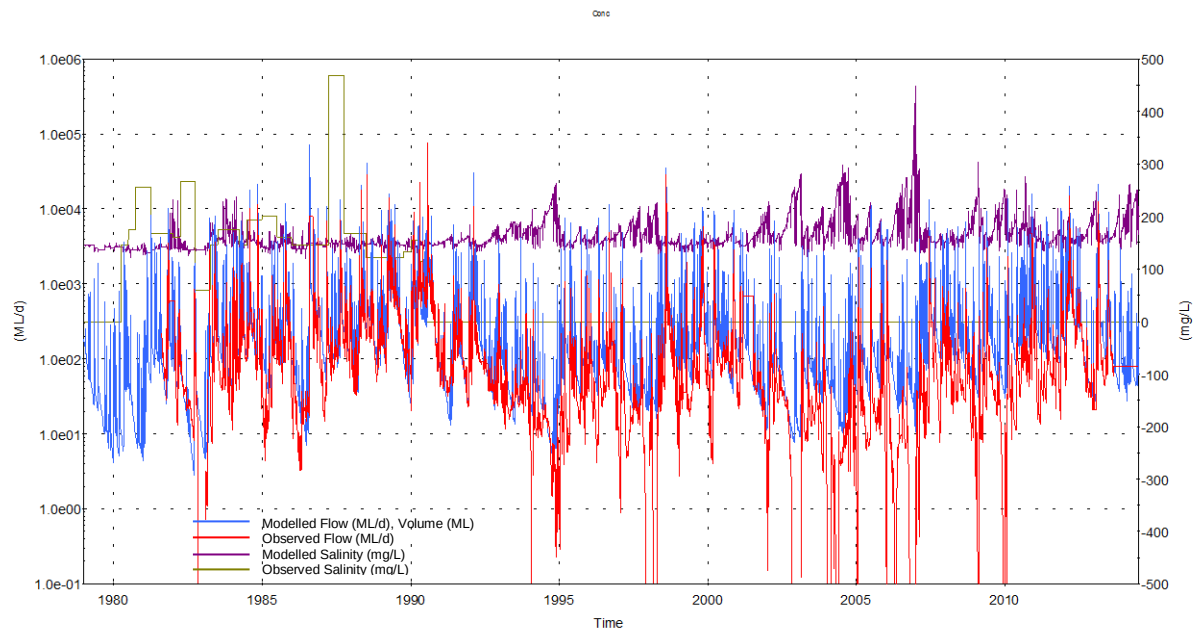


Figure 3.29 : Calibration Time-Series Chart at #221 (Coxs River above Little River, Gauge No. 212045)

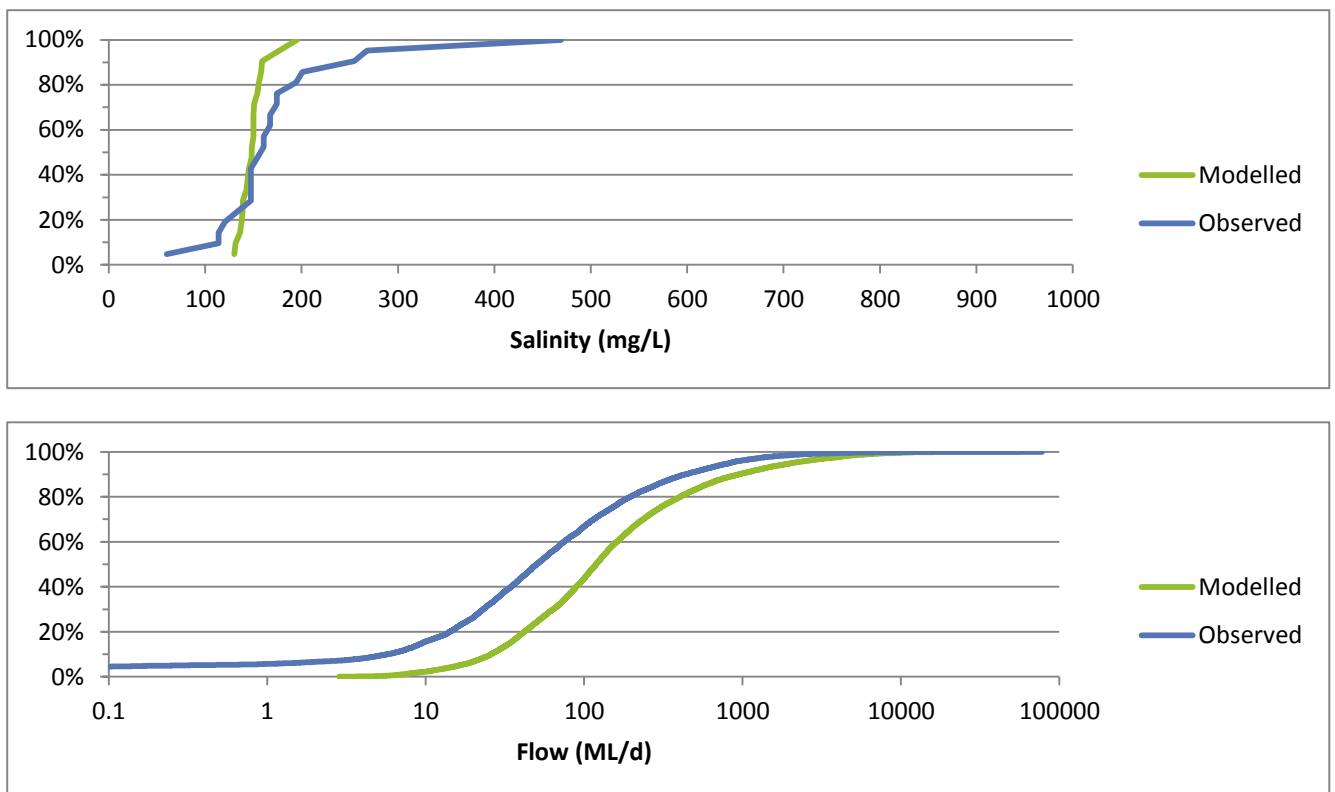


Figure 3.30 : Calibration Distribution Plot at #221 (Coxs River above Little River, Gauge No. 212045)

Table 3.15 : Calibration Daily Statistics at #221 (Coxs River above Little River)

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	0.0	2.8	60	130
5%	0.3	16.3	111	132
10%	5.7	25.9	114	136
20%	14.2	41.8	131	139
50%	50.4	119.2	161	149
80%	196.8	404.7	196	156
90%	441.1	954.4	256	161
95%	832.1	2,052.0	278	178
Maximum	77,905 (n=11,301)	55,241 (n=11,301)	469 (n=21)	195 (n=21)

The modelled fit to salinity data at Node #221 is reasonable, although water quality data was only available from the 1980s. Node #221 also corresponds with NSW Office of Water Station No. 212045. Review of Figure 3.29 and Figure 3.30 implies catchment response / baseflow processes are well represented by AWBM, however, the magnitude of modelled median flows are higher than observed. The overall fit is acceptable, however, for the purpose of impact assessment.

Figure 3.31 presents the time-series output from the calibration model and Figure 3.32 presents a distribution plot of observed versus modelled with respect to salinity. Table 3.16 summarises the distribution plot.

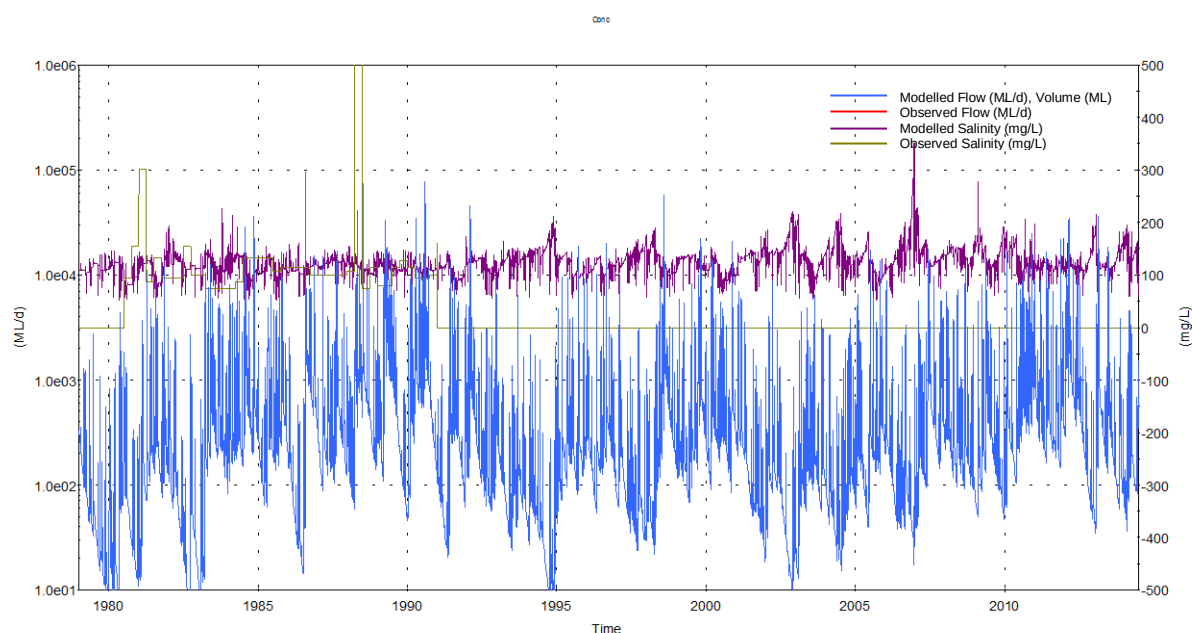


Figure 3.31 : Calibration Time-Series Chart at #225 (Coxs River above Lake Burragorang)

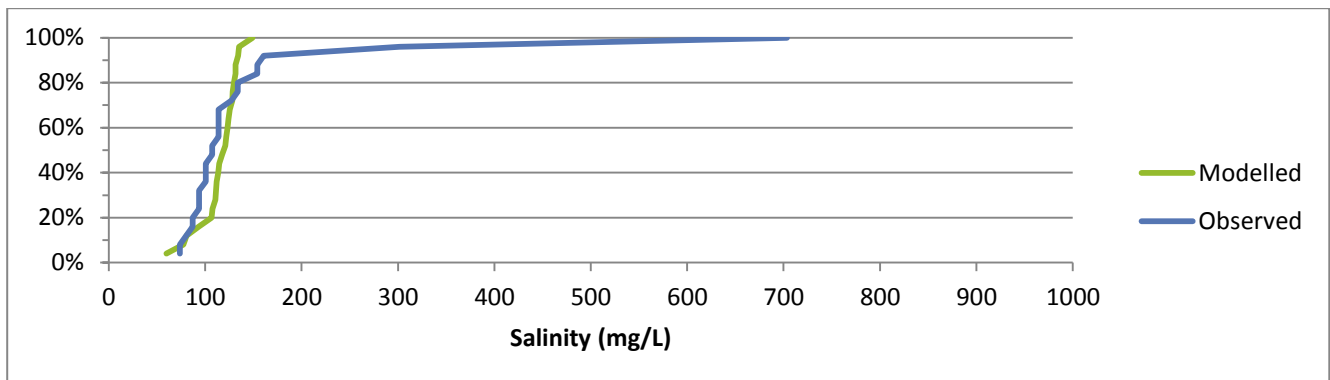


Figure 3.32 : Calibration Distribution Plot at #225 (Coxs River above Lake Burragorang)

Table 3.16 : Calibration Daily Statistics at #225 (Coxs River above Lake Burragorang)

Percentile	OBSD Flow (ML/d)	CAL Flow (ML/d)	OBSD Salinity (mg/L)	CAL Salinity (mg/L)
Minimum	n/a	n/a	74	77
5%	n/a	n/a	74	83
10%	n/a	n/a	82	97
20%	n/a	n/a	90	109
50%	n/a	n/a	107	121
80%	n/a	n/a	134	131
90%	n/a	n/a	154	134
95%	n/a	n/a	160	135
Maximum	n/a	n/a	302 (n=24)	149 (n=25)

There is limited water quality observation data at Node #225, which lies immediately upstream of Lake Burragorang. Modelled salinity is comparable to observation. The large spike in salinity in 1988 is thought to be a transcription error, as noted in RPS (2014a).

The calibration simulation of Lake Burragorang (Node #280) is presented in Figure 3.33. The update to climatic inputs and calibration parameters has led to a less responsive change in stored volume in Lake Burragorang with time. As noted in RPS (2014a), operation of Lake Burragorang was represented in the water quality model in only a simple manner; with environmental releases of 22ML/d between April and October in the model and 30ML/d otherwise and a constant demand of 1,080ML/d. As an example, there was no account for bulk water transfer from and into Lake Burragorang.

From Figure 3.33, modelled salinity during calibration period is 96mg/L, with a maximum of 104mg/L and a minimum of 86mg/L.



Figure 3.33 : Calibration Time-Series Chart at #280 (Lake Burrangor)

3.3 Sensitivity Analysis

Three sets of sensitivity analyses were undertaken. The objective of sensitivity analysis is to identify model parameters that significantly affect calibrated fit to observation data. These parameters may then be included in the uncertainty analysis on prediction simulations. The adopted sensitivity analysis scenarios consist:

- 20% change to assumed salinities of land-use classes
- 20% change to average surface soil storage capacity (AWBM parameter)

- 20% change to baseflow index, BFI (AWBM parameter).

The outcome of sensitivity analysis is presented at locations where there is comprehensive observation record with respect to flow and / or salinity. These locations include:

- Node #047 (Coxs River above Lake Wallace, NSW Office of Water Station No. 212054)
- Node #174 (Lake Lyell)

3.3.1 Change to Land-Use Class Salinity

This sensitivity analysis simulation compared an increase and decrease by 20% of assumed land-use class salinity with respect to each class: Natural, Pasture, Urban, Disturbed and Channel. The assumed land-use class salinity of each class is presented in Table 3.17.

Table 3.17 : Assumed Land-Use Class Salinities in Sensitivity Analysis Simulation

Land-Use	Base Case (CAL) (mg/L)	Increase 20% (mg/L)	Decrease 20% (mg/L)
Natural	50	60	40
Pasture	150	180	120
Urban	400	480	320
Disturbed	600	720	480
Channel	325	390	260

The model control files for the simulations were:

- 002a_SEN-SALu-Jun14_01a.gsm
- 002a_SEN-SALd-Jun14_01a.gsm

Figure 3.34 presents the time-series simulation with respect to increased and decreased salinity at Node #047. The base calibration case is also presented as well as the available observation record. Figure 3.35 presents the distribution plot of these data. It is noted that outputs from the model with respect to flow are not included in Figure 3.34 or Figure 3.35, since changes to assumed land-use salinity have no effect on modelled flow.

Table 3.18 presents a summary of the distribution plot including observation at Node #047. As identified above, the analysis presented in Figure 3.35 and Table 3.18 is based on direct comparison of model output at dates where an observation of flow or salinity is available. The number of observations is noted at the bottom of Table 3.18.

From Figure 3.34 and Figure 3.35, there is only a minor difference between sensitivity analysis simulations and base calibration run. Analysis indicates that model outcome is moderately sensitive to assumed land-use salinity at this location and implies that assumed salinity of mine water discharge at Angus Place is of greater significance.

Review of Table 3.18 indicates the 20% increase and decrease in salinity leads to a median modelled salinity of between 312mg/L (increase of 7.2%) and 270mg/L (decline of 7.2%) at Node #047, in comparison to 291mg/L in the base calibration case.

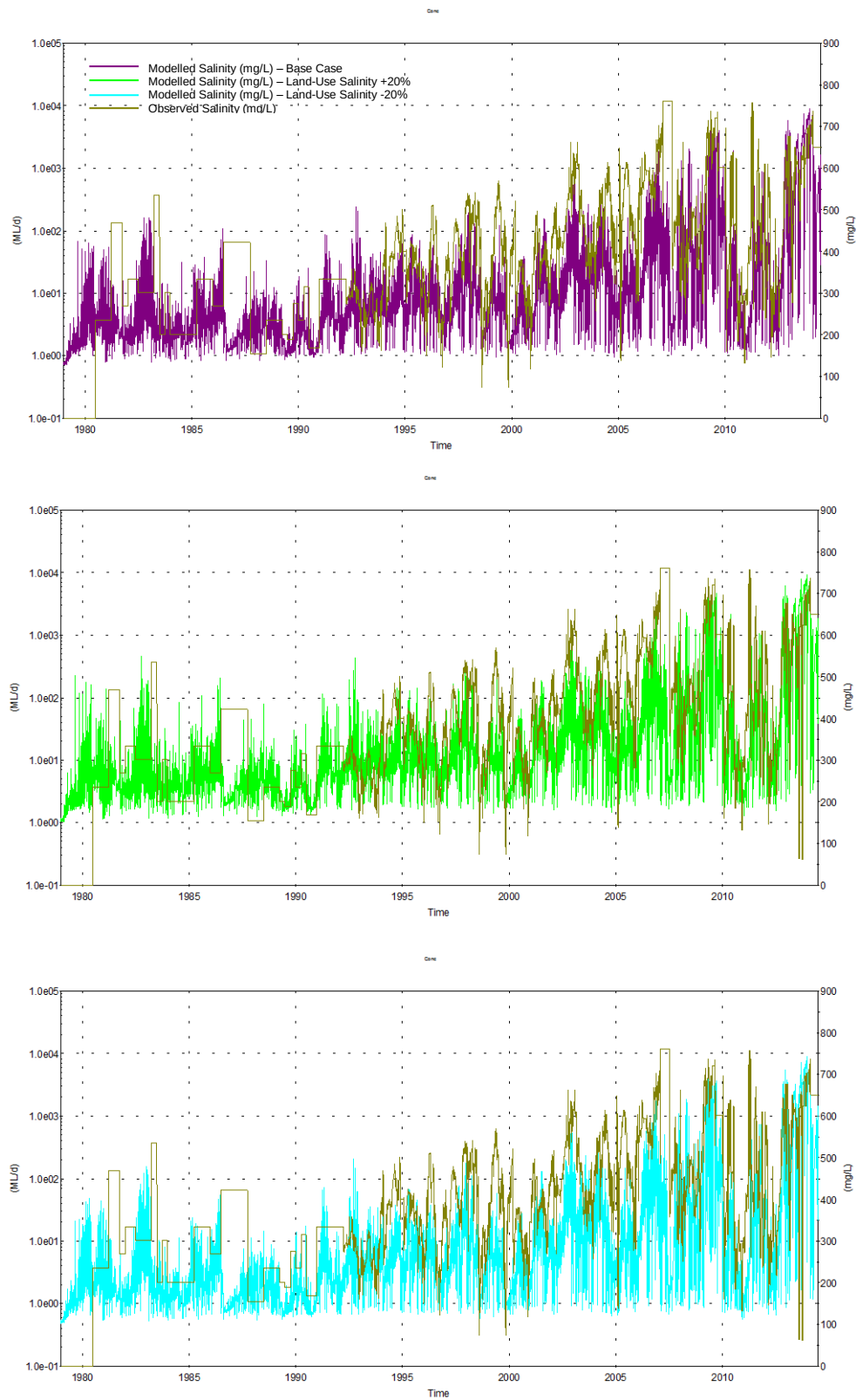


Figure 3.34 : Sensitivity Analysis (Land-Use Salinity) Time-Series Chart at #047 (Coxs River above Lake Wallace)

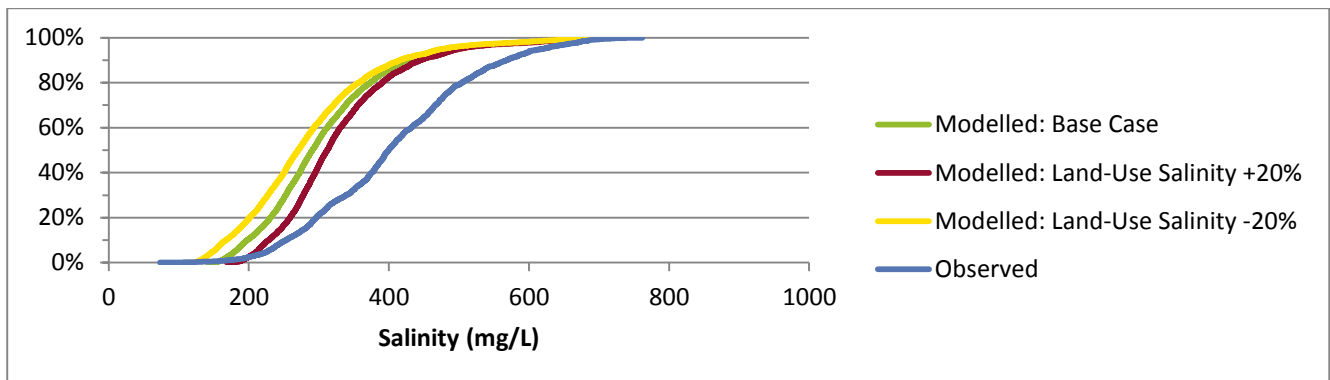


Figure 3.35 : Sensitivity Analysis (Land-Use Salinity) Distribution Plot at #047 (Coxs River above Lake Wallace)

Table 3.18 : Sensitivity Analysis (Land-Use Salinity) Daily Statistics at #047 (Coxs River above Lake Wallace) – Salinity

Percentile	OBSD (mg/L)	CAL (mg/L)	SEN (mg/L) +20% Increase	SEN (mg/L) -20% Decrease
Minimum	73	141	169	113
5%	227	180	212	149
10%	253	198	229	167
20%	296	231	259	201
50%	399	291	312	270
80%	504	373	390	357
90%	568	429	445	416
95%	620	487	500	476
Maximum	762 (n=5,280)	733 (n=5,280)	735 (n=5,280)	730 (n=5,280)

Figure 3.36 presents the time-series simulation with respect to increased and decreased salinity at Node #174. The distribution plot is presented in Figure 3.37 and is summarised in Table 3.19.

From Figure 3.36, each time-series chart is quite similar in the period 2010 onward. In the period 1990 to 2000, model outcome is quite sensitive to the assumed land-use salinity.

From Table 3.19, median modelled salinity in Lake Lyell (Node #174) is 336mg/L (increase of 15.1%) and 249mg/L (decline of 14.7%), compared to 292mg/L in the base calibration run.

Analysis indicates that the adopted value of land-use salinity is moderately sensitive on model outcome.



Figure 3.36 : Sensitivity Analysis (Land-Use Salinity) Time-Series Chart at #174 (Lake Lyell) - Salinity

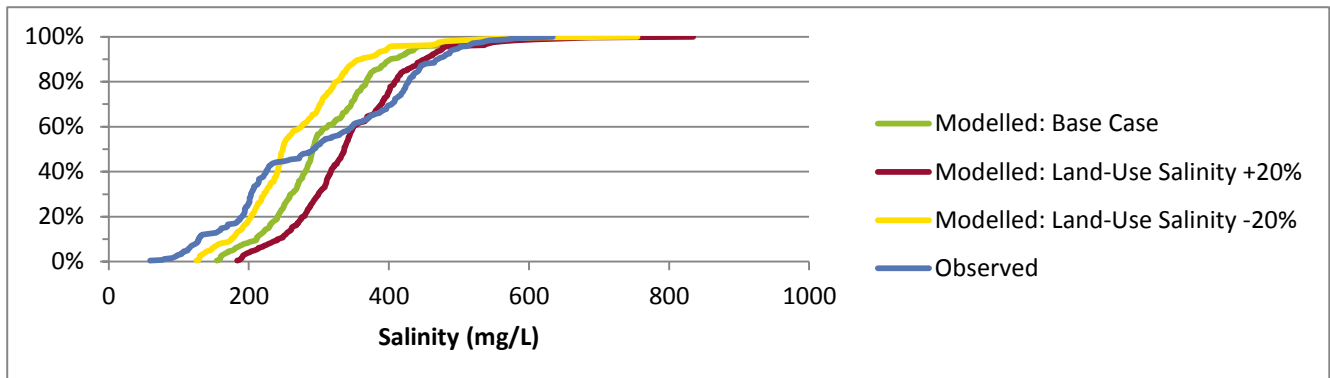


Figure 3.37 : Sensitivity Analysis (Land-Use Salinity) Distribution Plot at #174 (Lake Lyell)

Table 3.19 : Sensitivity Analysis (Land-Use Salinity) Daily Statistics at #174 (Lake Lyell) – Salinity

Percentile	OBSD (mg/L)	CAL (mg/L)	SEN (mg/L) +20% Increase	SEN (mg/L) -20% Decrease
Minimum	59	154	183	125
5%	114	180	211	147
10%	129	211	244	176
20%	192	242	280	204
50%	295	292	336	249
80%	428	368	409	326
90%	471	403	452	362
95%	500	438	477	399
Maximum	634 (n=242)	795 (n=242)	834 (n=242)	755 (n=242)

3.3.2 Change to Average Soil Storage Capacity

This sensitivity analysis simulation comprised an increase and decrease, by 20%, of average soil storage capacity for each land-use class. The average soil storage capacity is distributed in a default pattern of 0.134, 0.433 and 0.433 respectively for each of 'buckets', C1, C2 and C3 illustrated in Figure 3.1. As presented in RPS (2014a), these separate capacities account for differing storage capacity within a catchment / sub-catchment. Table 3.20 presents the average soil storage capacity for each land-use class.

Table 3.20 : Assumed Average Soil Storage Capacities in Sensitivity Analysis Simulation

Land-Use	Base Case (CAL) (mm)	Increase 20% (mm)	Decrease 20% (mm)
Natural	168	202	134
Pasture	192	230	154
Urban	27	32	22
Disturbed	79	95	63
Channel	27	32	22

The model control files for the simulations were:

- 002a_SEN-CAPu-Jun14_01a.gsm
- 002a_SEN-CAPd-Jun14_01a.gsm

Figure 3.38 and Figure 3.39 present time-series simulation results with respect to increase and decrease of average soil storage capacity, including base case calibration output. It is noted that time-series chart for salinity and flow are presented separately, for the purpose of clarity.

Figure 3.40 presents the distribution plot and is summarised in Table 3.21 (salinity) and Table 3.22 (flow).

From Figure 3.38, Figure 3.39 and Figure 3.40, the water quality model is not particularly sensitive to average storage capacity in regard to flow or salinity at Node #047.

From Table 3.21, median modelled salinity is 291mg/L in the base calibration model, and is 300mg/L (increase of 3.1%) and 279mg/L (decline of 4.1%) in the sensitivity analysis cases.

From Table 3.22, median modelled flow is 13.0ML/d in the base calibration case and is 12.0 (decline of 7.6%) to 14.5ML/d (increase of 11.5%) in the sensitivity analysis cases.

Table 3.21 : Sensitivity Analysis (Average Capacity) Daily Statistics at #047 (Coxs River above Lake Wallace) – Salinity

Percentile	OBSD (mg/L)	CAL (mg/L)	SEN (mg/L) +20% Increase	SEN (mg/L) -20% Decrease
Minimum	73	141	146	129
5%	227	180	187	173
10%	253	198	209	189
20%	296	231	240	221
50%	399	291	300	279
80%	504	373	385	360
90%	568	429	442	417
95%	620	487	501	473
Maximum	762 (n=5,280)	733 (n=5,280)	736 (n=5,280)	728 (n=5,280)

Table 3.22 : Sensitivity Analysis (Average Capacity) Daily Statistics at #047 (Coxs River above Lake Wallace) – Flow

Percentile	OBSD (ML/d)	CAL (ML/d)	SEN (ML/d) +20% Increase	SEN (ML/d) -20% Decrease
Minimum	0.3	2.0	1.9	2.3
5%	3.1	5.0	4.7	5.3
10%	4.5	6.1	5.8	6.5
20%	6.8	7.8	7.3	8.4
50%	13.1	13.0	12.0	14.5
80%	26.1	31.8	28.5	37.3
90%	47.7	63.1	53.9	76.2
95%	94.7	126.4	111.3	145.8
Maximum	5,321 (n=7,906)	4,318 (n=7,906)	3,314 (n=7,906)	4,741 (n=7,906)

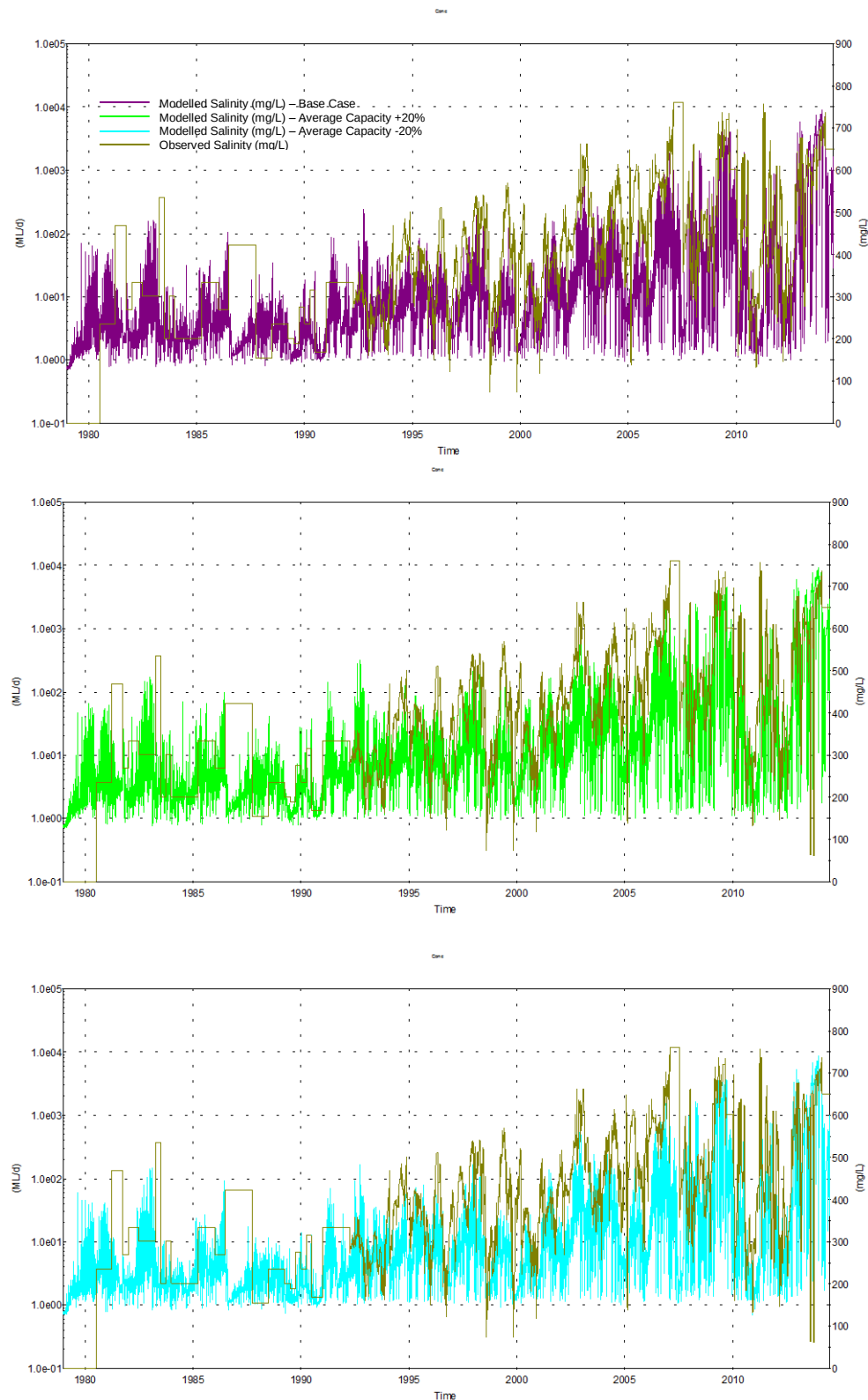


Figure 3.38 : Sensitivity Analysis (Average Capacity) Time-Series Chart at #047 (Coxs River above Lake Wallace) - Salinity

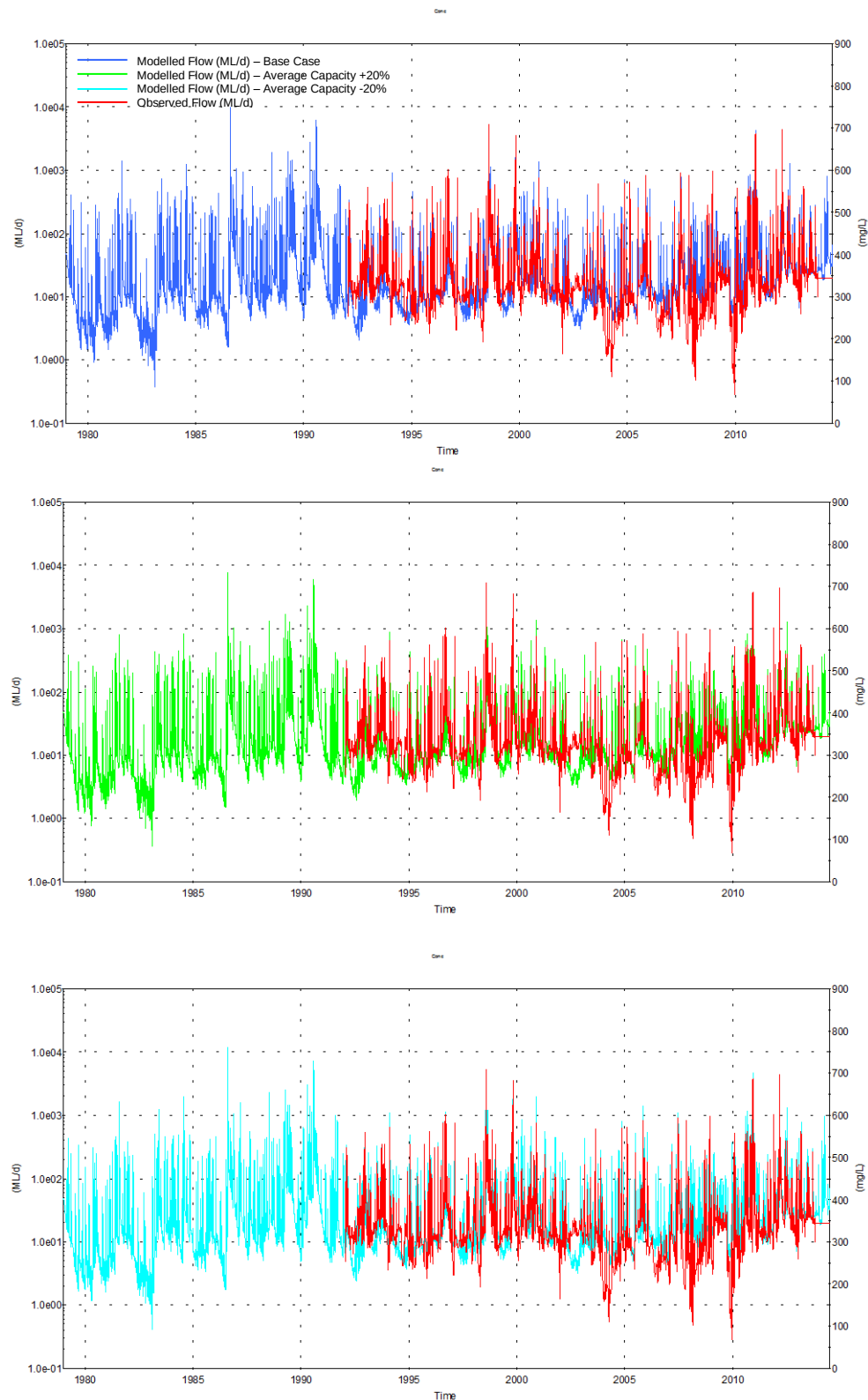


Figure 3.39 : Sensitivity Analysis (Average Capacity) Time-Series Chart at #047 (Coxs River above Lake Wallace) – Flow

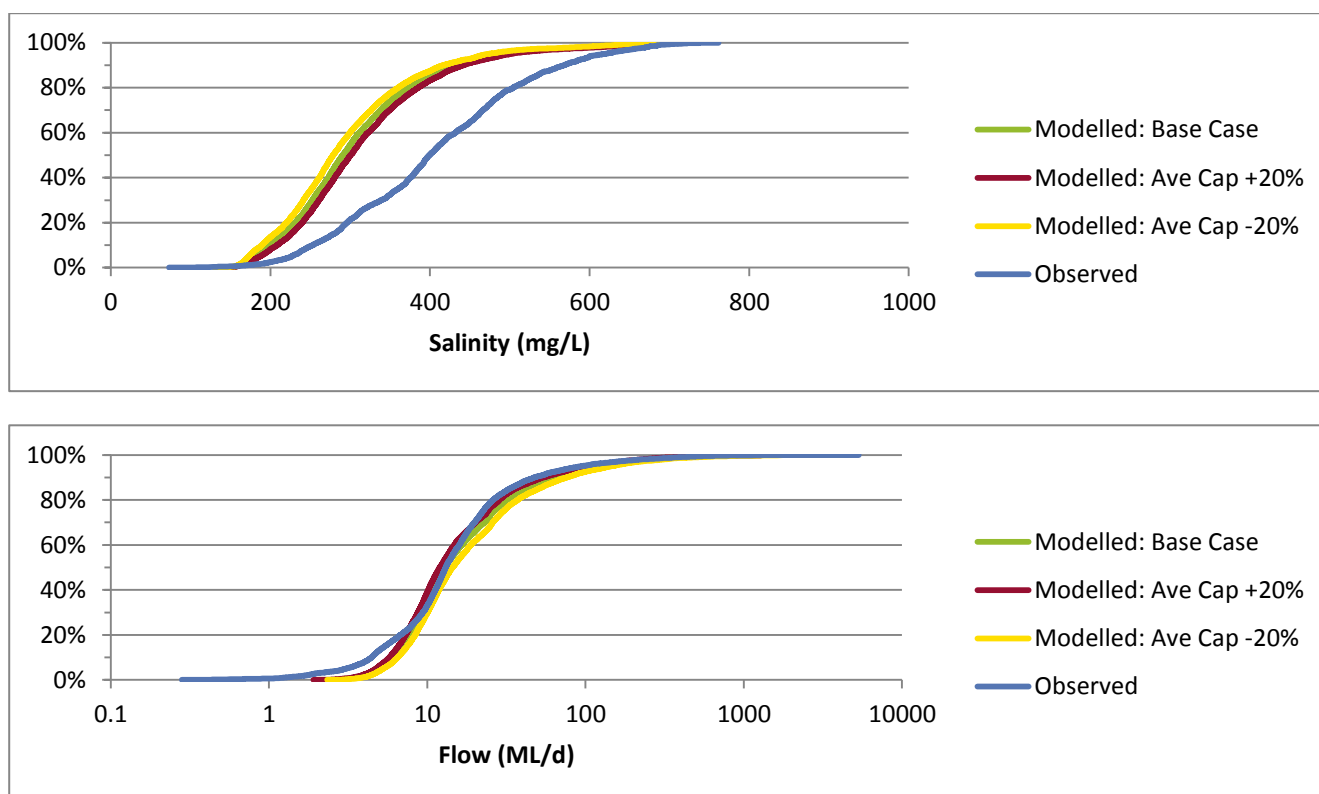


Figure 3.40 : Sensitivity Analysis (Average Soil Storage Capacity) Distribution Plot at #047 (Coxs River above Lake Wallace)

For Lake Lyell, Node #174, Figure 3.41 presents the time-series model output, including modelled storage volume (ML). Figure 3.42 presents the distribution plot of that data and is summarised in Table 3.23.

From Figure 3.41, the average soil storage capacity has minor effect on modelled salinity in Lake Lyell (Node #174), which is confirmed in Figure 3.42 and Table 3.23. From Figure 3.41, modelled storage volume (ML) is, however, quite sensitive to average soil storage capacity, which is expected.

Table 3.23 : Sensitivity Analysis (Average Soil Storage Capacity) Daily Statistics at #174 (Lake Lyell) - Salinity

Percentile	OBSD (mg/L)	CAL (mg/L)	SEN (mg/L) +20% Increase	SEN (mg/L) -20% Decrease
Minimum	59	154	155	152
5%	114	180	178	176
10%	129	211	216	205
20%	192	242	250	233
50%	295	292	301	281
80%	428	368	391	343
90%	471	403	451	365
95%	500	438	523	400
Maximum	634 (n=242)	795 (n=242)	916 (n=242)	468 (n=242)

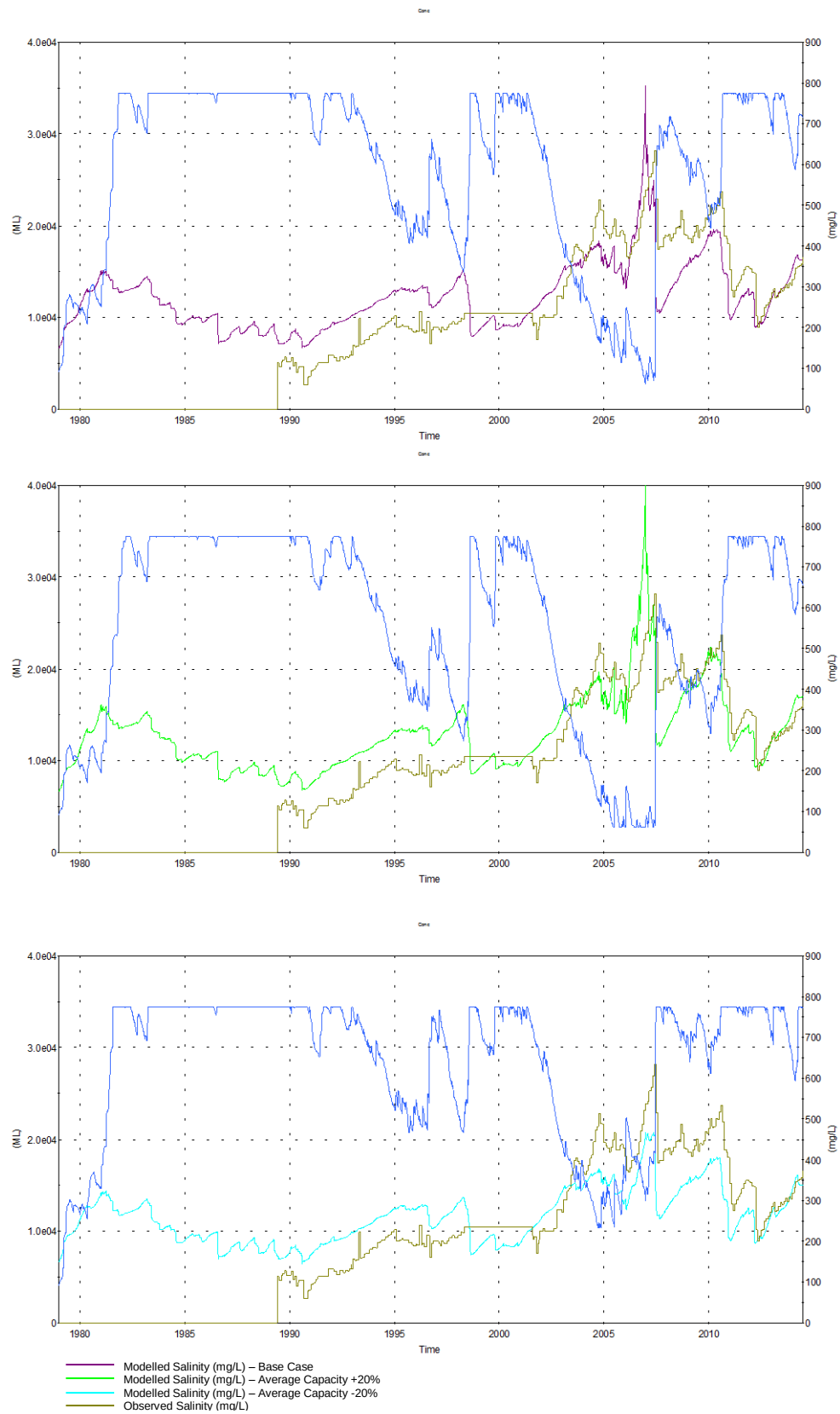


Figure 3.41 : Sensitivity Analysis (Average Soil Storage Capacity) Time-Series Chart at #174 (Lake Lyell)

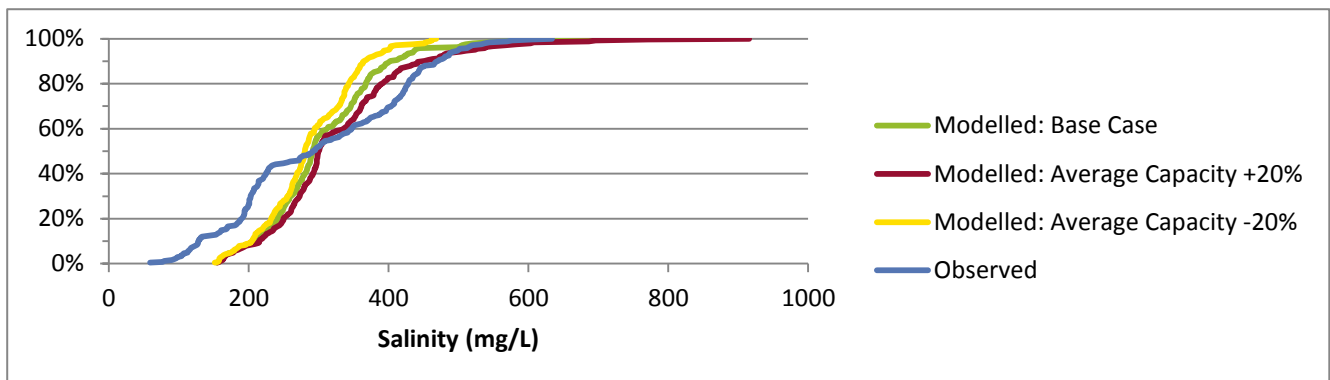


Figure 3.42 : Sensitivity Analysis (Average Soil Storage Capacity) Distribution Plot at #174 (Lake Lyell)

3.3.3 Change to Baseflow Index

This scenario analysis condition comprised a 20% increase and decrease in the baseflow index. As illustrated in Figure 3.1, the Baseflow Index, BFI, partitions rainfall excess to the baseflow and surface store. For the calibration simulation, a BFI of 0.25 meant that 25% of rainfall excess was diverted to the baseflow store. The baseflow store is then depleted in accordance with the daily recession constant, K_b .

The model control files for these simulations are:

- 002a_SEN-BFId-Jun14_01a.gsm
- 002a_SEN-BFId-Jun14_01a.gsm

Figure 3.43 and Figure 3.44 presents the time-series model output with respect to the base calibration case, and the sensitivity analysis conditions at Node #047. Figure 3.45 presents the distribution plot and is summarised in Table 3.24 and Table 3.25.

From Figure 3.43, Figure 3.44 and Figure 3.45, model output shows minor sensitivity with respect to salinity as well as flow. Modelled median salinity in Table 3.24 is 283mg/L (decline of 2.7%) and 300mg/L (increase of 3.1%) at Node #047, compared to the base calibration median of 291mg/L. From Table 3.25, modelled median flow at Node #047 is 14.0ML/d (increase of 7.7%) and 11.9ML/d (decline of 8.5%).

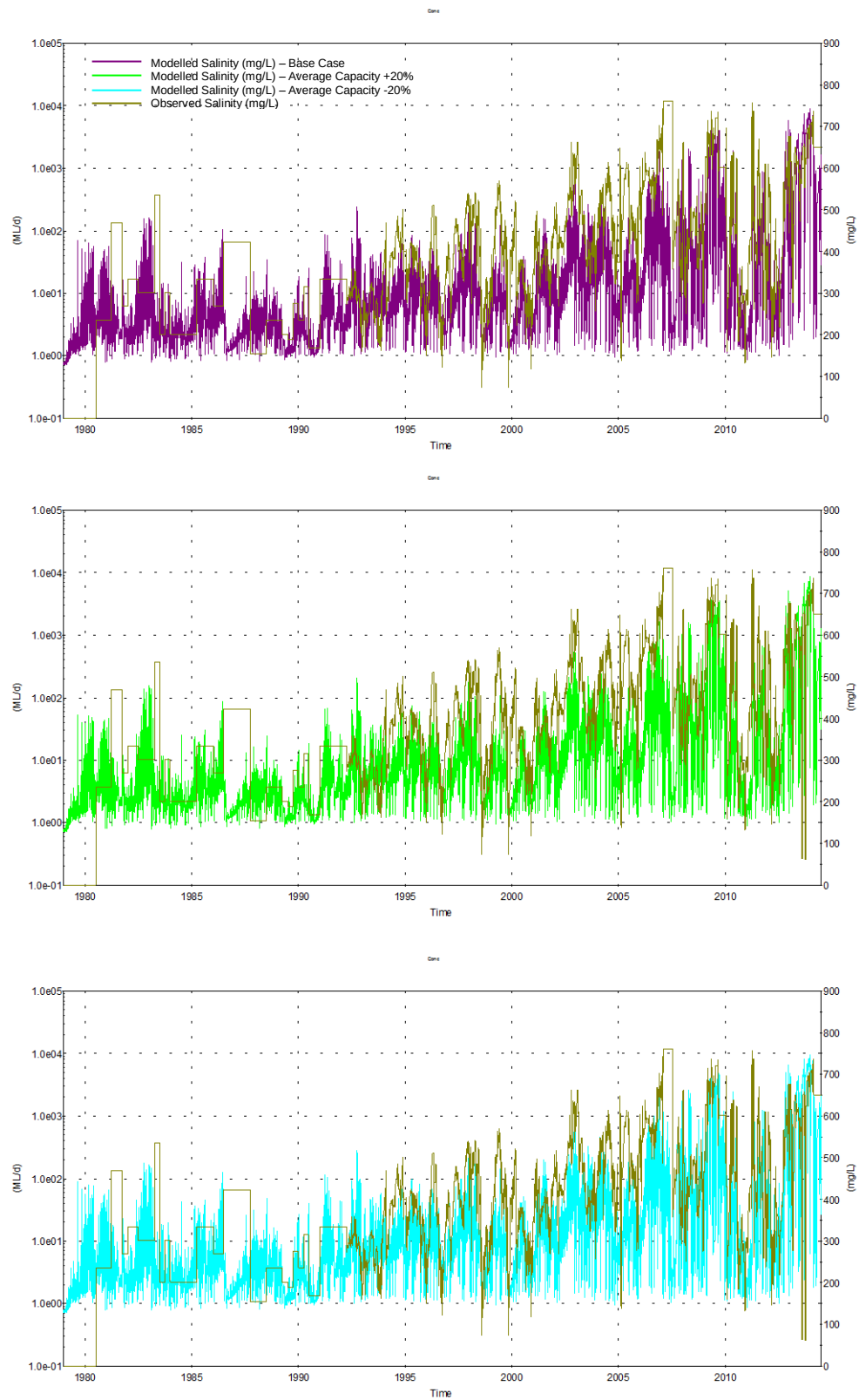


Figure 3.43 : Sensitivity Analysis (Baseflow Index) Time-Series Chart at #047 (Coxs River above Lake Wallace) - Salinity

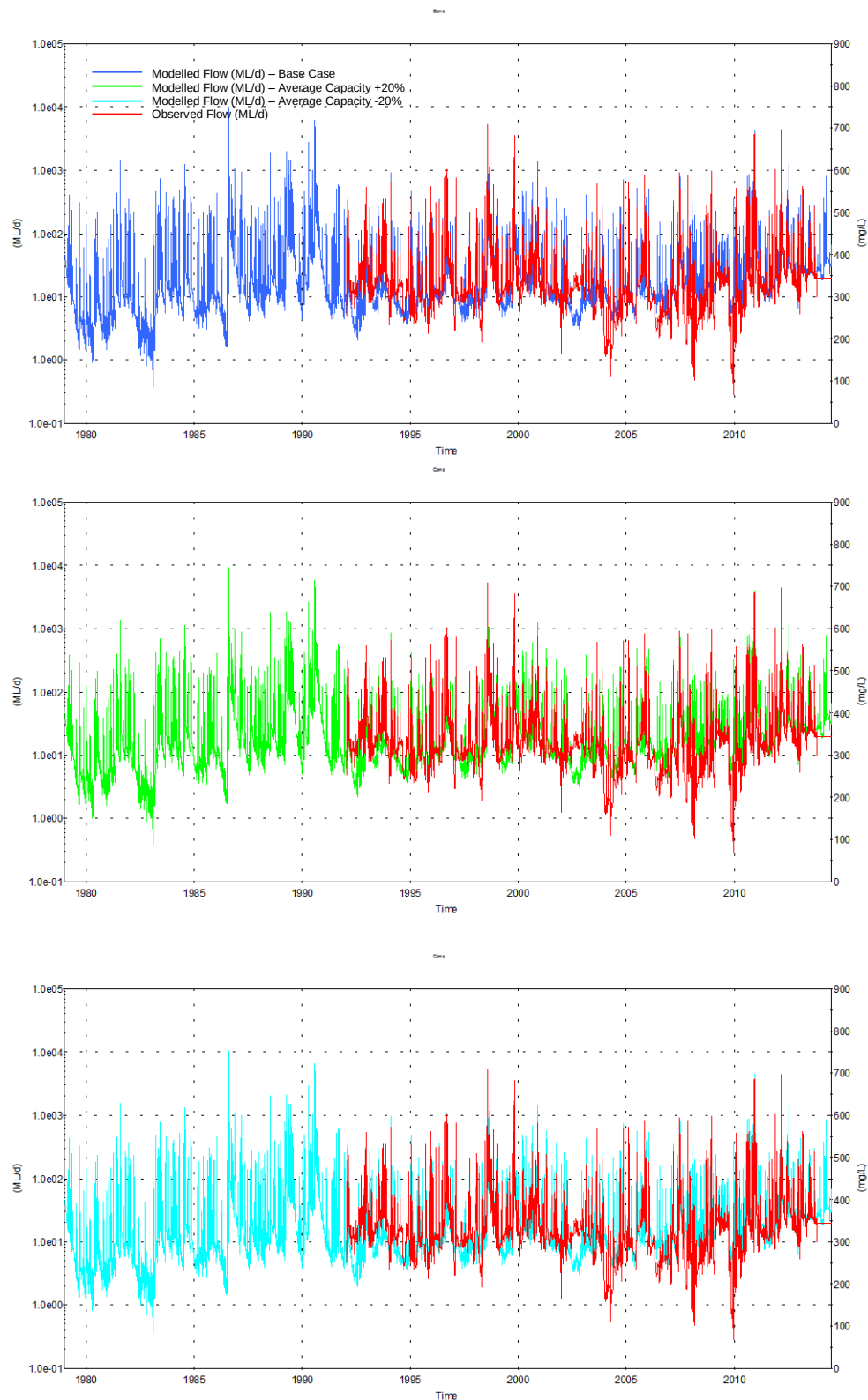


Figure 3.44 : Sensitivity Analysis (Baseflow Index) Time-Series Chart at #047 (Coxs River above Lake Wallace) – Flow

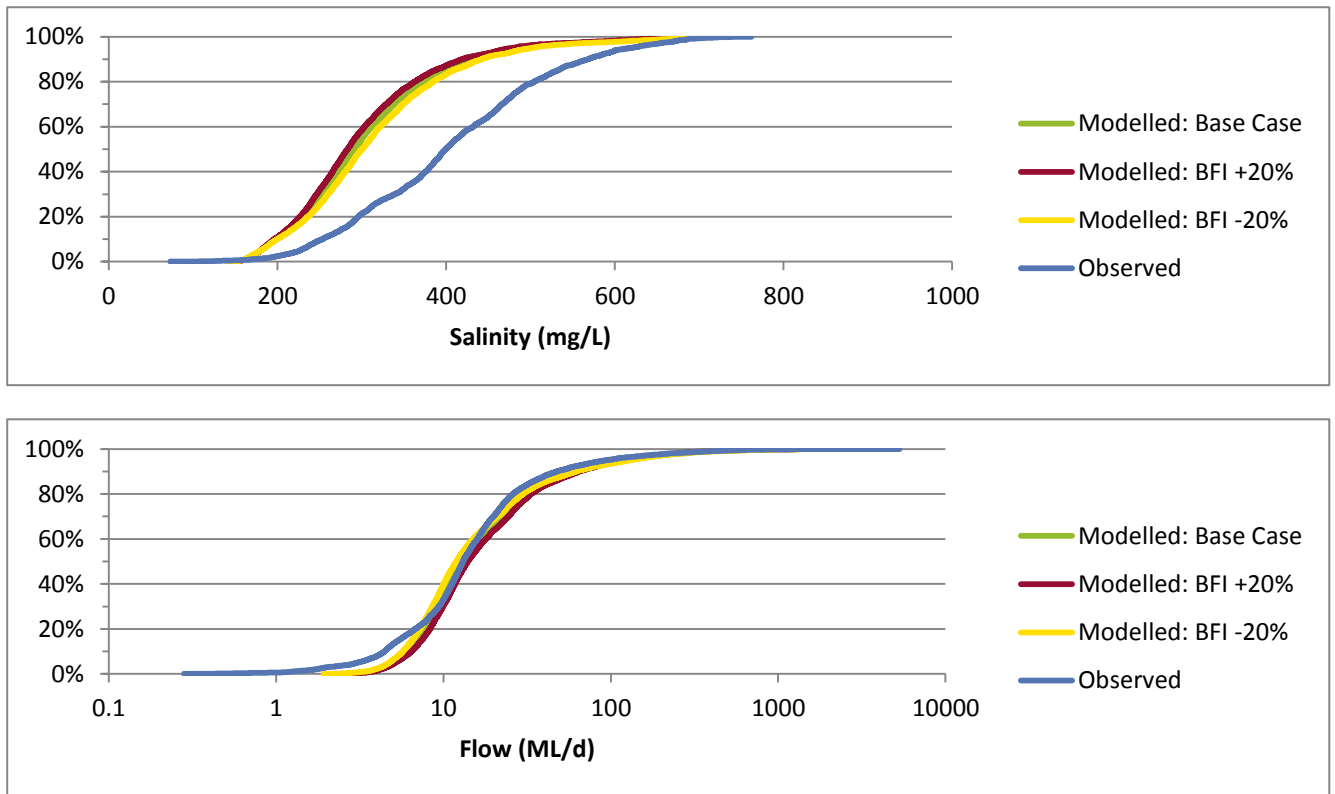


Figure 3.45 : Sensitivity Analysis (Baseflow Index) Distribution Plot at #047 (Coxs River above Lake Wallace)

Table 3.24 : Sensitivity Analysis (Baseflow Index) Daily Statistics at #047 (Coxs River above Lake Wallace) – Salinity

Percentile	OBSD (mg/L)	CAL (mg/L)	SEN (mg/L) +20% Increase	SEN (mg/L) -20% Decrease
Minimum	73	141	141	140
5%	227	180	180	180
10%	253	198	196	200
20%	296	231	227	236
50%	399	291	283	300
80%	504	373	363	384
90%	568	429	419	442
95%	620	487	478	501
Maximum	762 (n=5,280)	733 (n=5,280)	728 (n=5,280)	737 (n=5,280)

Table 3.25 : Sensitivity Analysis (Baseflow Index) Daily Statistics at #047 (Coxs River above Lake Wallace) – Flow

Percentile	OBSD (ML/d)	CAL (ML/d)	SEN (ML/d) +20% Increase	SEN (ML/d) -20% Decrease
Minimum	0.3	2.0	2.2	1.9
5%	3.1	5.0	5.2	4.7
10%	4.5	6.1	6.4	5.7
20%	6.8	7.8	8.3	7.3
50%	13.1	13.0	14.0	11.9
80%	26.1	31.8	33.3	30.0
90%	47.7	63.1	64.7	62.1
95%	94.7	126.4	120.9	130.2
Maximum	5,321 (n=7,906)	4,318 (n=7,906)	4,053 (n=7,906)	4,584 (n=7,906)

For Lake Lyell, Node #174, Figure 3.46 presents the time-series model output, including modelled storage volume (ML). Figure 3.47 presents the distribution plot of that data and is summarised in Table 3.26.

From Figure 3.46, the baseflow index has minor effect on modelled salinity and modelled storage volume (ML) in Lake Lyell (Node #174), which is confirmed in Figure 3.47 and Table 3.26. The Baseflow Index also has a minor effect on modelled storage volume (ML).

Table 3.26 : Sensitivity Analysis (Baseflow Index) Daily Statistics at #174 (Lake Lyell) – Salinity

Percentile	OBSD (mg/L)	CAL (mg/L)	SEN (mg/L) +20% Increase	SEN (mg/L) -20% Decrease
Minimum	59	154	154	154
5%	114	180	179	179
10%	129	211	211	211
20%	192	242	243	243
50%	295	292	293	291
80%	428	368	367	367
90%	471	403	417	395
95%	500	438	451	445
Maximum	634 (n=242)	795 (n=242)	864 (n=242)	570 (n=242)

3.3.4 Summary

In summary, sensitivity analysis indicates that assumed salinity of runoff from various land-use classes is moderately important to model prediction with respect to salinity, but is dominated by assumed water quality of mine water discharge, as would be expected. Sensitivity analysis results of changes to AWBM parameters indicate minimal impact to modelled salinity and minor impact to modelled flow, although modelled storage is moderately impacted with respect to assumed average soil storage capacity.

Although each of the sensitivity analysis scenarios leads to deviation of the model from the adopted calibration, the magnitude of deviation is acceptably small. Accordingly, the sensitivity analysis conditions were adopted in the uncertainty analysis, together with the original climatic uncertainty simulation.



Figure 3.46 : Sensitivity Analysis (Baseflow Index) Time-Series Chart at #174 (Lake Lyell)

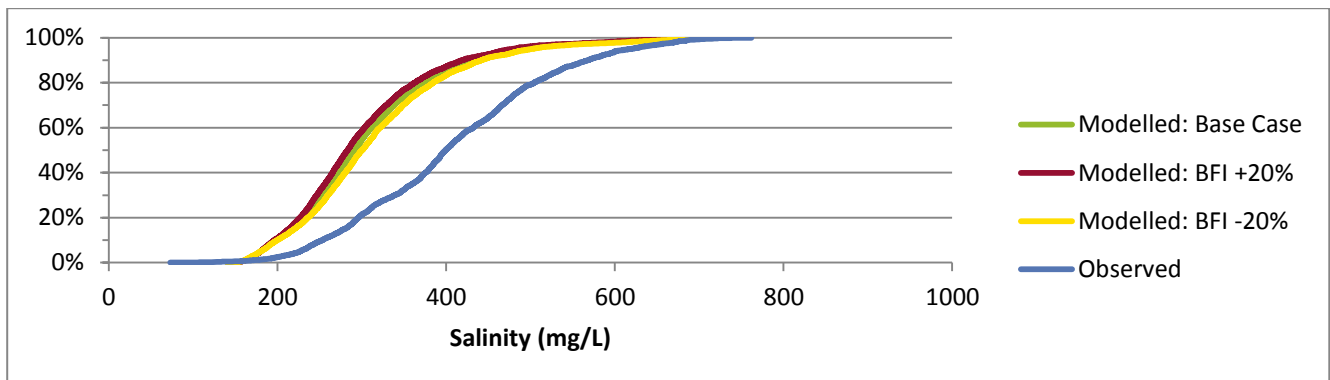


Figure 3.47 : Sensitivity Analysis (Baseflow Index) Distribution Plot at #174 (Lake Lyell)

3.4 Model Predictions

3.4.1 Model Setup

The prediction simulation extends from 1 July 2014 through to 31 December 2032. As presented in RPS (2014a), the rainfall dataset was reviewed and a period of median rainfall conditions was selected from the climatic record, based on 19 year totals of annual rainfall. The 50th percentile 19 year rainfall total corresponds with the period 1987 to 2005. Daily rainfall and evaporation climatic data was then applied from that period.

In the climatic uncertainty analysis scenarios, the Low Rainfall Condition (10th percentile, lowest 19 year rainfall total) was 1993 to 2011, and the High Rainfall Condition (90th percentile, highest 19 year rainfall total) was 1981 to 1999.

As presented in RPS (2014a), the prediction model was updated from the calibration model to account for changes in land-use within the catchment, predicted groundwater discharge from other mining operations including Centennial's Neubecks Open Cut, EnergyAustralia's Pine Dale Coal Mine as well as proposed mine water discharge at Angus Place Colliery and Springvale Mine.

It is noted that storage volumes, including mass, within each reservoir at the end of the calibration period were adopted as initial conditions in the prediction simulations. For uncertainty analysis condition simulations, the initial condition was obtained from the relevant sensitivity analysis simulation. The surface storage and baseflow storage within the AWBM calculation modules were also transcribed to the prediction and uncertainty analysis simulations.

Since the time of the previous RWQIAM report, Angus Place Colliery has been placed into Care & Maintenance. Accordingly, there are now two families of model predictions presented in this report:

- Concurrent Implementation
 - Both Angus Place Colliery and Springvale Mine implemented as per the EIS
- Sequential Implementation
 - Springvale Mine implemented as per the EIS, with Angus Place Colliery implemented following completion of work at Springvale Mine.

The modelled groundwater inflows for Angus Place Colliery in the Sequential Implementation were obtained from updated predictions from the COSFLOW groundwater model.

There are two water management strategies proposed with respect to the extension of Angus Place Colliery and Springvale Mine. These consist:

- Water Strategy WS1 – Angus Place Colliery discharging all mine water make at Angus Place via Angus Place LDP001 and Springvale Mine discharging all mine water make at Springvale via Springvale LDP009

- Water Strategy WS2a – Angus Place Colliery discharging to Springvale LDP009 via existing SDWTS pipeline, to the extent available, with excess discharged through Angus Place LDP001
- Water Strategy WS2b – Angus Place discharging to Springvale LDP009, with upgrade of the SDWTS pipeline to 50ML/d when combined mine water make exceeds 30ML/d, with discharge through Angus Place LDP001 at 2.0ML/d.

To reduce the complexity of this report, simulations of Water Strategy WS1, WS2a and WS2b are presented as 'base' predictions, however, assessment of potential Treatment Options and End of Pipe Targets are only presented with respect to WS2b. As noted in RPS (2014a), model results once downstream of confluence of Coxs River with Sawyers Swamp Creek are identical with respect to each strategy, WS1, WS2a and WS2b. Figure 3.50 presents assumed mine water discharge at Angus Place LDP001 and Springvale LDP009 of each water management strategy with respect to the concurrent implementation.

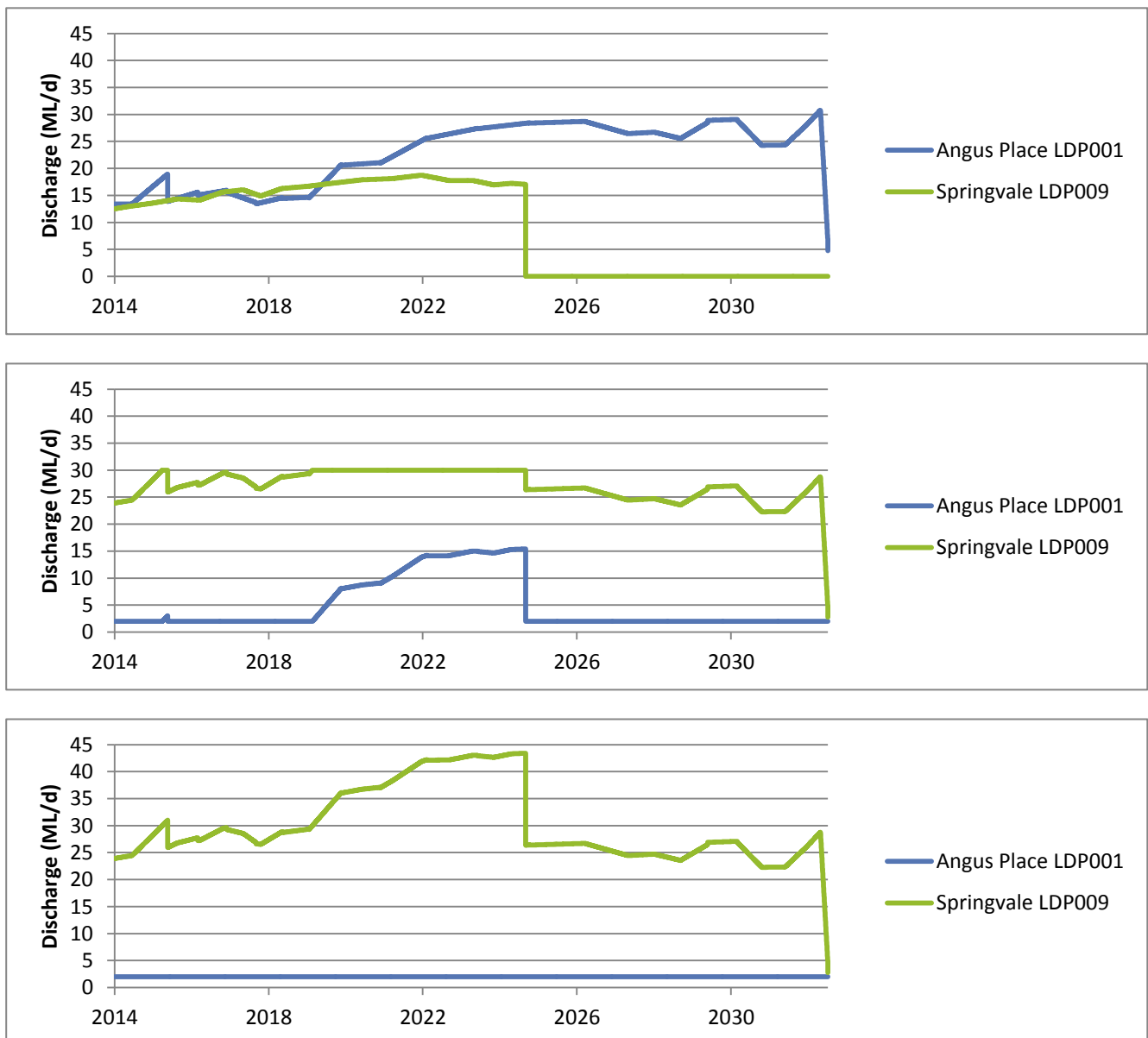


Figure 3.48 : Modelled Mine Water Discharge – Concurrent Implementation

Figure 3.49 presents the assumed mine water discharge of each water management strategy with respect to the sequential implementation.

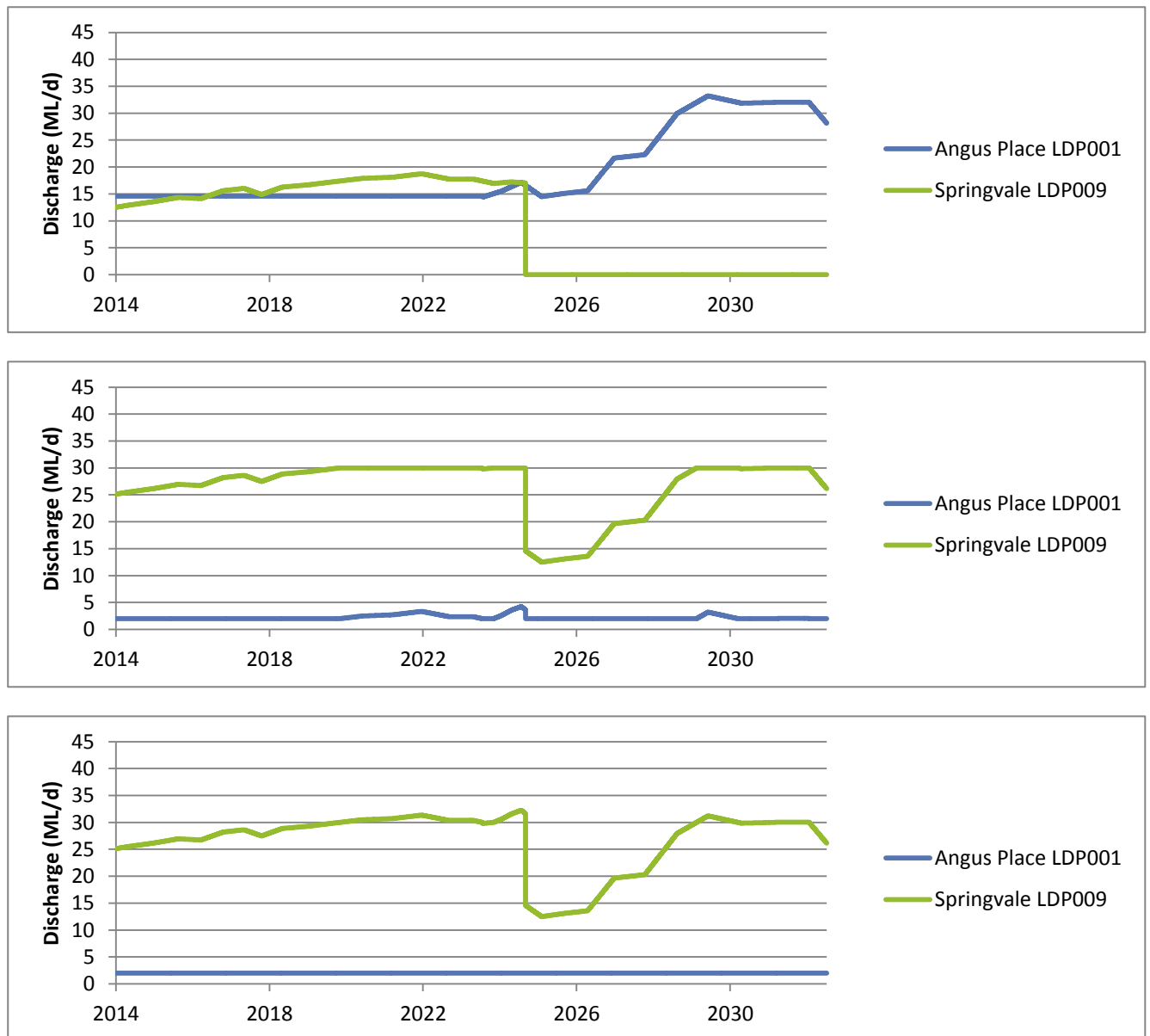


Figure 3.49 : Modelled Mine Water Discharge – Sequential Implementation

3.4.2 Prediction Results

The model control file pertaining to the prediction simulations are:

Concurrent Implementation

- 002a_PRD-WS1_03a.gsm
- 002a_PRD-WS1_03a_NUL.gsm
- 002a_PRD-WS2a_02a.gsm
- 002a_PRD-WS2b_02a.gsm

Sequential Implementation

- 002a_PRD-WS1-S_01a.gsm
- 002a_PRD-WS2a-S_01a.gsm
- 002a_PRD-WS2b-S_01a.gsm

It is noted that daily statistics for OBSD in respective results tables below are based on analysis of observation record, as available.

It is highlighted that the NUL simulation presents the predicted flow and salinity in the circumstance of both Angus Place Colliery and Springvale Mine extension projects not proceeding. As such, comparison of the prediction simulation and the NUL case presents the impact due to the Proposal.

Kangaroo Creek and Coxs River above Wangcol Creek / Blue Lagoon

Time-series prediction simulation in Kangaroo Creek at Node #011 is presented in Figure 3.50. A distribution plot of model output is presented in Figure 3.51, and is summarised in Table 3.27 and Table 3.28.

From Figure 3.51, predicted salinity in Kangaroo Creek during WS1 and WS1-S is consistently higher than the observation record, with modelled median being 788 and 784mg/L compared to 612mg/L. For WS2a and WS2b, predicted salinity distribution is essentially consistent with the observation record.

There is no flow gauging at Node #011. Review of Figure 3.51 indicates that proposed mine water discharge does dominate predicted flows in Kangaroo Creek under the NUL case. Median flow in WS1 is 26.4ML/d and 16.8ML/d in WS1-S compared to 0.5ML/d in the NUL case. For WS2a and WS2b, median flows are 2 to 3ML/d.

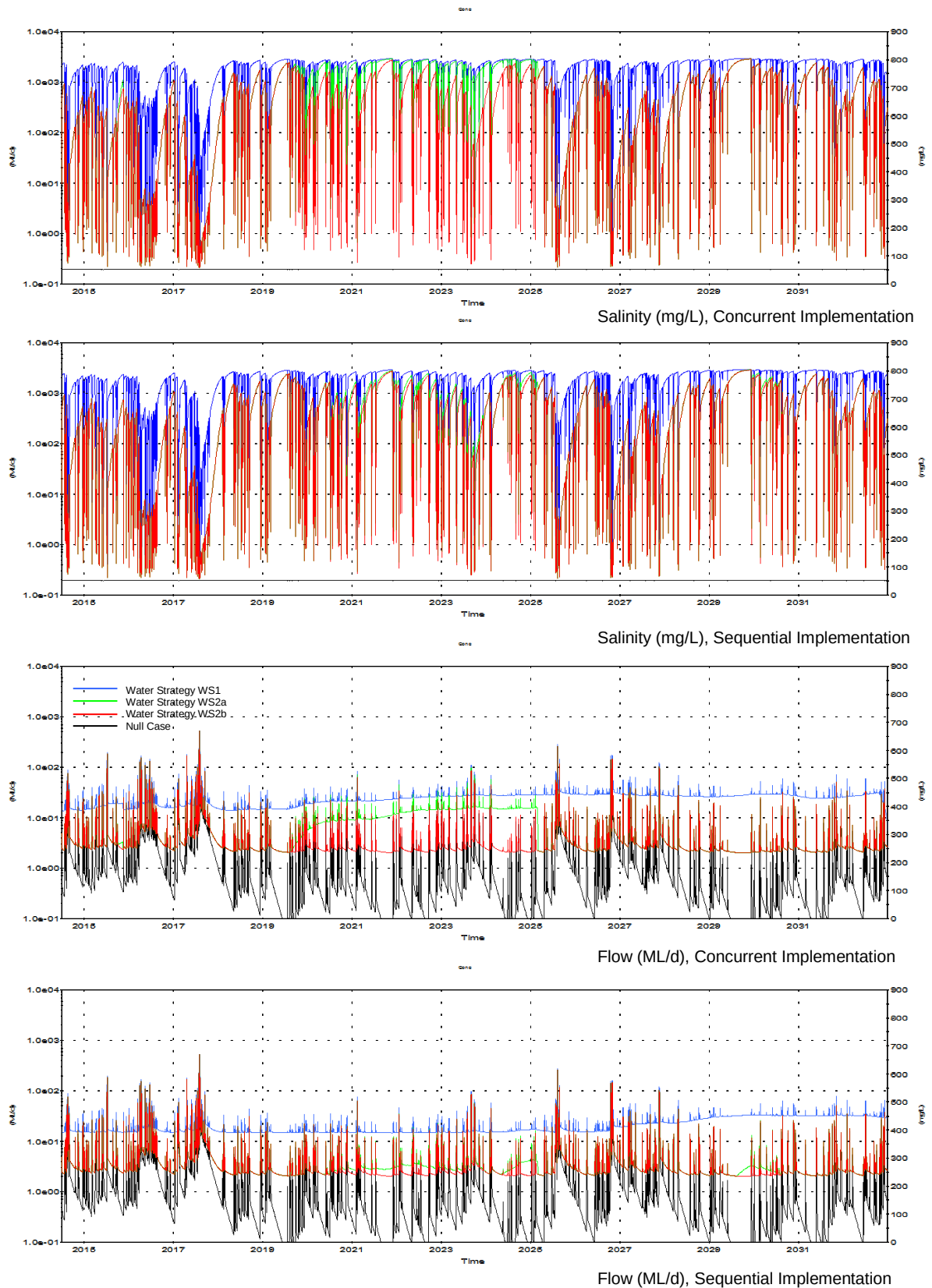


Figure 3.50 : Prediction Time-Series Chart at #011 (Kangaroo Creek, downstream of Angus Place LDP001)

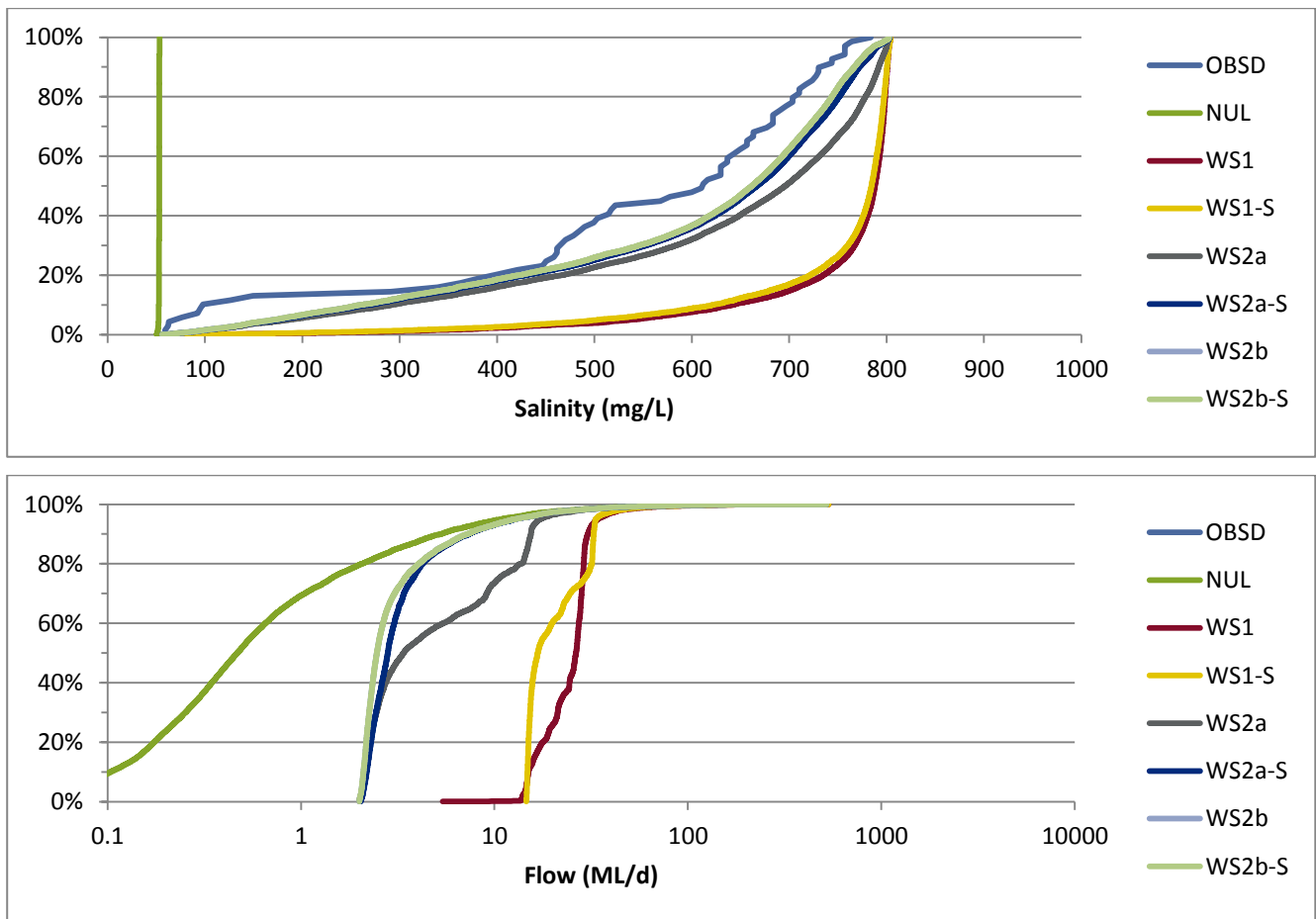


Figure 3.51 : Prediction Distribution Plot at #011 (Kangaroo Creek, downstream of Angus Place LDP001)

Table 3.27 : Prediction Daily Statistics at #011 (Kangaroo Creek, downstream of Angus Place LDP001) – Salinity (mg/L)

Percentile	OBSD	NUL	WS1	WS1-S	WS2a	WS2a-S	WS2b	WS2b-S
Minimum	59	50	74	74	56	56	56	56
5%	83	52	537	504	187	176	170	170
10%	120	53	642	622	292	268	260	259
20%	413	53	735	721	467	430	422	422
50%	612	53	788	784	696	667	662	662
80%	706	53	799	797	778	751	744	744
90%	733	53	801	800	792	772	767	767
95%	757	53	802	802	798	786	780	780
Maximum	784 (n=69)	53	804	804	803	803	803	803

Table 3.28 : Prediction Daily Statistics at #011 (Kangaroo Creek, downstream of Angus Place LDP001) – Flow (ML/d)

Percentile	OBSD	NUL	WS1	WS1-S	WS2a	WS2a-S	WS2b	WS2b-S
Minimum	n/a	0.0	5.4	14.6	2.0	2.0	2.0	2.0
5%	n/a	0.1	14.6	14.7	2.1	2.1	2.1	2.1
10%	n/a	0.1	15.0	14.8	2.2	2.2	2.1	2.1
20%	n/a	0.2	17.8	15.0	2.3	2.3	2.2	2.2
50%	n/a	0.5	26.4	16.8	3.4	2.8	2.5	2.5
80%	n/a	2.1	29.0	31.9	13.6	4.2	4.1	4.1
90%	n/a	5.3	30.4	32.6	15.4	7.4	7.3	7.3
95%	n/a	10.8	34.3	33.4	17.3	12.9	12.8	12.8
Maximum	n/a	519.5	534.6	534.1	521.5	521.5	521.5	521.5

The time-series chart for Node #056 is presented in Figure 3.52. This node is located on the Coxs River above the confluence with Wangcol Creek and is the site of Angus Place Colliery monitoring station, AP_COXS_DOWNSTREAM. Figure 3.53 presents the distribution plot of the prediction simulation output, and is summarised in Table 3.29 and Table 3.30.

From Figure 3.53, WS1 and WS1-S have modelled median salinity of 747 and 736mg/L, in comparison to median salinity from observation record of 345mg/L. The modelled salinity distribution in WS2a and WS2b is more consistent with the observation record than WS1.

Modelled flow in WS1 and WS1-S is higher than WS2a and WS2b water management strategies, being 28.0 and 21.4ML/d compared to 3.8 to 7.1ML/d. There is no observation of flow at this model node; however, median flow in the NUL case is 1.8ML/d, by comparison.

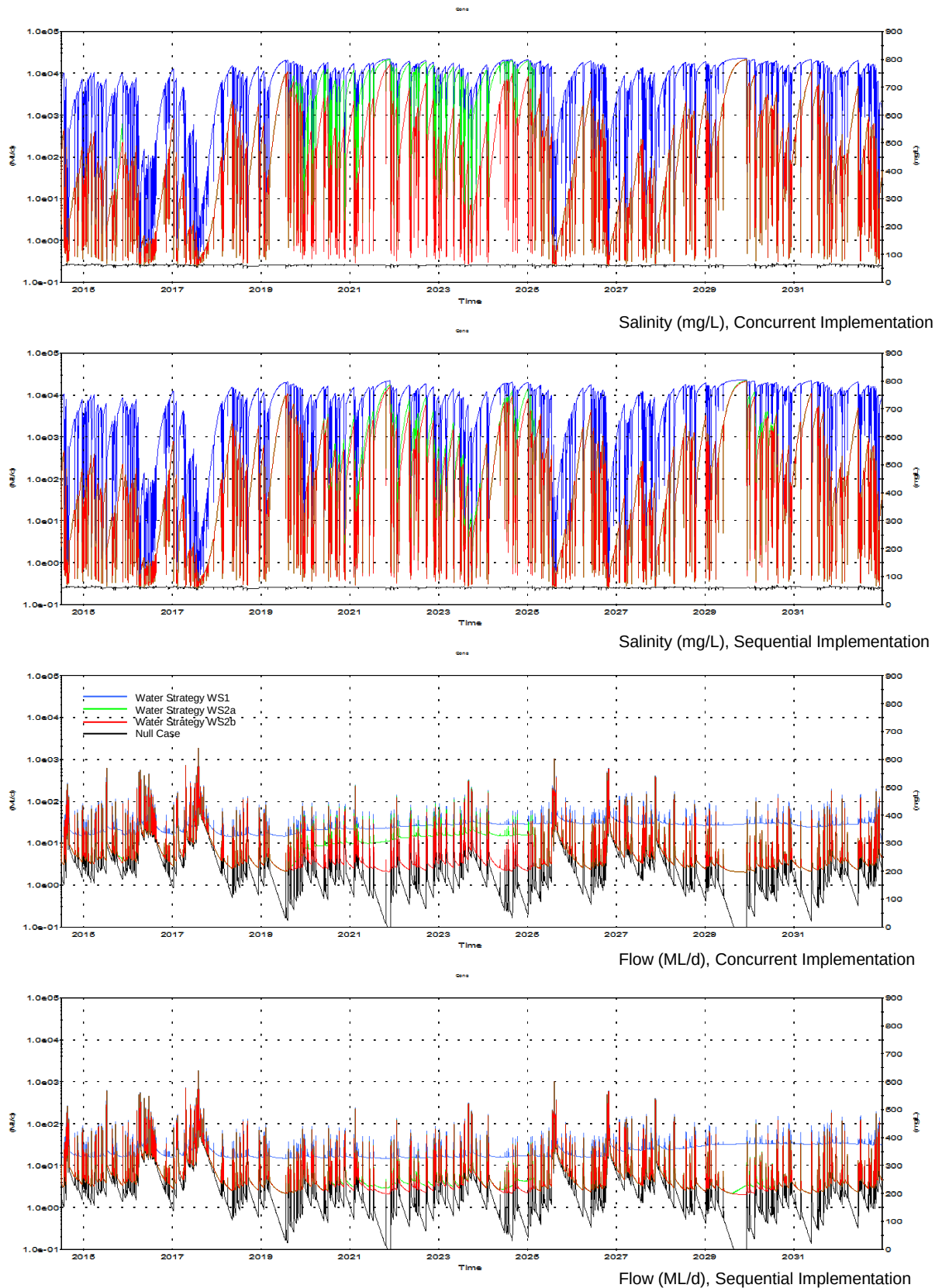


Figure 3.52 : Prediction Time-Series Chart at #056 (Coxs River above Wangcol Creek / Blue Lagoon)

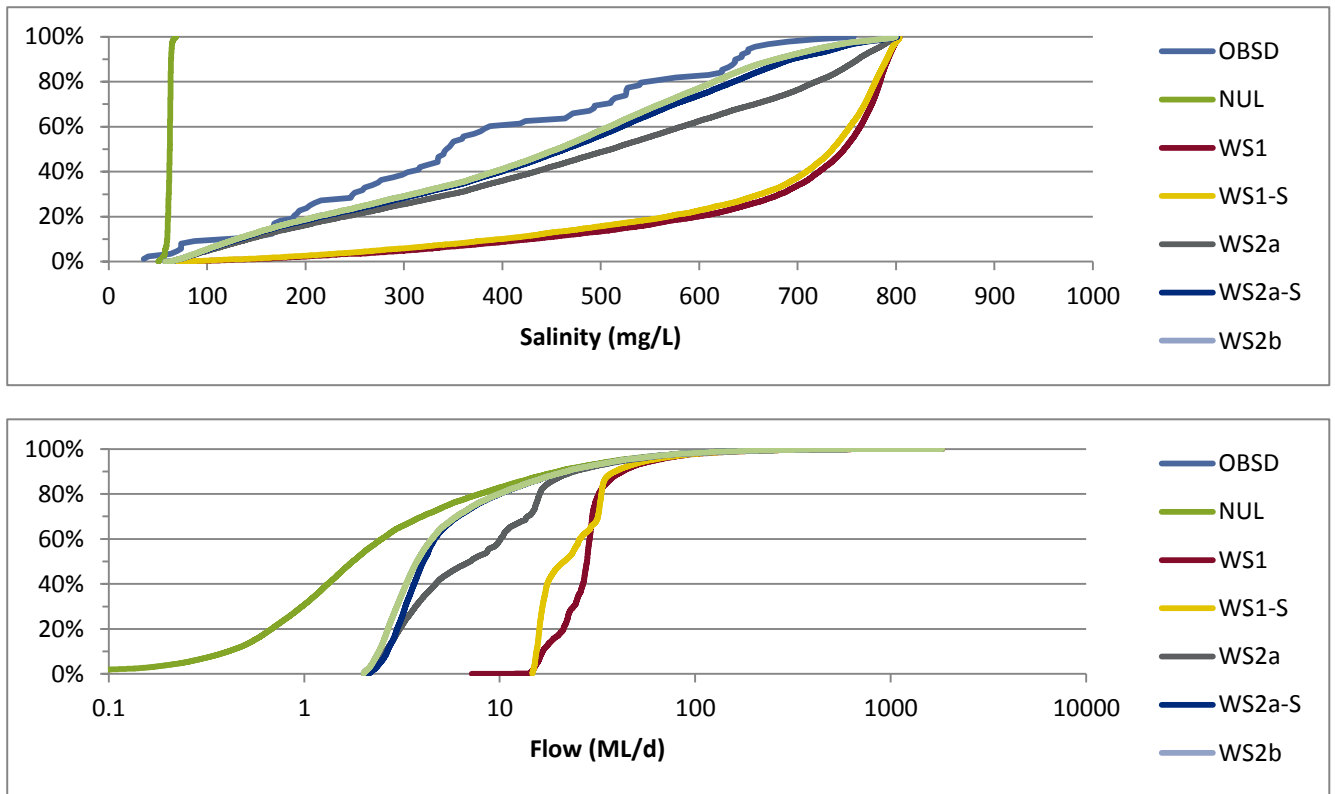


Figure 3.53 : Prediction Distribution Plot at #056 (Coxs River above Wangcol Creek / Blue Lagoon)

Table 3.29 : Prediction Daily Statistics at #056 (Coxs River above Wangcol Creek / Blue Lagoon) – Salinity (mg/L)

Percentile	OBSD	NUL	WS1	WS1-S	WS2a	WS2a-S	WS2b	WS2b-S
Minimum	36	50	70	70	57	57	57	57
5%	74	57	303	274	102	99	97	97
10%	146	59	429	397	142	132	129	129
20%	190	60	599	568	240	215	211	211
50%	345	62	747	736	511	464	455	455
80%	552	63	784	779	719	635	615	615
90%	639	63	792	790	762	694	678	678
95%	654	64	797	796	782	741	724	724
Maximum	757 (n=88)	69	804	804	800	801	800	800

Table 3.30 : Prediction Daily Statistics at #056 (Coxs River above Wangcol Creek / Blue Lagoon) – Flow (ML/d)

Percentile	OBSD	NUL	WS1	WS1-S	WS2a	WS2a-S	WS2b	WS2b-S
Minimum	n/a	0.0	7.2	14.7	2.0	2.1	2.0	2.0
5%	n/a	0.2	15.6	15.1	2.4	2.5	2.2	2.2
10%	n/a	0.4	16.6	15.4	2.6	2.7	2.4	2.4
20%	n/a	0.7	21.2	16.0	3.1	3.0	2.7	2.7
50%	n/a	1.8	28.0	21.4	7.1	4.1	3.8	3.8
80%	n/a	7.9	32.2	33.1	16.0	10.0	9.9	9.9
90%	n/a	19.9	42.4	38.9	24.2	22.0	21.9	21.9
95%	n/a	40.3	62.9	58.6	45.5	42.3	42.3	42.3
Maximum	n/a	1,830	1,846	1,845	1,832	1,832	1,832	1,832

Sawyers Swamp Creek

Node #166 is located on the Sawyers Swamp Creek immediately above the Coxs River. This node is understood to correspond with Centennial Western Coal Services monitoring location WCS_LDP003_DOWNSTREAM. Sawyers Swamp Creek receives mine water discharge via Springvale LDP009 further up the catchment. Springvale LDP009 is located adjacent Sawyers Swamp Creek Ash Dam.

Figure 3.54 presents the time-series predicted salinity and flow in Sawyers Swamp Creek at Node #166. Figure 3.55 presents the distribution plot, and is summarised in Table 3.31 and Table 3.32.

From Figure 3.55, proposed discharge to Sawyers Swamp Creek leads to predicted median salinity ranging between 716 and 715mg/L in WS1 and WS1-S respectively to 798mg/L in WS2a, WS2a-S, WS2b and WS2b-S. From Table 3.32, proposed discharge does dominate flows in Sawyers Swamp Creek.

There has been mine water discharge to Sawyers Swamp Creek since 2006, as presented in Jacobs (2014). Figure 3.13 indicates the fit of the calibration model to observed data was not particularly close, with the model under-estimating salinity. Predicted salinity presented in Figure 3.54 is essentially the same as the assumed salinity of mine water discharge of 804mg/L.

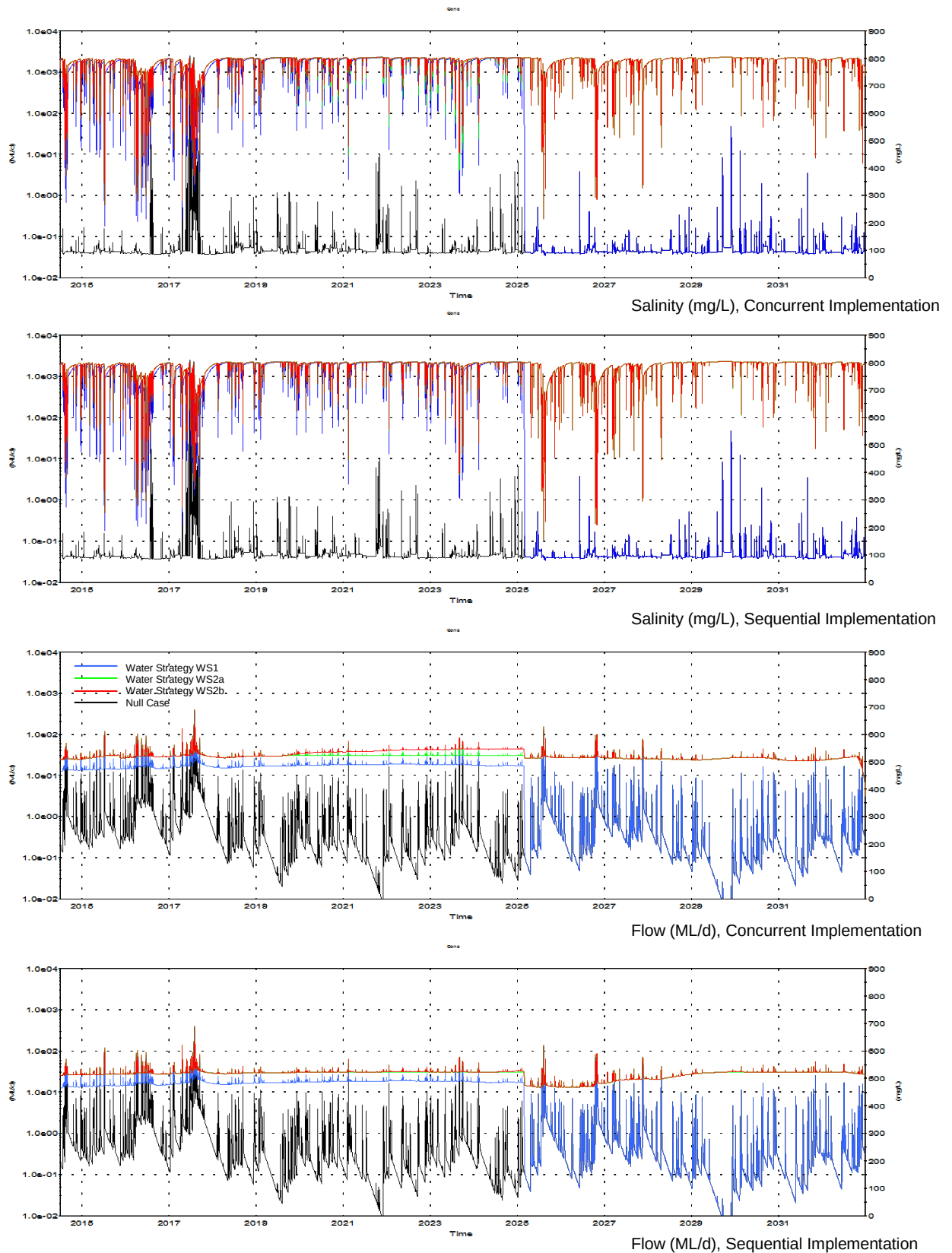


Figure 3.54 : Prediction Time-Series Chart at #166 (Sawyers Swamp Creek above Coxs River)

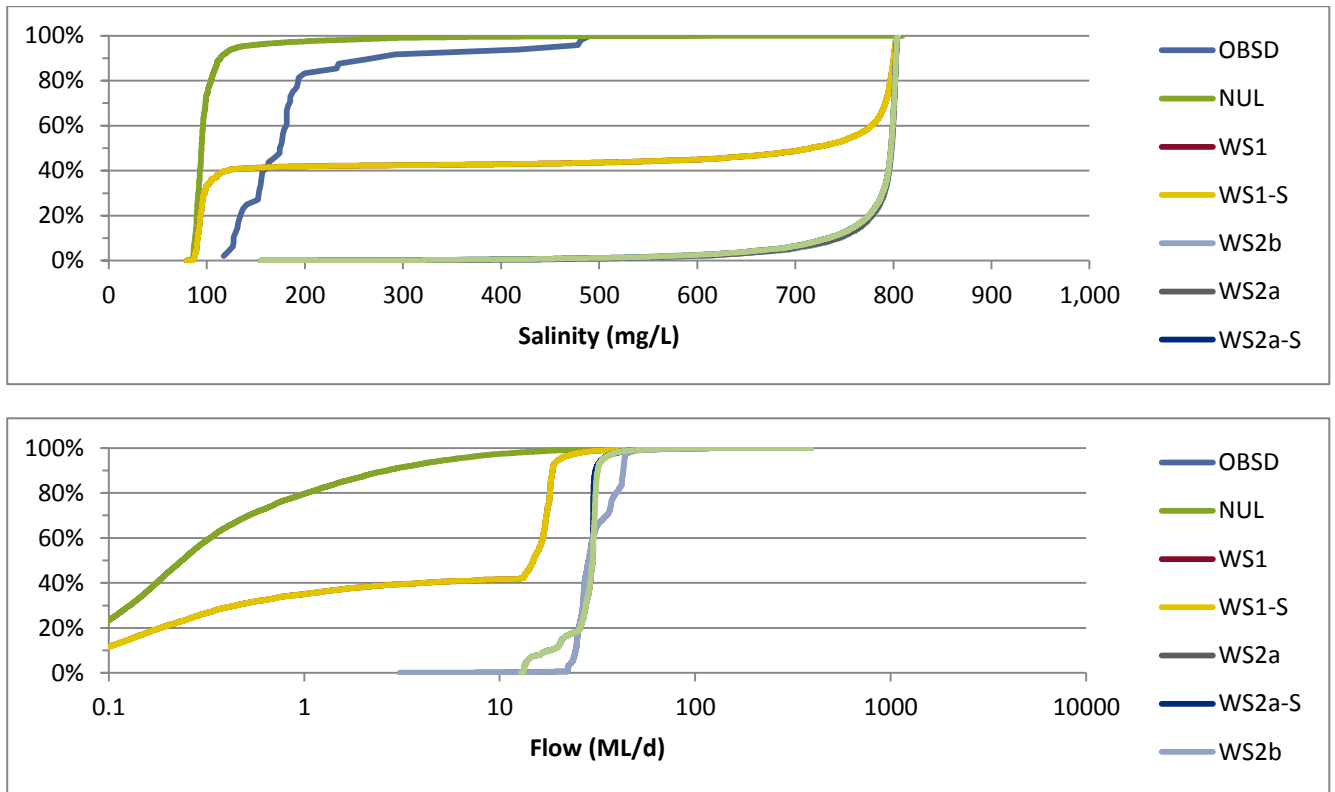


Figure 3.55 : Prediction Distribution Plot at #166 (Sawyers Swamp Creek above Coxs River)

Table 3.31 : Prediction Daily Statistics at #166 (Sawyers Swamp Creek above Coxs River) – Salinity (mg/L)

Percentile	OBSD	NUL	WS1	WS1-S	WS2a	WS2a-S	WS2b	WS2b-S
Minimum	117	79	79	79	214	155	214	155
5%	127	87	89	89	688	675	695	675
10%	129	88	91	91	743	733	745	733
20%	135	90	93	93	777	775	779	775
50%	175	95	716	715	798	798	798	798
80%	193	104	797	797	802	802	802	802
90%	272	114	800	800	803	803	803	803
95%	457	133	802	802	803	803	803	803
Maximum	490 (n=48)	809	806	806	805	805	805	805

Table 3.32 : Prediction Daily Statistics at #166 (Sawyers Swamp Creek above Coxs River) – Flow (ML/d)

Percentile	OBSD	NUL	WS1	WS1-S	WS2a	WS2a-S	WS2b	WS2b-S
Minimum	n/a	0.0	0.0	0.0	3.1	12.9	3.1	12.9
5%	n/a	0.0	0.1	0.1	23.5	13.7	23.5	13.7
10%	n/a	0.1	0.1	0.1	24.5	18.1	24.5	18.1
20%	n/a	0.1	0.2	0.2	25.4	25.9	25.4	25.9
50%	n/a	0.2	14.9	14.9	28.5	30.0	28.5	30.0
80%	n/a	1.0	18.1	18.1	30.2	30.2	39.5	30.9
90%	n/a	2.7	18.7	18.7	31.0	30.9	42.9	31.8
95%	n/a	5.8	20.3	20.3	33.7	33.6	43.5	33.8
Maximum	n/a	363.9	379.7	379.7	392.9	392.3	392.9	392.3

Lake Wallace

Figure 3.56 presents the time-series prediction of salinity and flow at Node #047. Node #047 corresponds with NSW Office of Water Station No. 212154 and is located immediately upstream of Lake Wallace. Figure 3.58 presents the distribution plot of the prediction simulation, and is summarised in Table 3.33. It is highlighted that prediction simulations WS1, WS2a and WS2b are identical below the confluence of Sawyers Swamp Creek with the Coxs River and therefore only WS1 is presented in Figure 3.56 and Figure 3.57 and equivalent figures below. The same applies for prediction simulation WS1-S compared to WS2a-S and WS2b-S.

Model results indicate median flow at Node #047 is 50.5ML/d and 43.8ML/d for simulation WS1 and WS1-S respectively. Median flow in the NUL case is 14.2ML/d and is comparable to median flow from the observation record of 13.1ML/d. Maximum flow at Node #047 is 5,321ML/d from the observation record and is 6,329ML/d in the NUL case. Modelled maximum flow in WS1 and WS1-S is 6,358ML/d.

Predicted median salinity is 706 and 699mg/L in simulation WS1 and WS1-S, in comparison to 399mg/L from the observation record. Predicted maximum salinity is 794 and 795mg/L (WS1 and WS1-S), however, is consistent with the maximum from the observation record of 762mg/L.

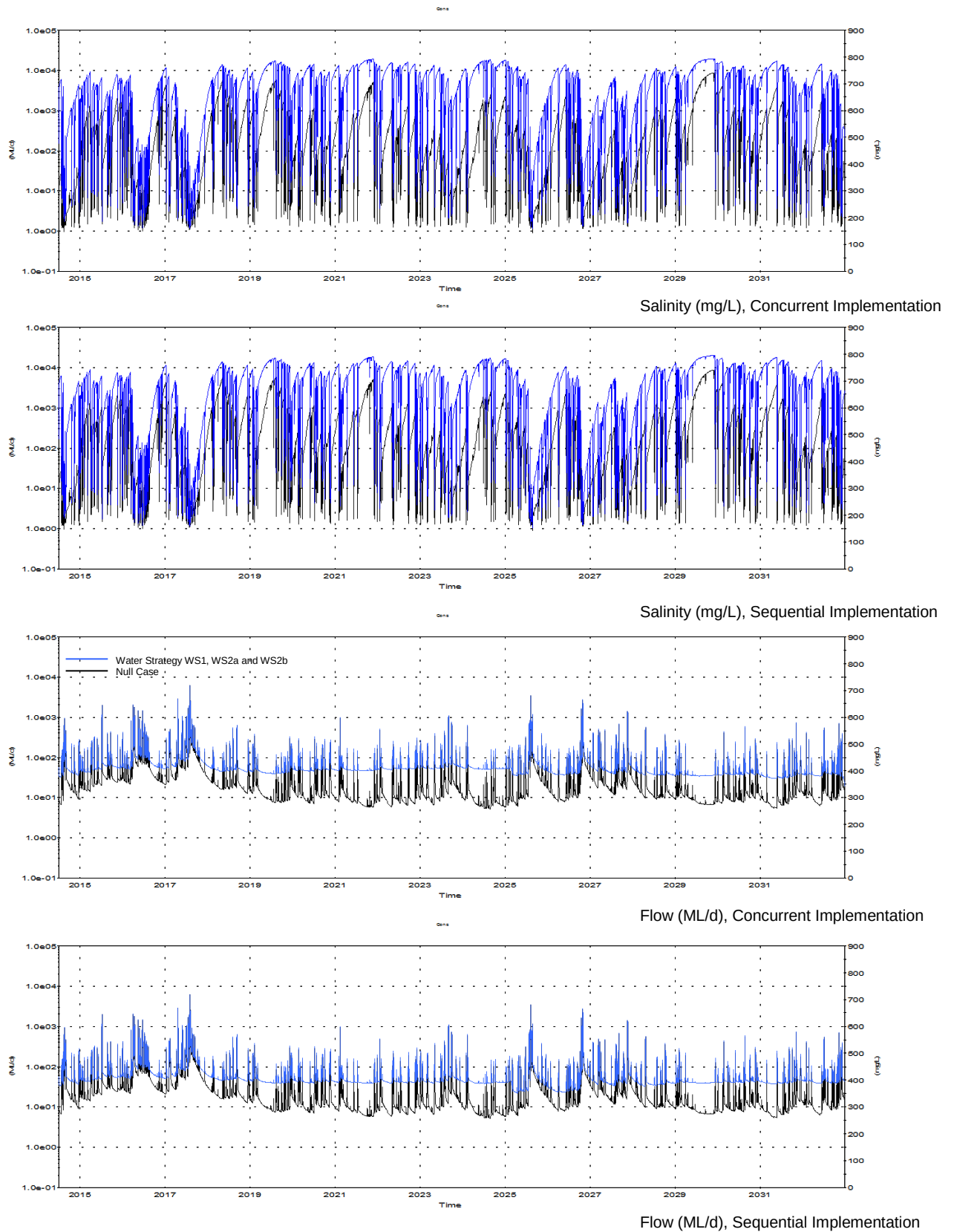


Figure 3.56 : Prediction Time-Series Chart at #047 (Coxs River above Lake Wallace, Gauge No. 212054)

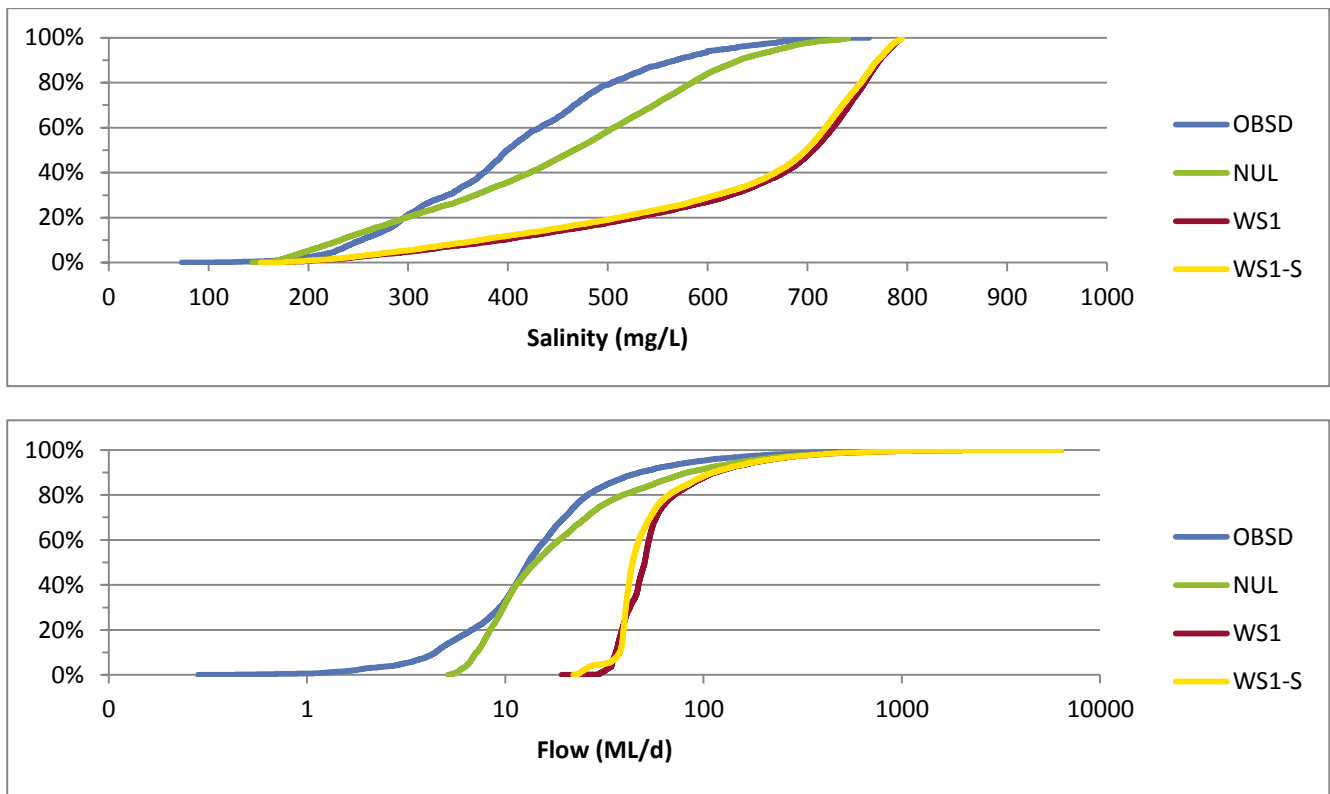


Figure 3.57 : Prediction Distribution Plot at #047 (Coxs River above Lake Wallace, Gauge No. 212054)

Table 3.33 : Prediction Daily Statistics at #047 (Coxs River above Lake Wallace, Gauge No. 212054)

Percentile	Flow (ML/d)				Salinity (mg/L)			
	OBSD	NUL	WS1	WS1-S	OBSD	NUL	WS1	WS1-S
Minimum	0.3	5.1	19.2	22.0	73	144	160	152
5%	3.1	6.5	34.5	32.0	227	198	305	290
10%	4.5	7.1	36.1	37.8	253	232	394	371
20%	6.8	8.4	38.8	39.5	296	298	528	510
50%	13.1	14.2	50.5	43.8	399	466	706	699
80%	26.1	39.2	71.2	67.1	504	584	757	754
90%	47.7	83.4	115.4	111.2	568	632	773	770
95%	94.7	162.5	194.7	190.8	620	673	783	781
Maximum	5,321(n=7,906)	6,327	6,358	6,358	762(n=5,280)	741	794	795

Predicted salinity in Lake Wallace (corresponding to Node #074) is presented in Figure 3.58. The distribution plot of model output is presented in Figure 3.59, and is summarised in Table 3.34.

Model results indicate that Lake Wallace operates full and median salinity in WS1 is 540mg/L and is 523mg/L in WS1-S. The median salinity in Lake Wallace from the observation record is 519mg/L.

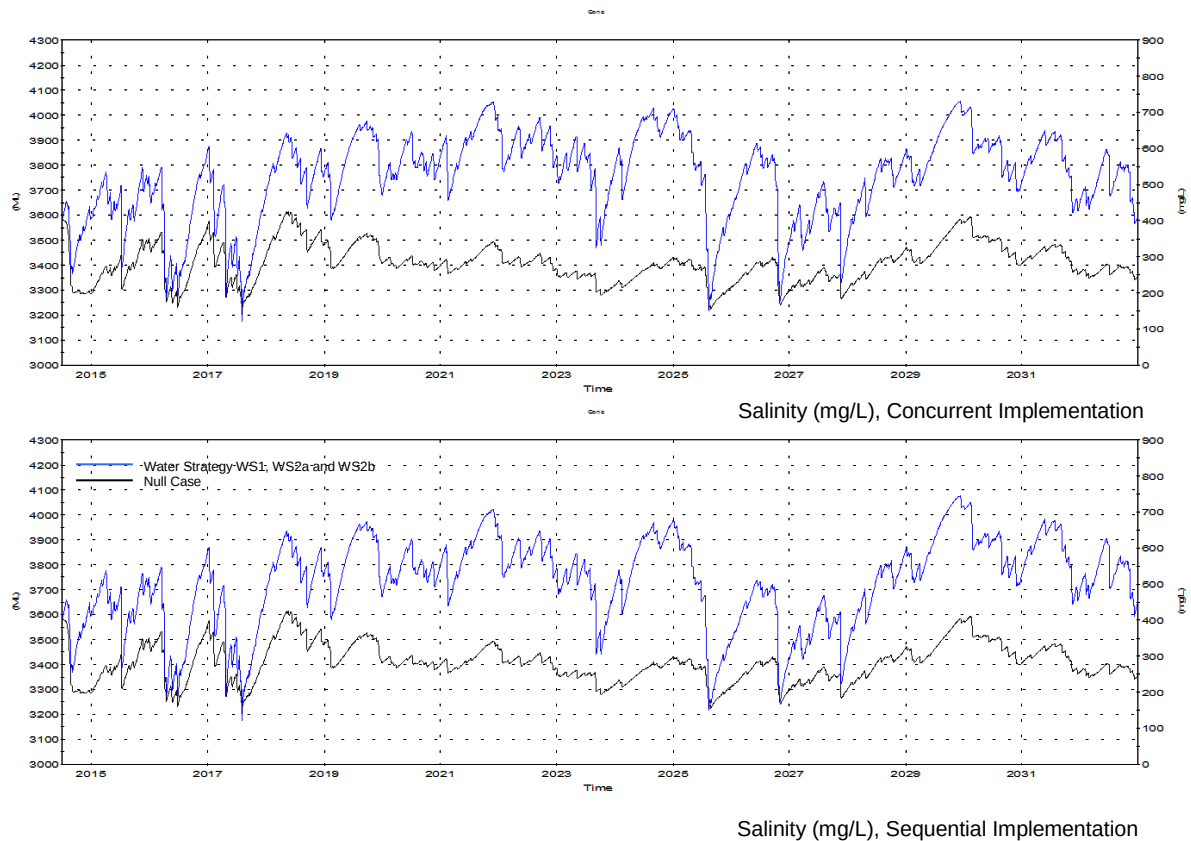


Figure 3.58 : Prediction Time-Series Chart at #074 (Lake Wallace)

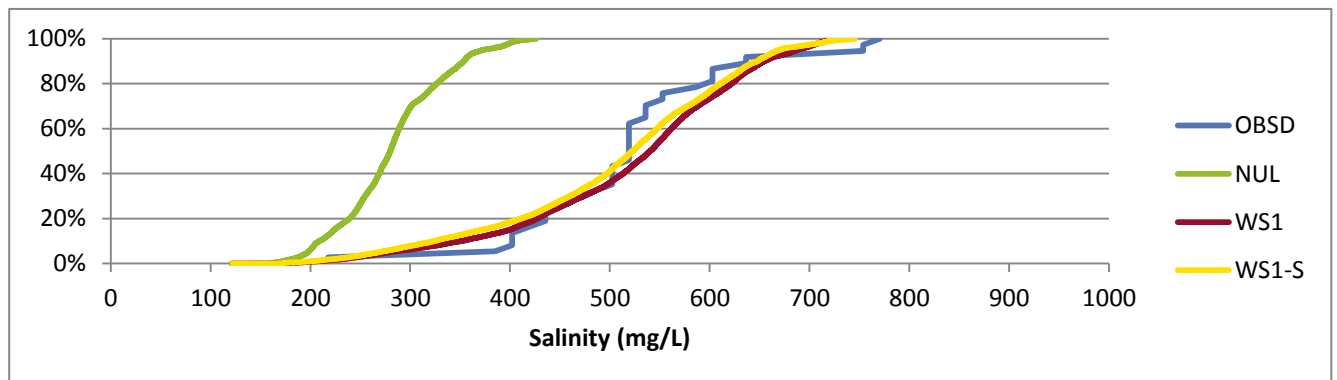


Figure 3.59 : Prediction Distribution Plot at #074 (Lake Wallace)

From Table 3.34, predicted maximum salinity in WS1 and WS1-S is consistent with maximum salinity from the observation record.

Table 3.34 : Prediction Daily Statistics at #074 (Lake Wallace)

Percentile	Volume (ML)				Salinity (mg/L)			
	OBSD	NUL	WS1	WS1-S	OBSD	NUL	WS1	WS1-S
Minimum	n/a	4,168	4,221	4,221	218	140	121	122
5%	n/a	4,221	4,221	4,221	398	197	279	268
10%	n/a	4,221	4,221	4,221	402	209	351	324
20%	n/a	4,221	4,221	4,221	436	239	427	411
50%	n/a	4,221	4,221	4,221	519	280	540	523
80%	n/a	4,221	4,221	4,221	603	327	622	611
90%	n/a	4,221	4,221	4,221	637	354	655	648
95%	n/a	4,221	4,221	4,221	754	374	688	670
Maximum	n/a	4,221	4,221	4,221	771 (n=37)	427	732	746

Lake Lyell

Node #154 lies between Lake Wallace and Lake Lyell and corresponds with location of NSW Office of Water Station No. 212058. Prediction time-series flow is presented in Figure 3.60. Figure 3.61 presents the distribution plot of model output and is summarised in Table 3.35.

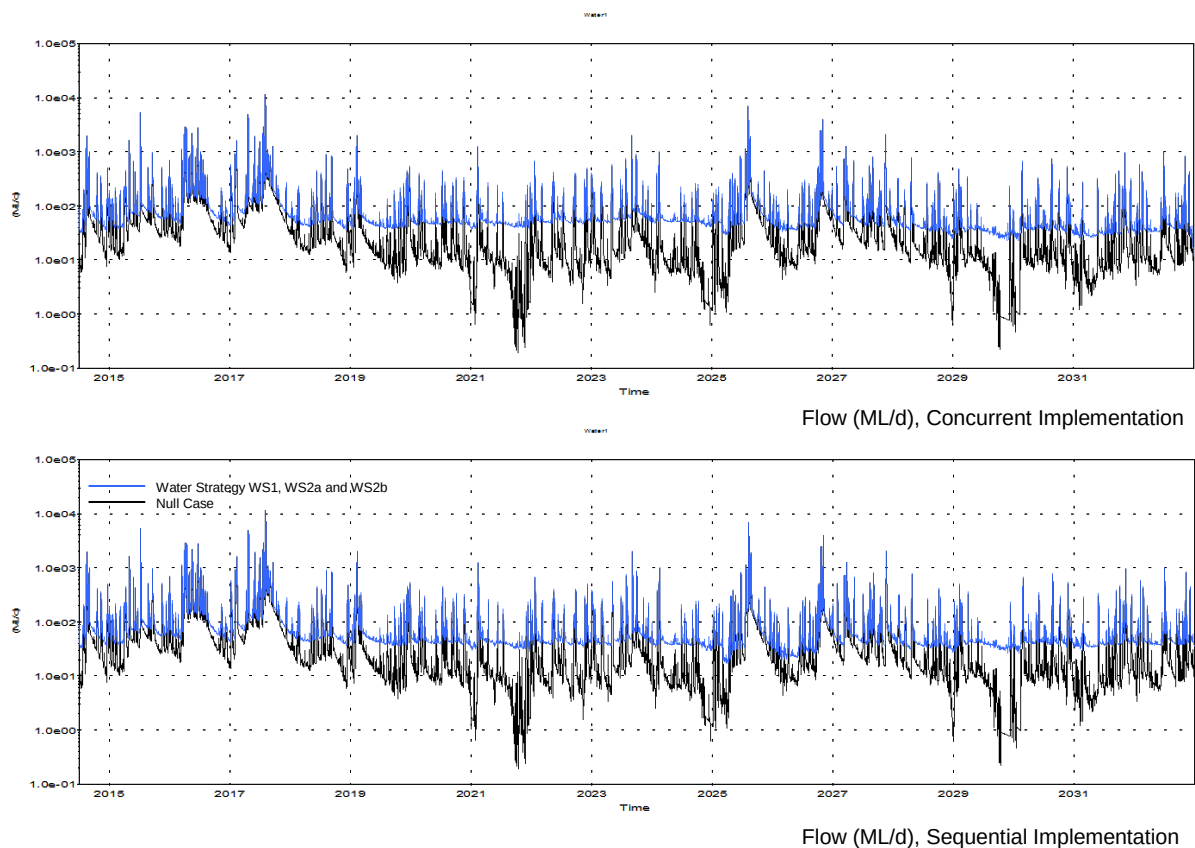


Figure 3.60 : Prediction Time-Series Chart at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

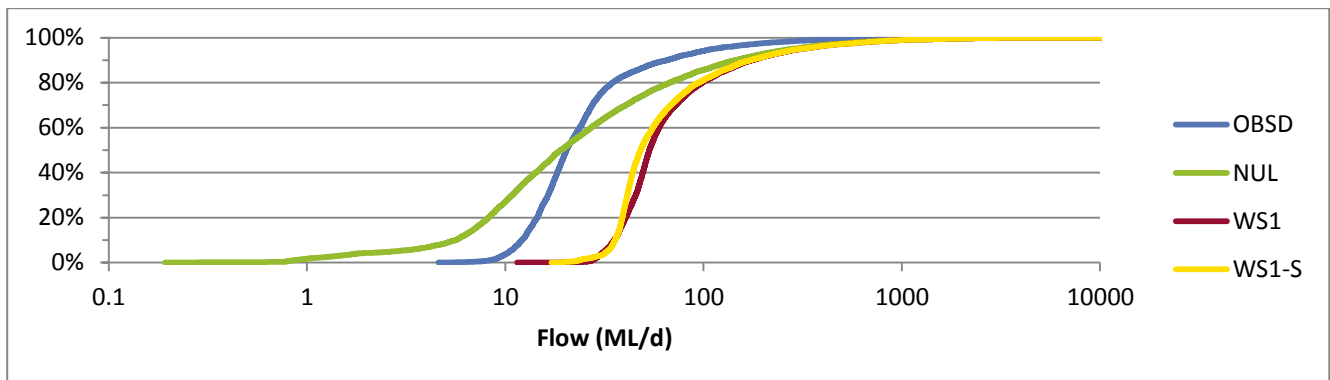


Figure 3.61 : Prediction Distribution Plot at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

Table 3.35 : Prediction Daily Statistics at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

Percentile	Flow (ML/d)				Salinity (mg/L)			
	OBSD	NUL	WS1	WS1-S	OBSD	NUL	WS1	WS1-S
Minimum	4.6	0.2	11.5	17.1	n/a	66	109	109
5%	10.5	2.7	31.6	32.6	n/a	142	218	208
10%	12.1	5.6	35.5	35.8	n/a	158	278	258
20%	14.5	8.3	40.4	38.9	n/a	178	356	337
50%	20.4	19.0	53.3	48.2	n/a	223	492	475
80%	34.7	67.3	98.5	94.4	n/a	274	594	580
90%	65.4	144.7	176.9	172.5	n/a	306	635	626
95%	112.1	280.5	310.1	306.8	n/a	326	672	657
Maximum	6,750(n=4,563)	11,487	11,518	11,518	n/a	420	731	745

Model results indicate that modelled median flow is 53.3ML/d in WS1 and is 48.2ML/d in WS1-S. This is compared to modelled median flow of 19.0ML/d in the NUL case and 20.4ML/d from the observation record. Modelling indicates that mine water discharge is significant in low and median flow conditions at this location, however, is comparable in high flow conditions, 90th%. Maximum modelled flow is ~11,500ML/d.

Figure 3.62 presents time-series model output (salinity) at Node #035. This node is located between Lake Wallace and Lake Lyell and corresponds with EnergyAustralia monitoring location COX5. Figure 3.63 presents the distribution plot of model output, and is summarised in Table 3.36.

Figure 3.63 indicates that predicted salinity in the Coxs River at this location is considerably lower than that experienced in the past. Modelled median salinity from the observation record is 737mg/L (n=36), compared to 490 and 473mg/L in prediction simulation WS1 and WS1-S respectively.

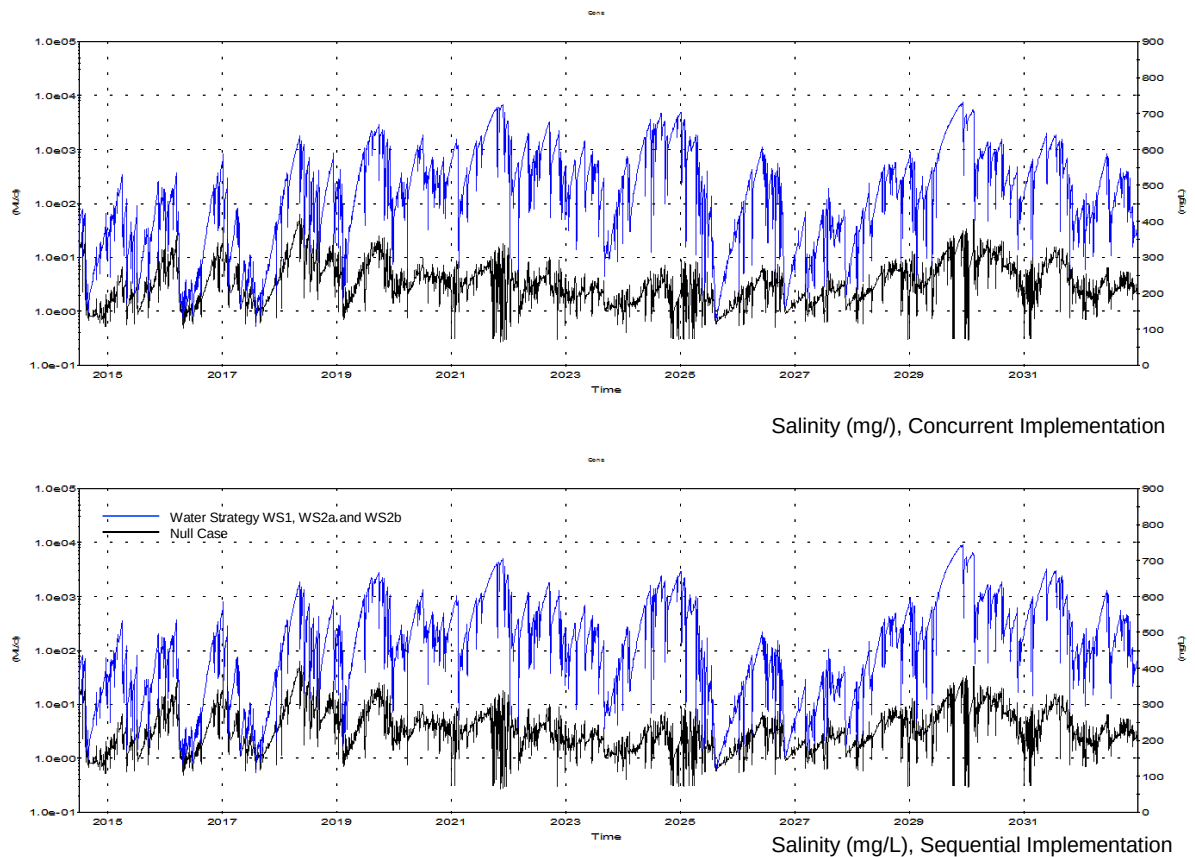


Figure 3.62 : Prediction Time-Series Chart at #035 (Coxs River above Lake Lyell, at location of EnergyAustralia station COX5)

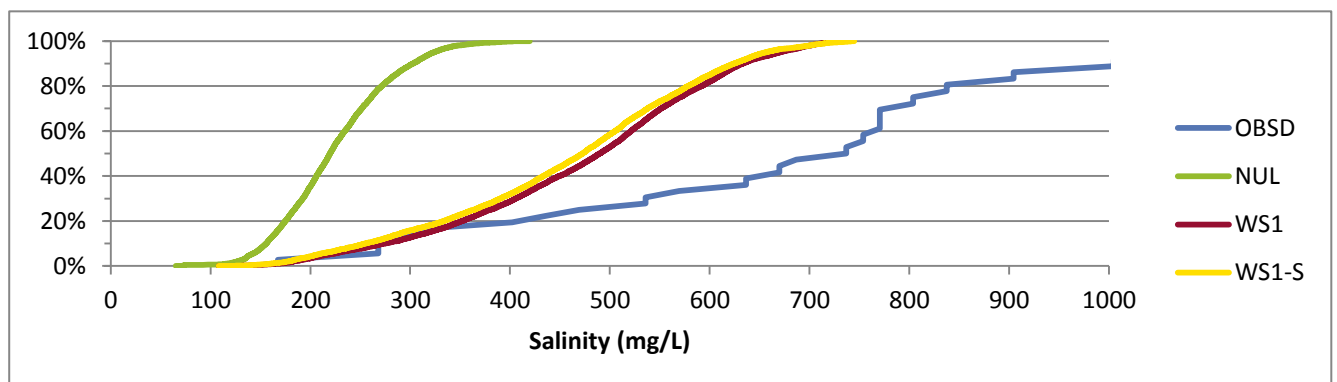


Figure 3.63 : Prediction Distribution Plot at #035 (Coxs River above Lake Lyell, at location of EnergyAustralia station COX5)

Table 3.36 : Prediction Daily Statistics at #035 (Coxs River above Lake Lyell, at location of EnergyAustralia station COX5)

Percentile	Flow (ML/d)				Salinity (mg/L)			
	OBSD	NUL	WS1	WS1-S	OBSD	NUL	WS1	WS1-S
Minimum	n/a	0.2	11.8	17.2	168	65	108	108
5%	n/a	2.8	31.7	32.7	268	140	217	206
10%	n/a	5.7	35.6	35.9	285	156	275	255
20%	n/a	8.4	40.5	39.1	436	175	352	334
50%	n/a	19.3	53.6	48.5	737	220	490	473
80%	n/a	68.5	99.6	95.5	838	271	592	579
90%	n/a	147.1	178.3	174.7	1005	303	633	625
95%	n/a	285.9	316.4	313.7	1114	324	671	656
Maximum	n/a	11,712	11,743	11,743	1240(n=6,759)	420	731	745

Lake Lyell is represented by Node #174 in the water quality model. Figure 3.64 presents the time-series modelled salinity and stored volume in Lake Lyell, including the NUL case. A distribution plot of this model output is presented in Figure 3.65, and is summarised in Table 3.37.

Modelling indicates predicted median salinity in Lake Lyell under WS1 and WS1-S is 398 and 381mg/L. In comparison, median salinity in the NUL case is 256mg/L and is 295mg/L from the observation record (n=242). Modelled salinity is consistent with observation record above the 90th% and is less than historical maximum from the observation record of 634mg/L.

Modelling indicates that proposed discharge to the Coxs River has a small positive benefit to modelled storage level in Lake Lyell (Figure 3.64).

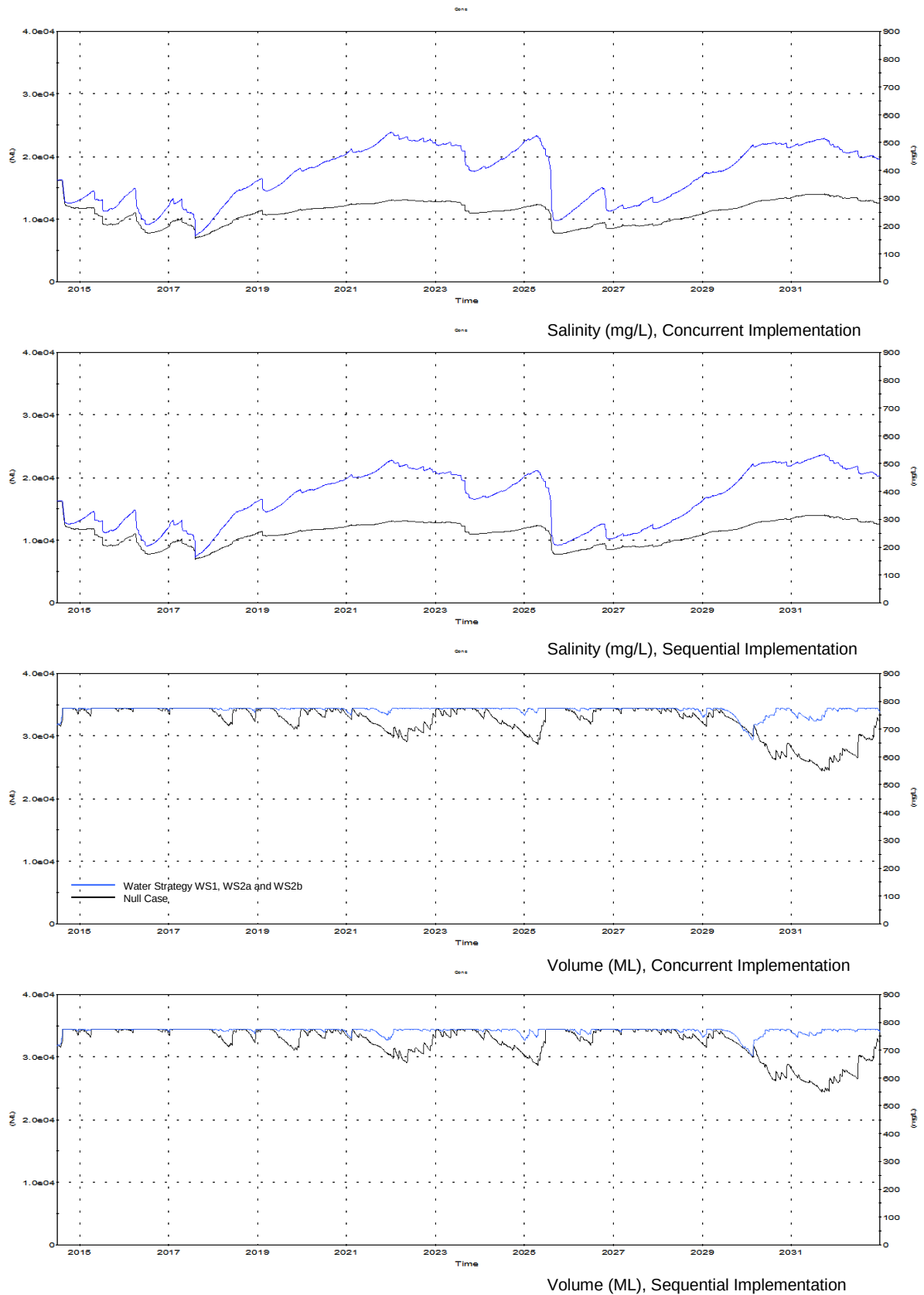


Figure 3.64 : Prediction Time-Series Chart at #174 (Lake Lyell)

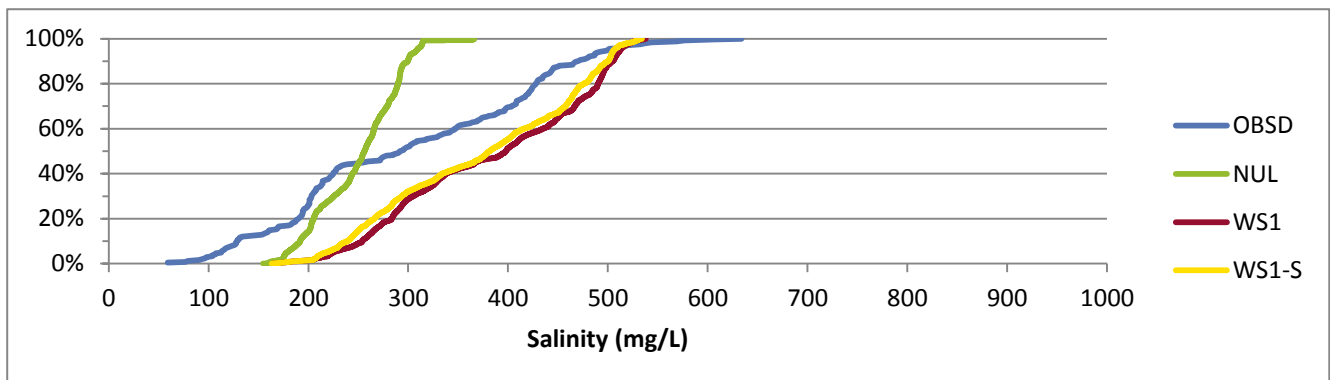


Figure 3.65 : Prediction Distribution Plot at #174 (Lake Lyell)

Table 3.37 : Prediction Daily Statistics at #174 (Lake Lyell)

Percentile	Volume (ML)				Salinity (mg/L)			
	OBSD	NUL	WS1	WS1-S	OBSD	NUL	WS1	WS1-S
Minimum	n/a	24,418	29,361	30,201	59	155	164	163
5%	n/a	26,527	32,639	33,160	114	179	225	218
10%	n/a	27,895	33,483	33,622	129	192	254	239
20%	n/a	30,795	34,183	34,178	192	205	283	266
50%	n/a	33,538	34,439	34,429	295	256	398	381
80%	n/a	34,447	34,451	34,451	428	290	490	476
90%	n/a	34,451	34,451	34,451	471	300	505	500
95%	n/a	34,451	34,451	34,451	500	309	513	506
Maximum	n/a	34,451	34,451	34,451	634 (n=242)	366	538	534

Thompsons Creek Reservoir

Prediction model output, salinity and volume, in Thompsons Creek Reservoir is presented in Figure 3.66. Figure 3.67 presents the distribution plot of model output, with Table 3.38 presenting a summary.

From Table 3.38, predicted median salinity in WS1 and WS1-S is 377 and 359mg/L, in comparison to modelled NUL case of 271mg/L. Median salinity from the observation record is 285mg/L.

Modelling indicates that proposed mine water discharge has minimum effect on stored volume in Thompsons Creek Reservoir.

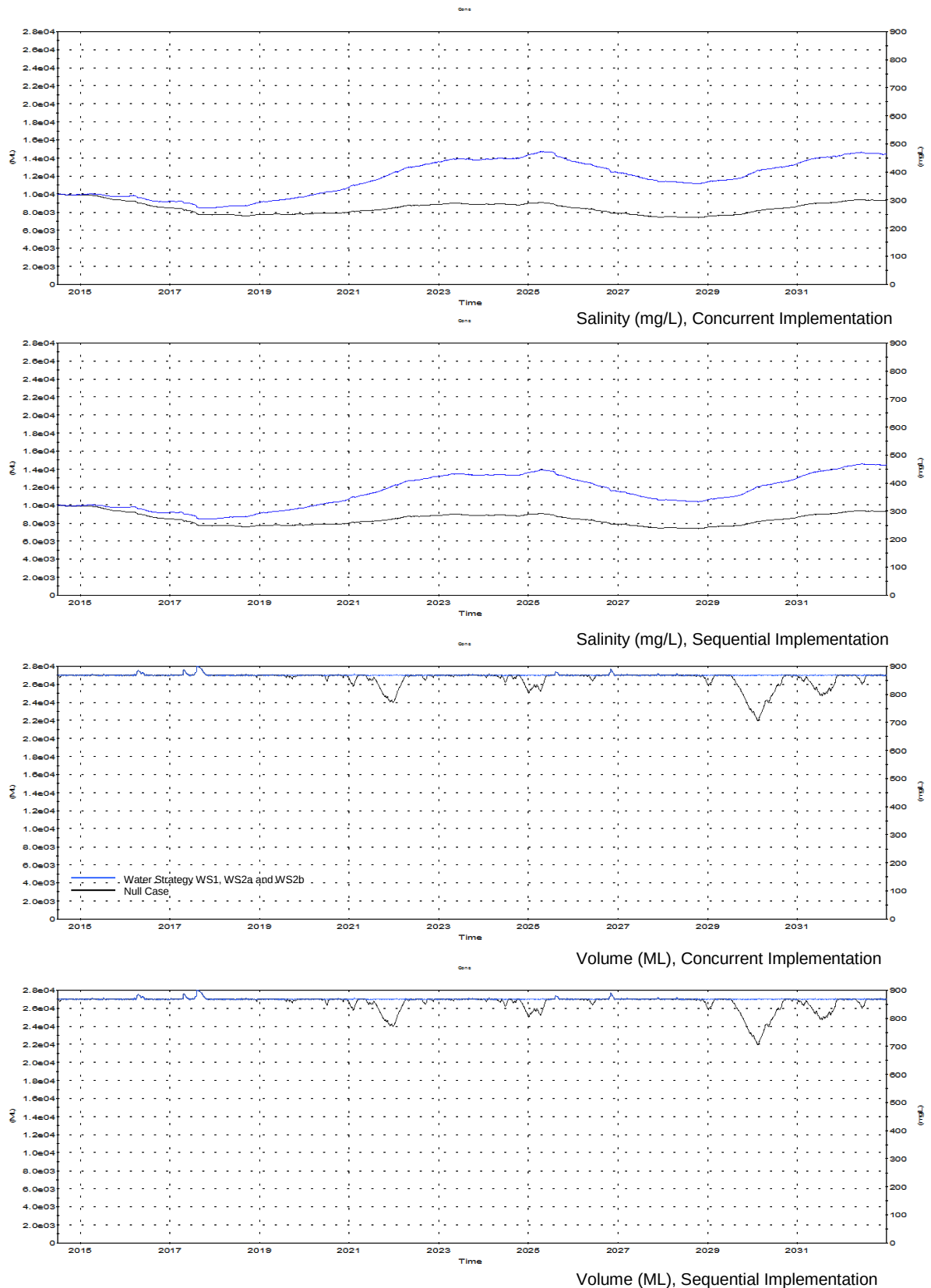


Figure 3.66 : Prediction Time-Series Chart at #272 (Thompsons Creek Reservoir)

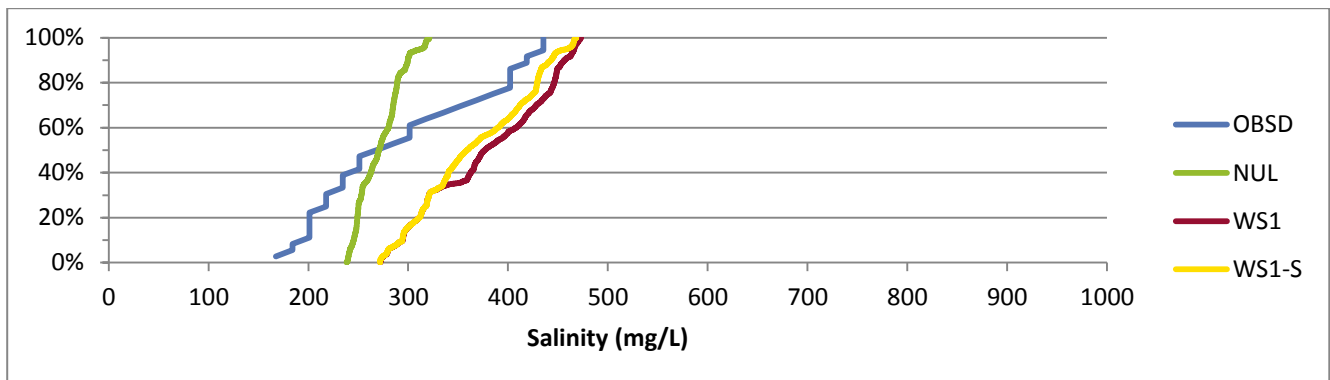


Figure 3.67 : Prediction Distribution Plot at #272 (Thompsons Creek Reservoir)

Table 3.38 : Prediction Daily Statistics at #272 (Thompsons Creek Reservoir)

Percentile	Volume (ML)				Salinity (mg/L)			
	OBSD	NUL	WS1	WS1-S	OBSD	NUL	WS1	WS1-S
Minimum	n/a	21,953	26,926	26,927	184	238	272	272
5%	n/a	24,791	26,977	26,977	196	241	280	279
10%	n/a	25,619	26,984	26,984	201	245	295	294
20%	n/a	26,594	26,992	26,992	214	249	311	311
50%	n/a	26,996	27,003	27,003	285	271	377	359
80%	n/a	27,014	27,020	27,020	402	289	446	429
90%	n/a	27,029	27,037	27,037	419	300	456	443
95%	n/a	27,077	27,086	27,084	436	313	466	459
Maximum	n/a	28,000	28,000	28,000	436 (n=36)	321	473	468

Lake Burragorang and above Lake Burragorang

Node #225 is located immediately above Lake Burragorang. There is a limited observation record at this location (n=25), from the 1980s.

Figure 3.68 presents the time-series predicted salinity and flow at this node. Figure 3.69 presents the distribution plot of prediction model output and is summarised in Table 3.39.

From Figure 3.69, proposed mine water discharge has negligible impact to median flow at this location. Modelled median salinity in WS1 is 156mg/L and is 152mg/L in WS1-S. In comparison, modelled median salinity in the NUL case is 128mg/L and median salinity from the observation record is 111mg/L. Modelled salinity in prediction simulations is below the default ANZECC trigger level value for salinity, of 234mg/L (equivalent to 350µS/cm, if conversion factor is 0.67).

Maximum salinity in WS1 and WS1-S is 468 and 443mg/L respectively and is higher than the observation record, if the spike in observed salinity that was attributed to a transcription error or other is neglected.

It is noted that a reduced scale is used in Figure 3.69 with respect to salinity compared to other distribution plots presented above.

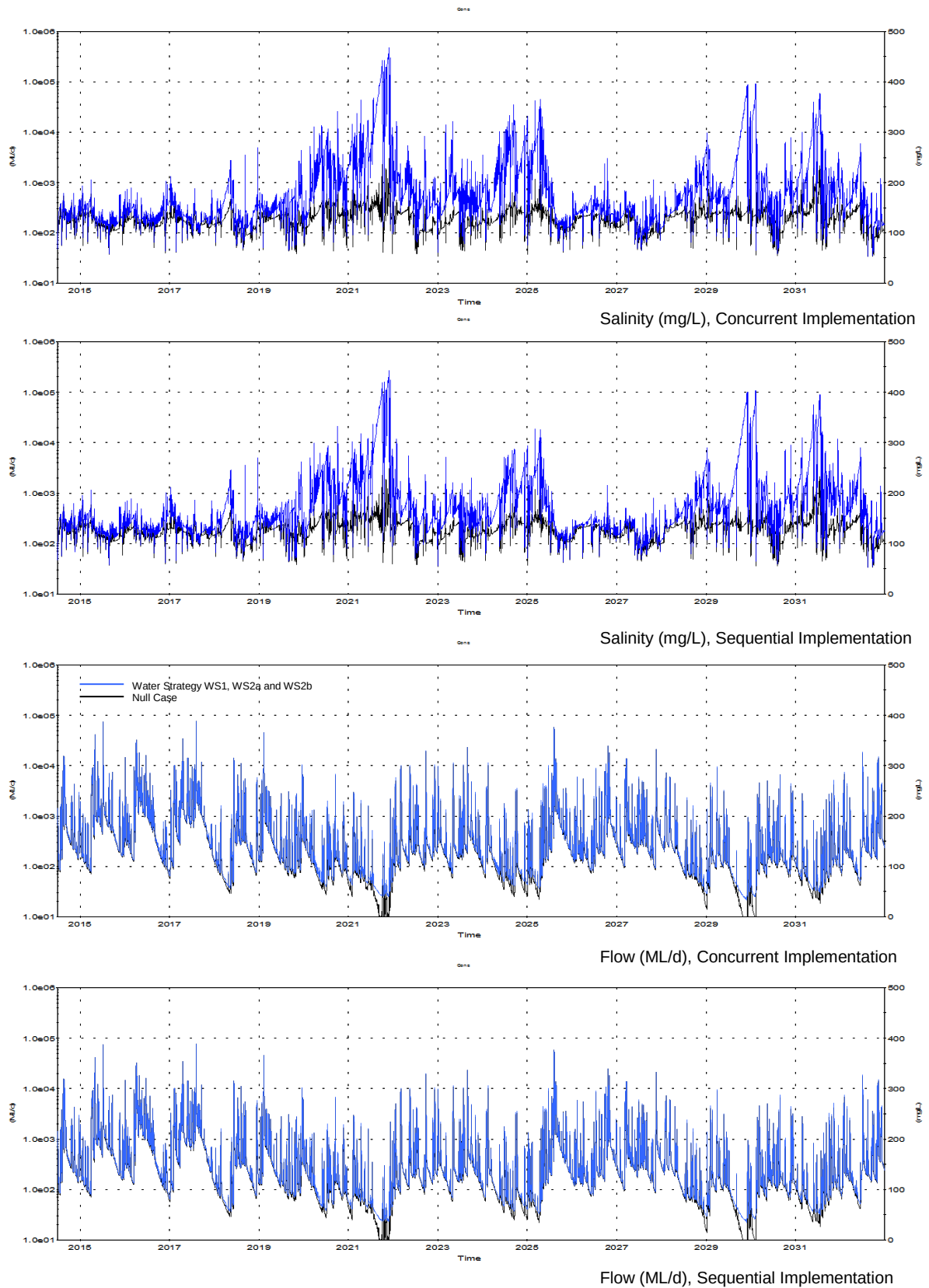


Figure 3.68 : Prediction Time-Series Chart at #225 (Coxs River above Lake Burragorang)

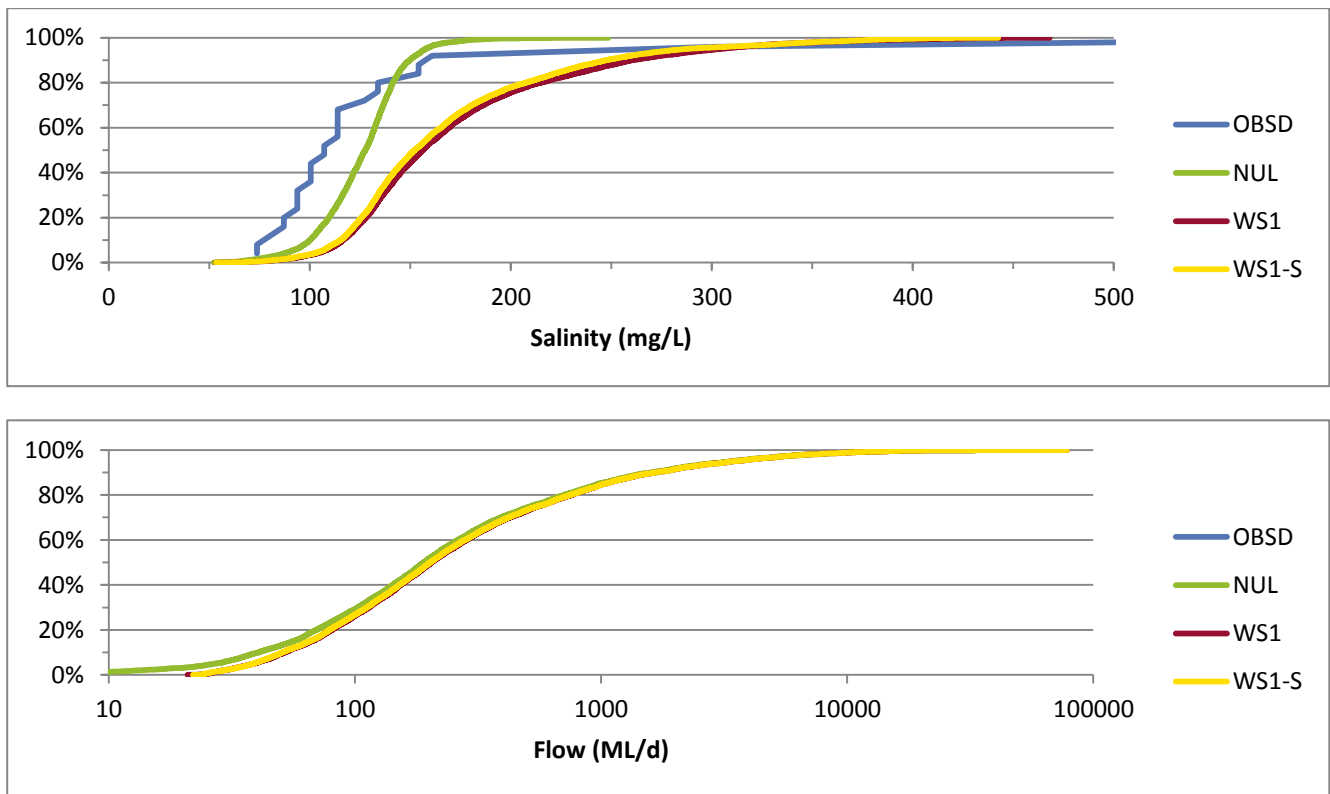


Figure 3.69 : Prediction Distribution Plot at #225 (Coxs River above Lake Burragorang)

Table 3.39 : Prediction Daily Statistics at #225 (Coxs River above Lake Burragorang)

Percentile	Flow (ML/d)				Salinity (mg/L)			
	OBSD	NUL	WS1	WS1-S	OBSD	NUL	WS1	WS1-S
Minimum	n/a	6	21	22	74	52	53	53
5%	n/a	27	39	39	74	90	107	105
10%	n/a	41	52	51	82	100	116	115
20%	n/a	70	81	79	90	110	128	126
50%	n/a	190	205	202	107	128	156	152
80%	n/a	711	762	749	134	141	215	208
90%	n/a	1,601	1,676	1,666	154	150	260	248
95%	n/a	3,380	3,470	3,478	160	158	304	287
Maximum	n/a	78,103	78,134	78,133	302	249	468	443

Figure 3.70 presents the time-series model output in Lake Burragorang (Node #280). Figure 3.71 presents the distribution plot of model output. It is noted that a reduced scale is used in Figure 3.71 compared to other distribution plots presented above. Table 3.40 presents a statistical summary of the model output.

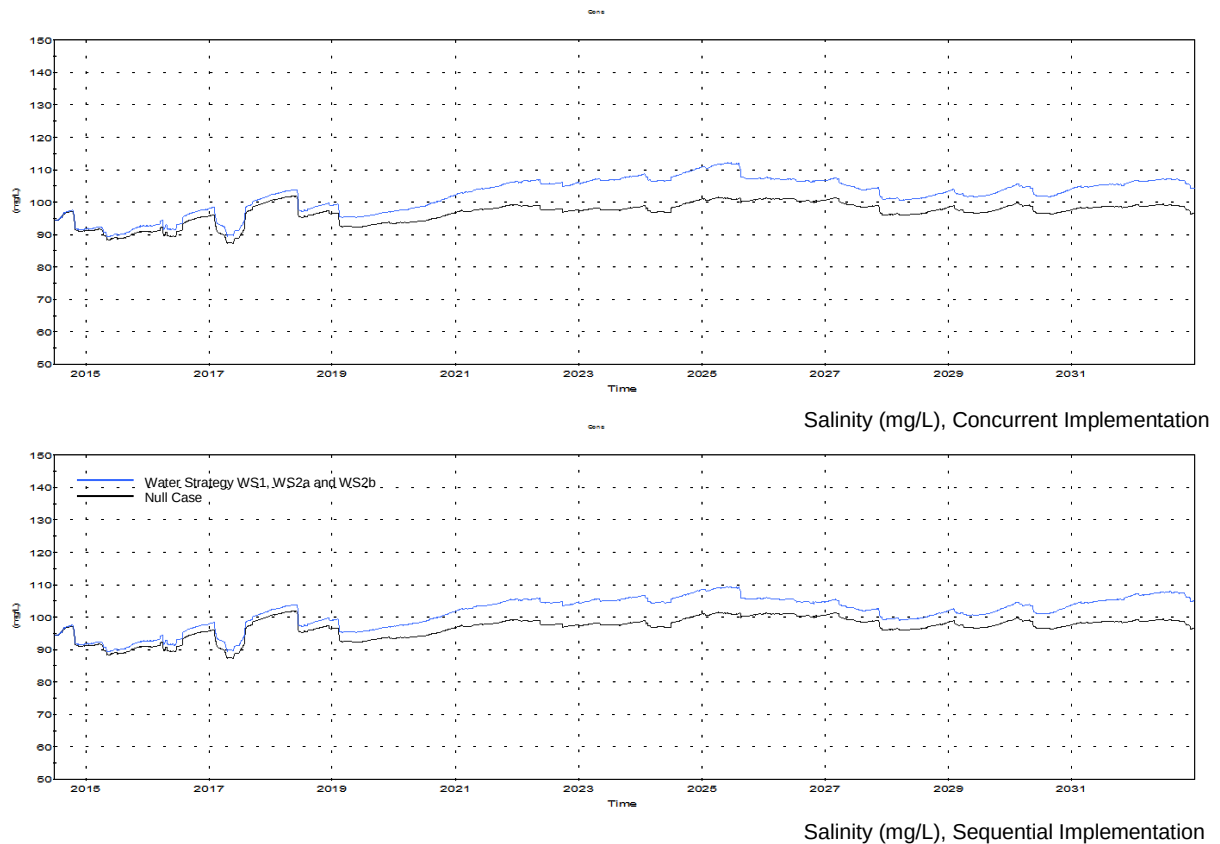


Figure 3.70 : Prediction Time-Series Chart at #280 (Lake Burragorang)

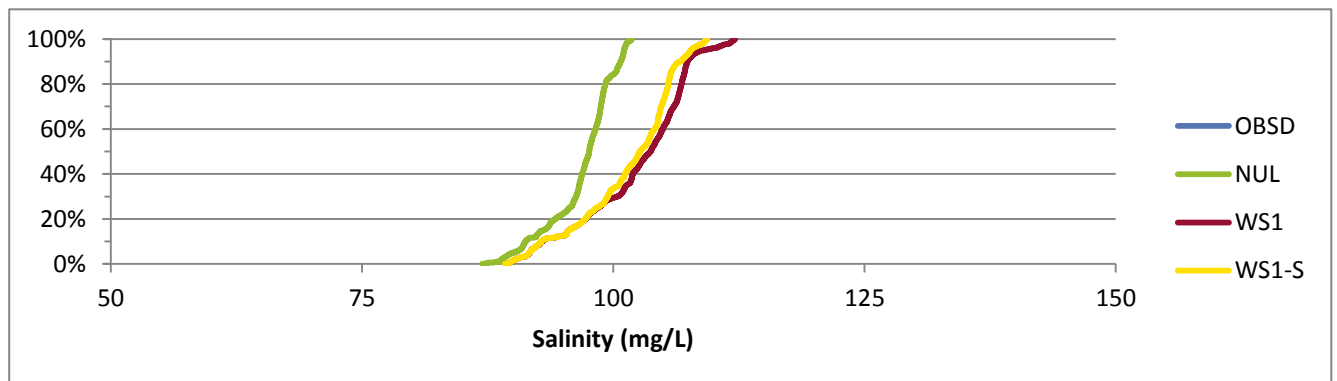


Figure 3.71 : Prediction Distribution Plot at #280 (Lake Burragorang)

Modelled median salinity in Lake Burragorang is 104 and 103mg/L in WS1 and WS1-S, in comparison to the NUL case where modelled median is 98mg/L. Minimum modelled salinity is 89mg/L in WS1 and WS1-S, compared to 87mg/L in the NUL case and is 112 and 109mg/L in WS1 and WS1-S at maximum, compared with 102mg/L in the NUL case.

Modelling indicates the proposed discharge to the Coxs River will lead to a 6% and 5% increase in median salinity in Lake Burragorang and accordingly is considered to have a neutral impact to water quality. Further discussion of the Neutral or Beneficial Effect assessment is presented in Section 4 of RPS (2014a) and in

Table 3.40 : Prediction Daily Statistics at #280 (Lake Burragorang)

Percentile	Volume (ML)				Salinity (mg/L)			
	OBSD	NUL	WS1	WS1-S	OBSD	NUL	WS1	WS1-S
Minimum	n/a	n/a	n/a	n/a	n/a	87	89	89
5%	n/a	n/a	n/a	n/a	n/a	90	92	92
10%	n/a	n/a	n/a	n/a	n/a	91	93	93
20%	n/a	n/a	n/a	n/a	n/a	94	97	97
50%	n/a	n/a	n/a	n/a	n/a	98	104	103
80%	n/a	n/a	n/a	n/a	n/a	99	107	105
90%	n/a	n/a	n/a	n/a	n/a	101	107	107
95%	n/a	n/a	n/a	n/a	n/a	101	109	108
Maximum	n/a	n/a	n/a	n/a	n/a	102	112	109

Centennials' response to comments received from NSW Office of Environment and Heritage (NSW EPA, 2014) and Sydney Catchment Authority (SCA, 2014) (summarised in Jacobs (2014)).

3.5 End of Pipe Targets

3.5.1 End of Pipe Target Setup

These simulations were prepared based on the WS2b simulation presented above.

The methodology adopted comprised calibration of level of treatment of mine water required such that resultant discharge met a specified target. Relevant assumptions include:

- no account of pre-treatment requirement
- treatment was assumed to occur instantaneously
- no account of other analytes, only salinity was considered
- assumed influent salinity from Angus Place Colliery and Springvale Mine was 804mg/L, if conversion factor is 0.67
- assumed effluent salinity from continuous treatment is 50mg/L
- no account of brine stream, salt was removed from model
- no account for potential dilution, albeit small, of runoff from catchment upstream of point of discharge

It is noted that prediction treatment volumes presented here are indicative, being based on simple mass balance. Predicted volumes do not take into account the pre-treatment and other water treatment process requirements and therefore are expected to have an accuracy of +/-15%. Further detail on treatment requirements are contained in the treatment option assessment, presented elsewhere.

3.5.2 End of Pipe Target Scenarios

An assessment of potential End of Pipe target salinities is presented for WS2b with respect to predicted salinity in:

- Node #047 (Coxs River above Lake Wallace, corresponding to location of NSW Office of Water Station No. 212054)
- Node #174 (Lake Lyell)
- Node #280 (Lake Burragorang)

The End of Pipe targets consist:

- 350 μ S/cm, default ANZECC trigger value for SE Australia upland watercourses (equivalent to 234mg/L)
- 700 μ S/cm (equivalent to 469mg/L)
- 800 μ S/cm (equivalent to 536mg/L)
- 900 μ S/cm (equivalent to 603mg/L)

Current assumed salinity of mine water discharge from Angus Place Colliery and Springvale Mine is 1,200 μ S/cm, by comparison.

3.5.3 End of Pipe Target Results

The model control files pertaining to these End of Pipe Targets are:

Concurrent Implementation

- 002a_PRD-WS2b_02a_T350uS.gsm
- 002a_PRD-WS2b_02a_T700uS.gsm
- 002a_PRD-WS2b_02a_T800uS.gsm
- 002a_PRD-WS2b_02a_T900uS.gsm

Sequential Implementation

- 002a_PRD-WS2b-S_01a_T350.gsm
- 002a_PRD-WS2b-S_01a_T700.gsm
- 002a_PRD-WS2b-S_01a_T800.gsm
- 002a_PRD-WS2b-S_01a_T900.gsm

Lake Wallace

Figure 3.72 and Figure 3.73 present time-series model output at Node #047, which lies immediately upstream of Lake Wallace. Figure 3.74 presents the distribution plot of that model output, which is summarised in Table 3.41 and Table 3.42 in regard to concurrent and sequential implementation respectively.

From Figure 3.72 and Figure 3.73, predicted salinity at this node with respect to the End of Pipe Target at 350 μ S/cm is significantly below that observed in the historical record, since 1979.

The impact of treatment is presented in Figure 3.74, with median salinity in WS2b being reduced from 706mg/L to 567mg/L, at an End of Pipe target of 900 μ S/cm. For WS2b-S, the median salinity reduces from 699mg/L to 564mg/L, for the equivalent target.

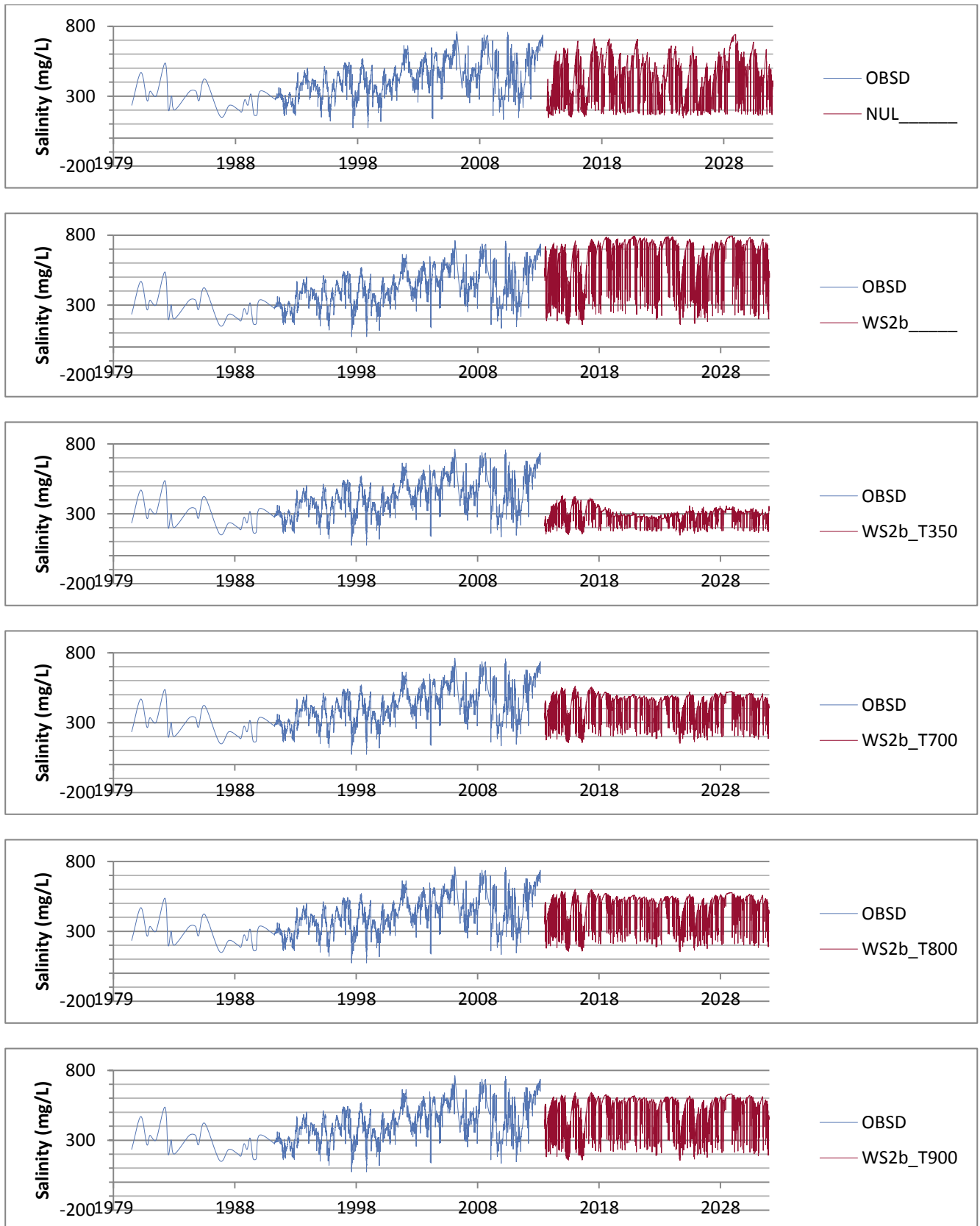


Figure 3.72 : End of Pipe Target Time-Series chart at #047 (Coxs River above Lake Wallace, Gauge No. 212054) - Concurrent

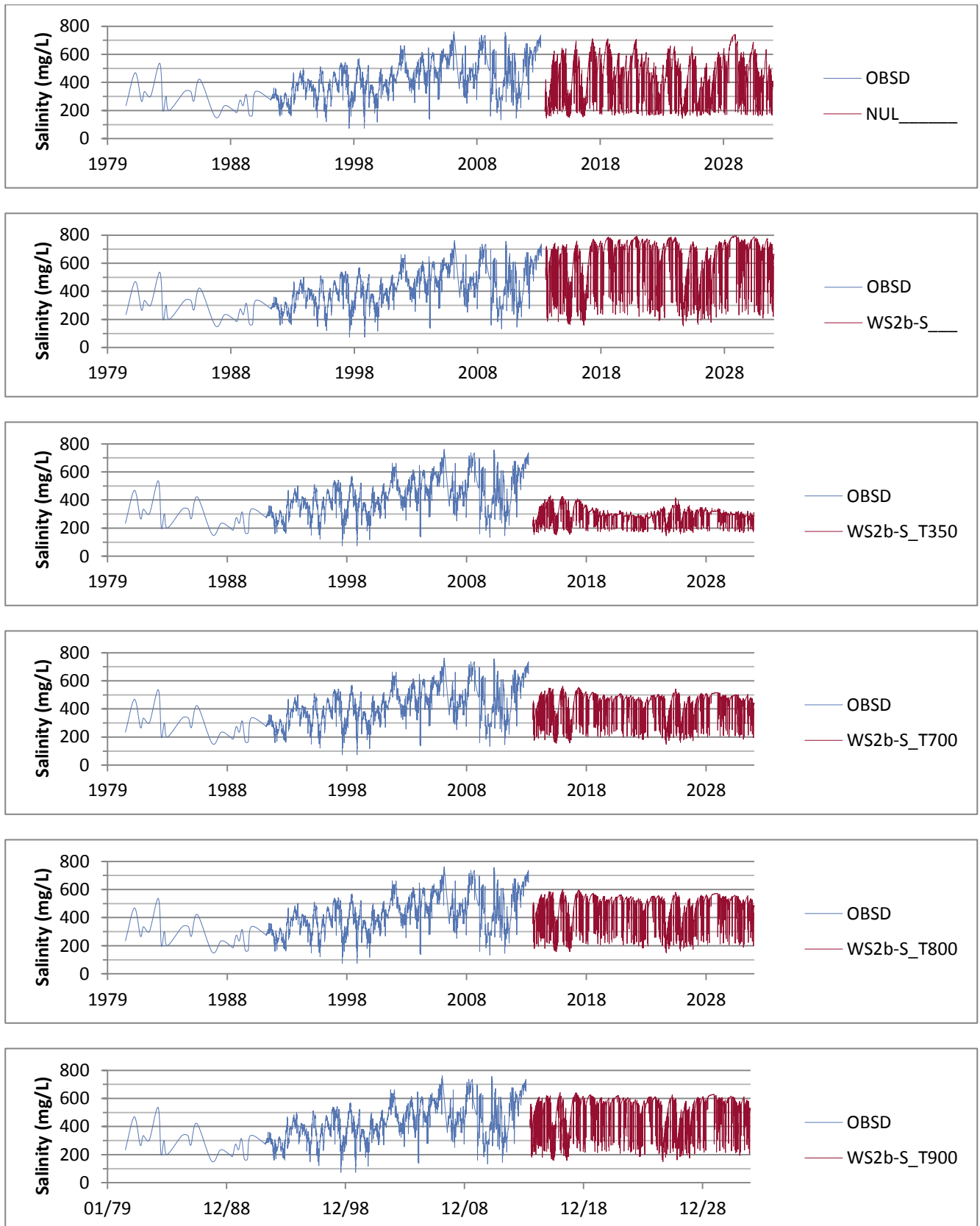


Figure 3.73 : End of Pipe Target Time-Series chart at #047 (Coxs River above Lake Wallace, Gauge No. 212054) - Sequential

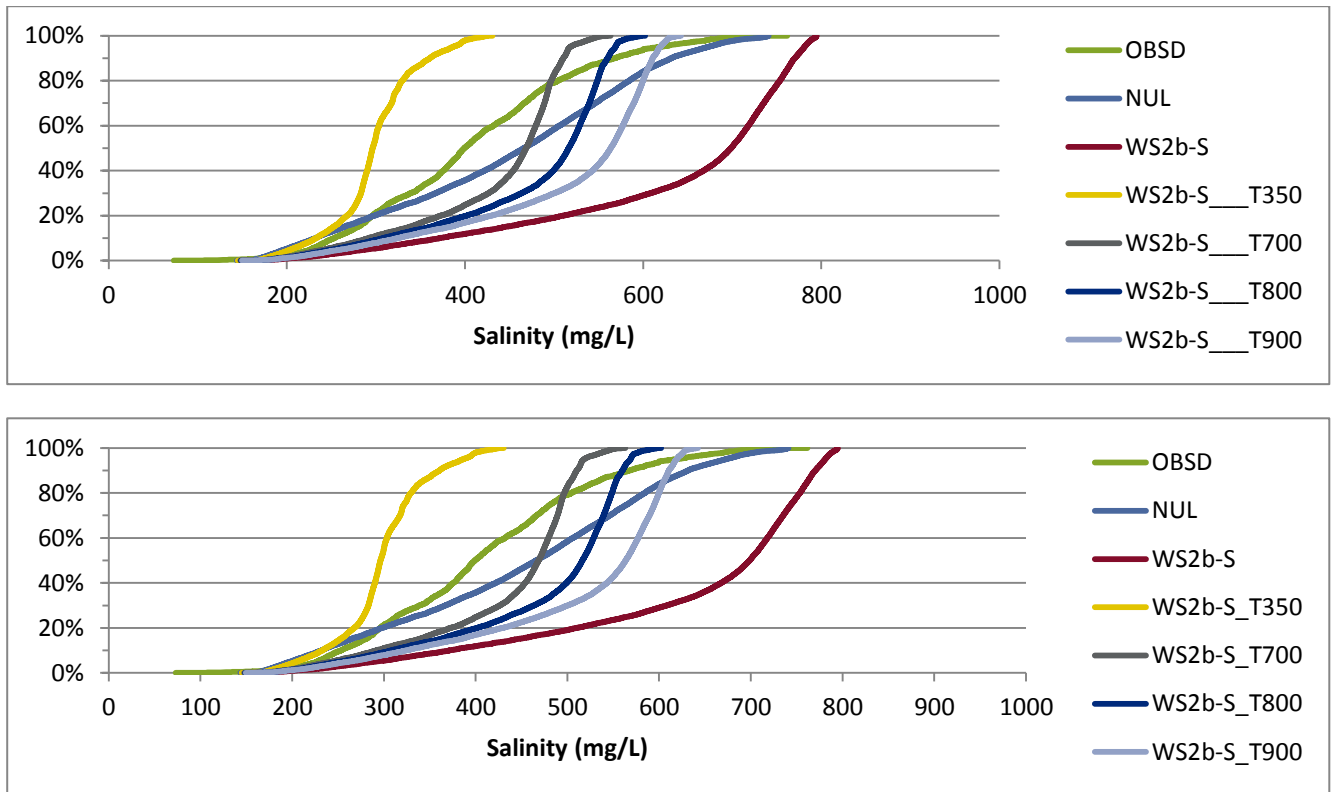


Figure 3.74 : End of Pipe Target Distribution Plot at #047 (Coxs River above Lake Wallace, Gauge No. 212054)

Table 3.41 : End of Pipe Target Daily Statistics at #047 (Coxs River above Lake Wallace) - Concurrent

Percentile	Salinity (mg/L)						
	OBSD	NUL	WS2b	WS2b_T350	WS2b_T700	WS2b_T800	WS2b_T900
Minimum	73	145	160	151	155	157	158
5%	227	198	305	205	248	259	271
10%	253	232	394	233	301	320	339
20%	296	298	528	264	380	411	441
50%	399	466	706	292	469	518	567
80%	504	584	758	327	496	547	600
90%	568	632	773	353	512	560	610
95%	620	673	783	385	520	569	620
Maximum	762 (n=5,280)	741	794	431	562	601	643

Table 3.42 : End of Pipe Target Daily Statistics at #047 (Coxs River above Lake Wallace) - Sequential

Percentile	Salinity (mg/L)						
	OBSD	NUL	WS2b-S	WS2b-S_T350	WS2b-S_T700	WS2b-S_T800	WS2b-S_T900
Minimum	73	145	160	151	155	157	158
5%	227	198	290	204	243	253	262
10%	253	232	372	233	292	308	324
20%	296	298	511	268	373	402	430
50%	399	466	699	296	469	516	564
80%	504	584	754	330	497	549	600
90%	568	632	770	361	510	560	611
95%	620	673	781	387	518	569	619
Maximum	762 (n=5,280)	741	795	431	563	602	642

Lake Lyell

Figure 3.75 and Figure 3.76 present the time-series output at Node #174. Node #174 corresponds with Lake Lyell. The available observation record is also presented in Figure 3.75 and Figure 3.76. Figure 3.77 presents the distribution plot of the model output, including the observation and NUL case. Table 3.43 and Table 3.44 summarises the distribution plot presented in Figure 3.77.

From Figure 3.75 and Figure 3.76, predicted salinity in Lake Lyell is within the historical range, including for WS2b and WS2b-S without treatment. For End of Pipe Target at 900µS/cm, predicted salinity is less than 430mg/L (equivalent to 640µS/cm) in the sequential implementation scenario and is less than 410mg/L (610µS/cm) in the concurrent implementation case.

From Figure 3.77, the End of Pipe Target at 350µS/cm has a median modelled salinity of 255mg/L. This is below the modelled median salinity from the observation record of 295mg/L.

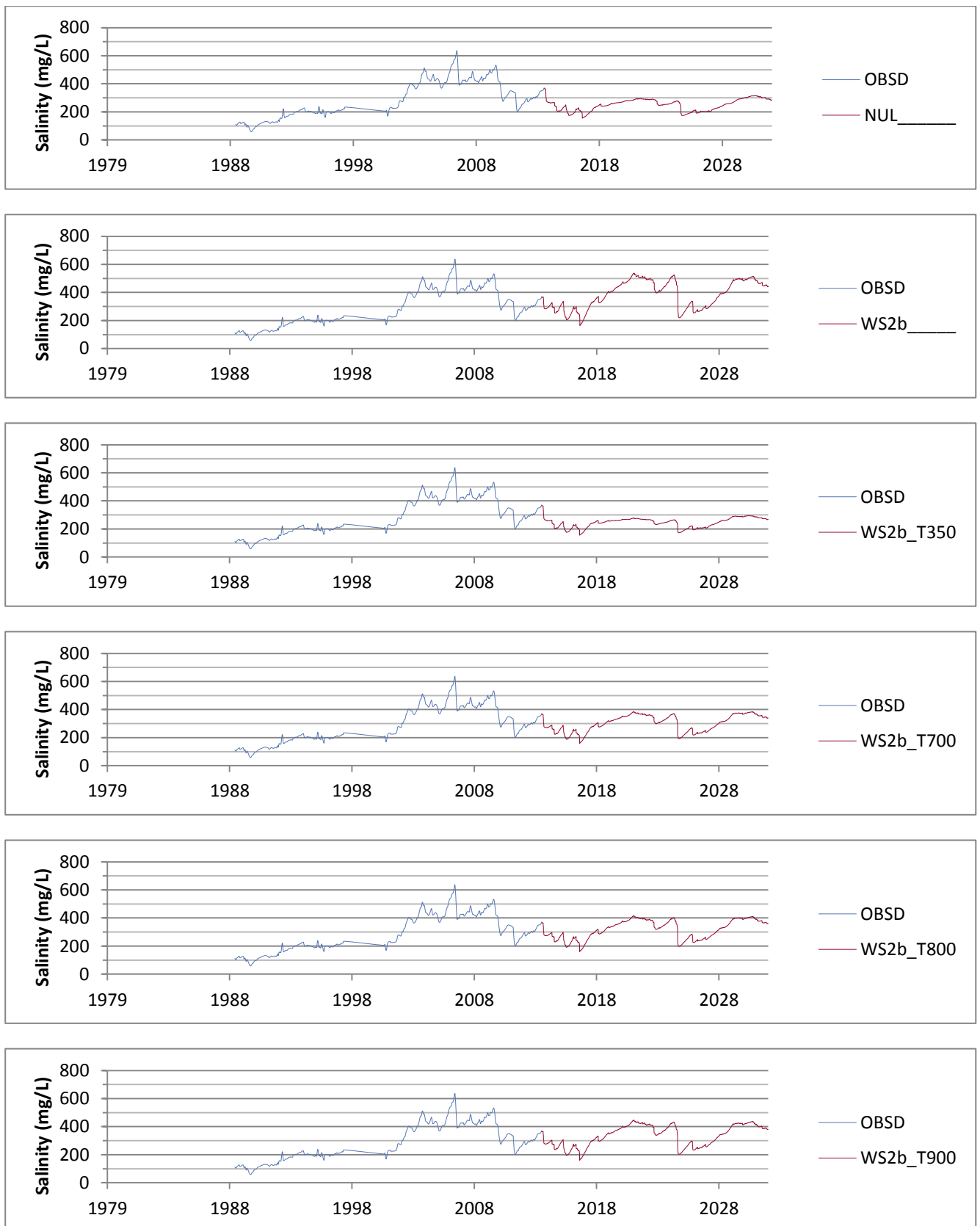


Figure 3.75 : End of Pipe Target Time-Series chart at #174 (Lake Lyell) – Concurrent

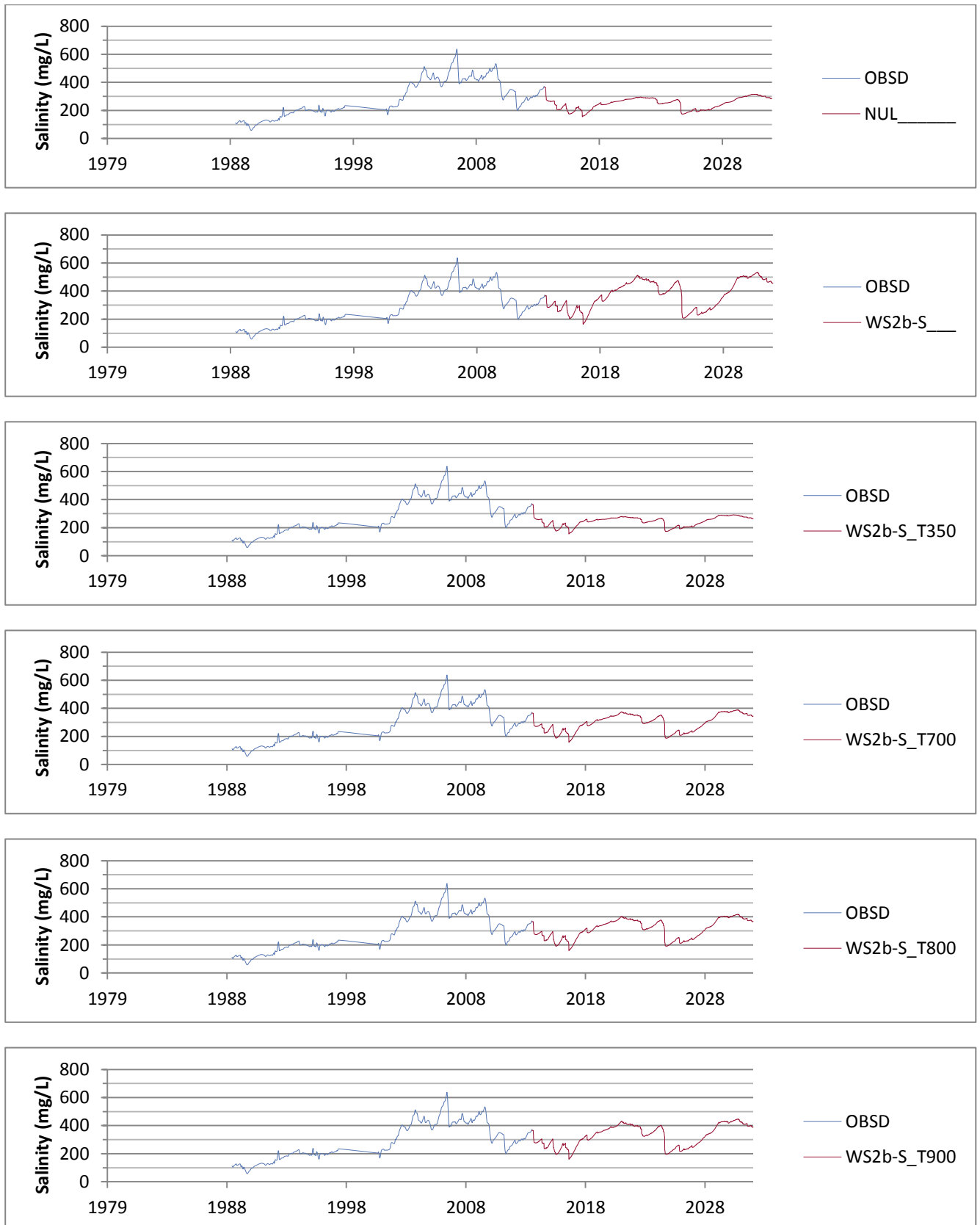


Figure 3.76 : End of Pipe Target Time-Series chart at #174 (Lake Lyell) – Sequential

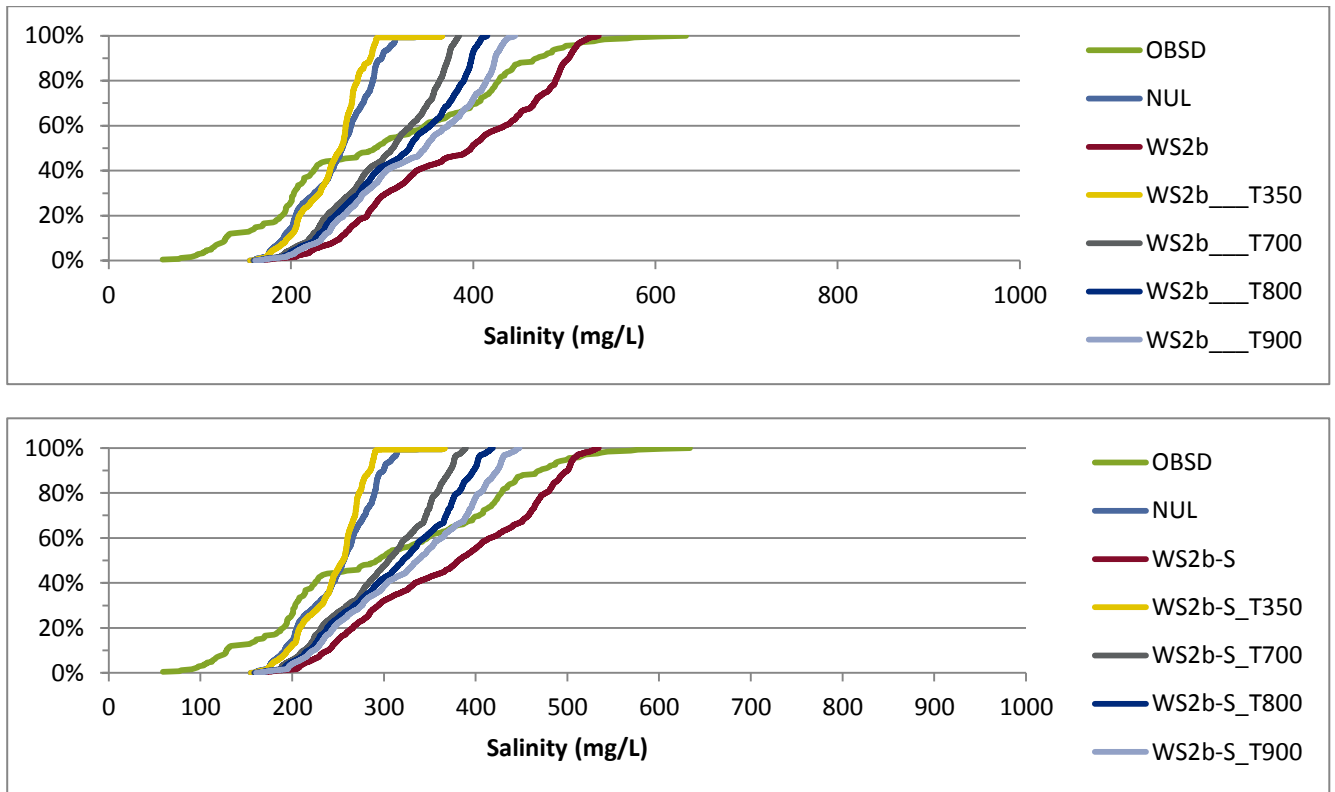


Figure 3.77 : End of Pipe Target Distribution Plot at #174 (Lake Lyell)

Table 3.43 : End of Pipe Target Daily Statistics at #174 (Lake Lyell) - Concurrent

Percentile	Salinity (mg/L)						
	OBSD	NUL	WS2b	WS2b_T350	WS2b_T700	WS2b_T800	WS2b_T900
Minimum	59	155	164	155	159	160	161
5%	114	179	225	182	201	206	211
10%	129	192	254	197	221	228	234
20%	192	205	284	209	240	249	258
50%	295	256	398	255	312	330	347
80%	428	290	490	273	363	390	415
90%	471	300	505	287	373	398	424
95%	500	309	513	291	376	403	430
Maximum	634 (n=242)	366	538	366	385	415	446

Table 3.44 : End of Pipe Target Daily Statistics at #174 (Lake Lyell) - Sequential

Percentile	Salinity (mg/L)						
	OBSD	NUL	WS2b-S	WS2b-S_T350	WS2b-S_T700	WS2b-S_T800	WS2b-S_T900
Minimum	59	155	164	155	159	160	161
5%	114	179	218	181	196	201	205
10%	129	192	239	195	213	218	223
20%	192	205	266	208	232	238	245
50%	295	256	382	255	305	321	337
80%	428	290	476	273	358	380	404
90%	471	300	500	285	372	398	424
95%	500	309	506	288	377	403	429
Maximum	634 (n=242)	366	534	366	390	419	448

Lake Burragorang

Figure 3.78 and Figure 3.79 presents the time-series model output at Lake Burragorang (Node #280). The output from the calibration run is also presented in these figures, since there was no observation data available in Lake Burragorang. Figure 3.80 presents the distribution plot, and is summarised in Table 3.45 and Table 3.46 for concurrent and sequential implementation respectively. It is noted that the scale in Figure 3.80 is reduced compared to other distribution plots.

From Table 3.45, predicted median salinity in Lake Burragorang for the End of Pipe target of 350µS/cm simulation is 100mg/L and is 102mg/L in the End of Pipe target of 900µS/cm simulation. Median salinity in WS2b, without treatment, is 104mg/L and is 98mg/L in the NUL case.

From Table 3.46, predicted median salinity in the sequential implementation case for an End of Pipe target of 350µS/cm is 99mg/L and is 102mg/L in the End of Pipe target of 900µS/cm simulation. This is compared to 98mg/L in the NUL case.

The maximum modelled salinity in Lake Burragorang is 102mg/L in the NUL case and is 104mg/L in the calibration simulation.

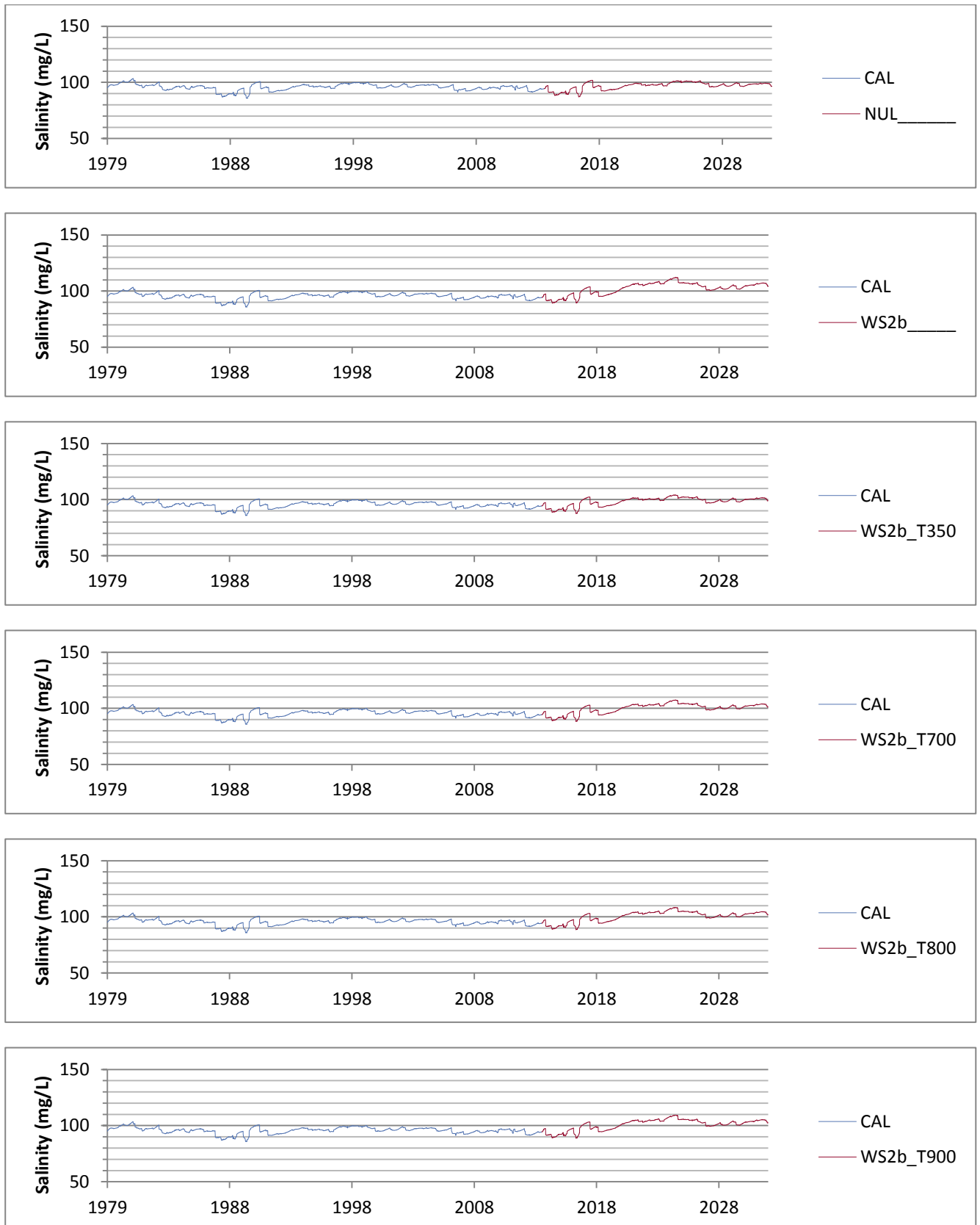


Figure 3.78 : End of Pipe Target Time-Series chart at #280 (Lake Burragorang) - Concurrent

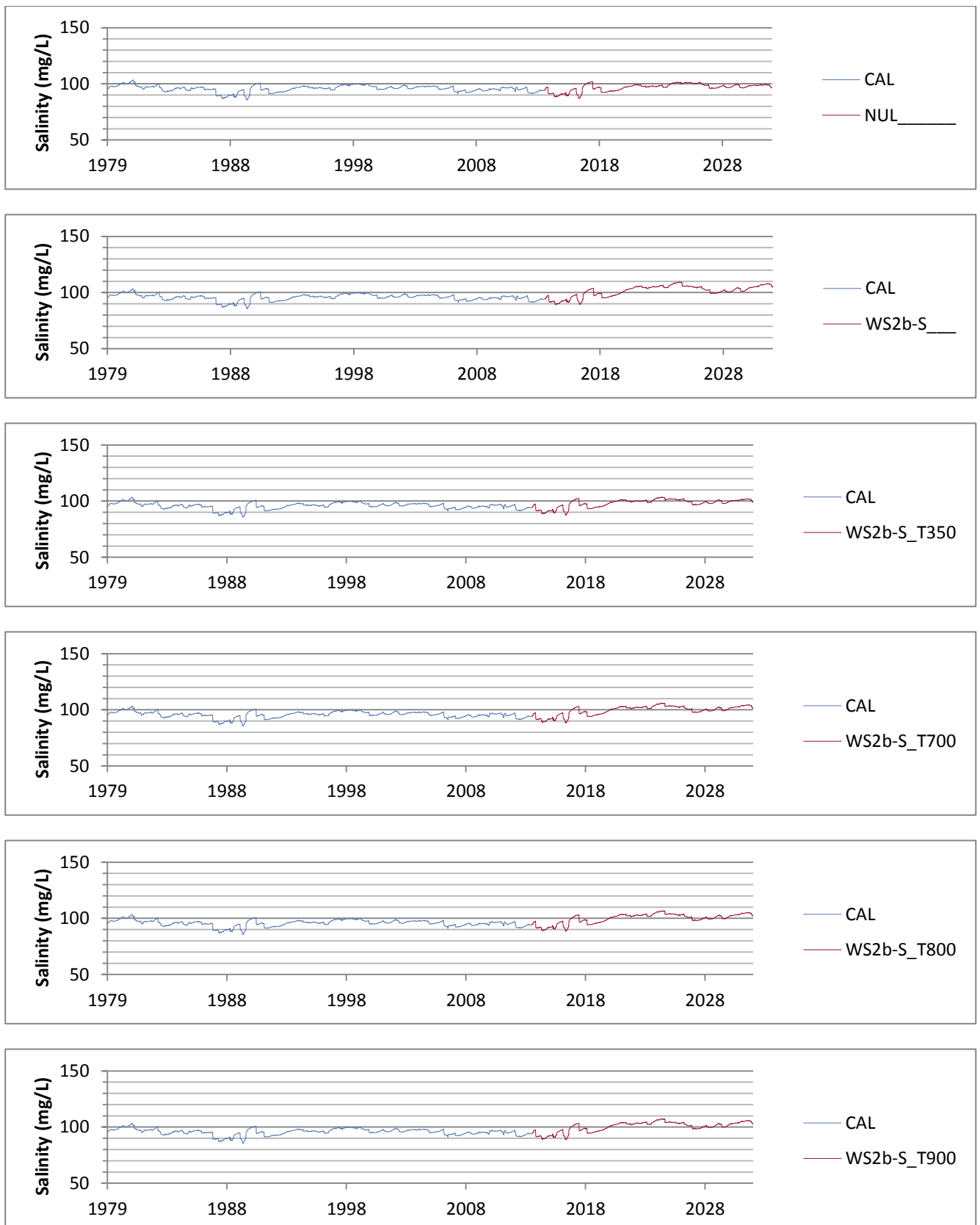


Figure 3.79 : End of Pipe Target Time-Series chart at #280 (Lake Burragorang) - Sequential

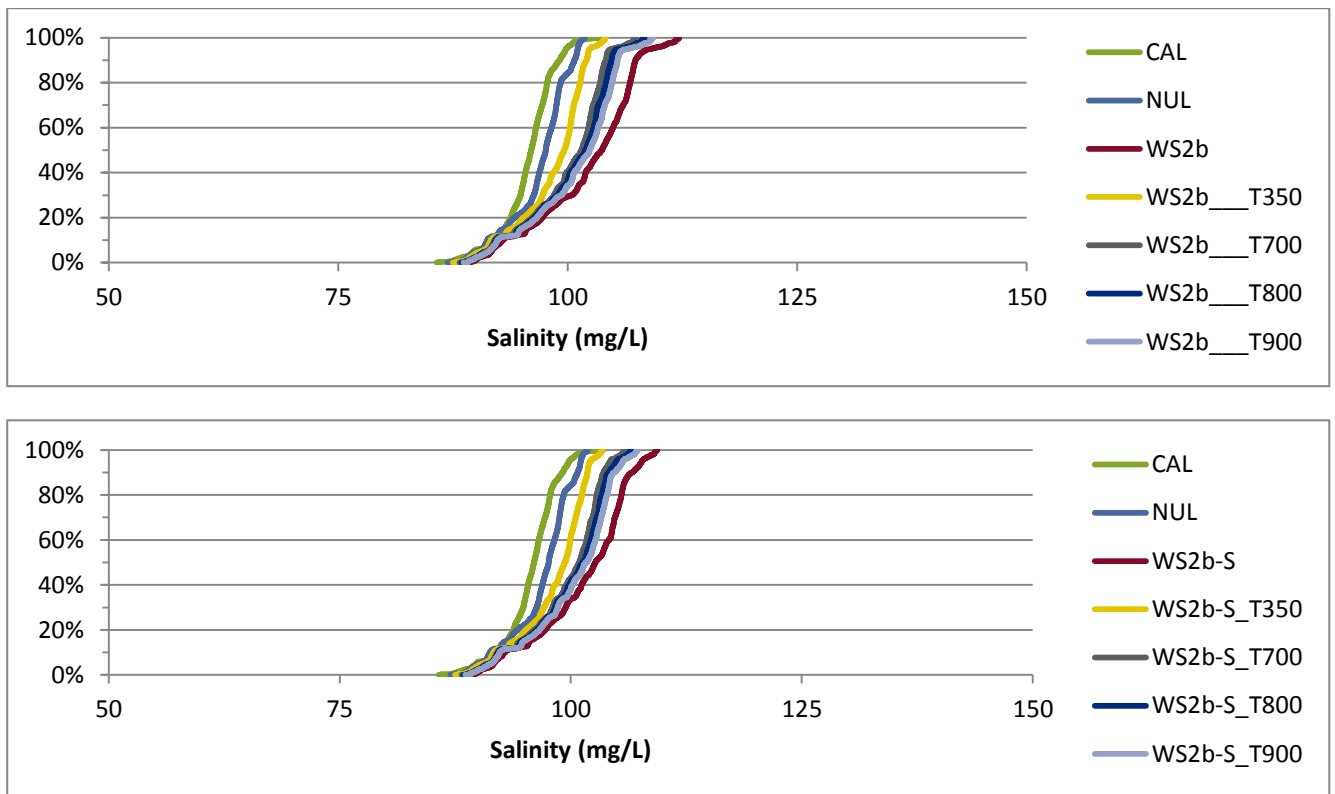


Figure 3.80 : End of Pipe Target Distribution Plot at #280 (Lake Burragorang)

Table 3.45 : End of Pipe Target Daily Statistics at #280 (Lake Burragorang) - Concurrent

Percentile	Salinity (mg/L)						
	CAL	NUL	WS2b	WS2b_T350	WS2b_T700	WS2b_T800	WS2b_T900
Minimum	86	87	89	88	88	89	89
5%	90	90	92	91	91	91	91
10%	92	91	93	92	92	92	92
20%	94	94	97	95	96	96	97
50%	96	98	104	100	102	102	102
80%	98	99	107	101	104	104	105
90%	99	101	107	102	104	105	105
95%	100	101	109	102	105	106	107
Maximum	104	102	112	104	107	108	109

Table 3.46 : End of Pipe Target Daily Statistics at #280 (Lake Burragorang) - Sequential

Percentile	Salinity (mg/L)						
	CAL	NUL	WS2b-S	WS2b-S_T350	WS2b-S_T700	WS2b-S_T800	WS2b-S_T900
Minimum	86	87	89	88	88	88	89
5%	90	90	92	91	91	91	91
10%	92	91	93	92	92	92	92
20%	94	94	97	95	96	96	97
50%	96	98	103	99	101	101	102
80%	98	99	105	101	103	103	104
90%	99	101	107	102	104	104	105
95%	100	101	108	102	104	105	106
Maximum	104	102	109	103	106	107	107

Treatment Volumes

Figure 3.81 presents the modelled treatment volume for the concurrent implementation case and the sequential implementation case. It is noted that prediction treatment volumes presented in Figure 3.81 are indicative and are based on simple mass balance and do not take into account the pre-treatment and other water treatment process requirements; although, the expected accuracy is +/- 15%. Further detail on model assumptions is presented in Section 3.5.1 above.

From Figure 3.81, modelled volumetric treatment requirement is up to 34.5ML/d in 2023 in the concurrent implementation simulation, for an End of Pipe target of 350µS/cm. For an End of Pipe target of 900µS/cm, treatment volume is up to 12.1ML/d in 2023. From Figure 3.81, the modelled volumetric treatment requirement is up to 25.9ML/d in the sequential implementation simulation, for an End of Pipe target of 350µS/cm and is up to 9.1ML/d for an End of Pipe target of 900µS/cm.

3.6 Treatment Options

3.6.1 Treatment Option Setup

There are several options potentially available to achieve an agreed Performance Outcome. Two of these options are presented in this report and are assessed in isolation and in combination, as relevant.

Necessarily, there is need to maintain flexibility in achieving the agreed Performance Outcome and the above-mentioned treatment options may or may not be adopted in practice.

This report does not address potential approval requirements for a pipeline from Clarence to Springvale Mine, however, does present the modelled impact to flow and salinity in the Cocks River of this potential option.

The Treatment Options presented in this report include:

- Supply of Clarence mine water discharge to Springvale, with discharge to the Cocks River via Sawyers Swamp Creek
- Continuous treatment of a nominal capacity of 6ML/d.

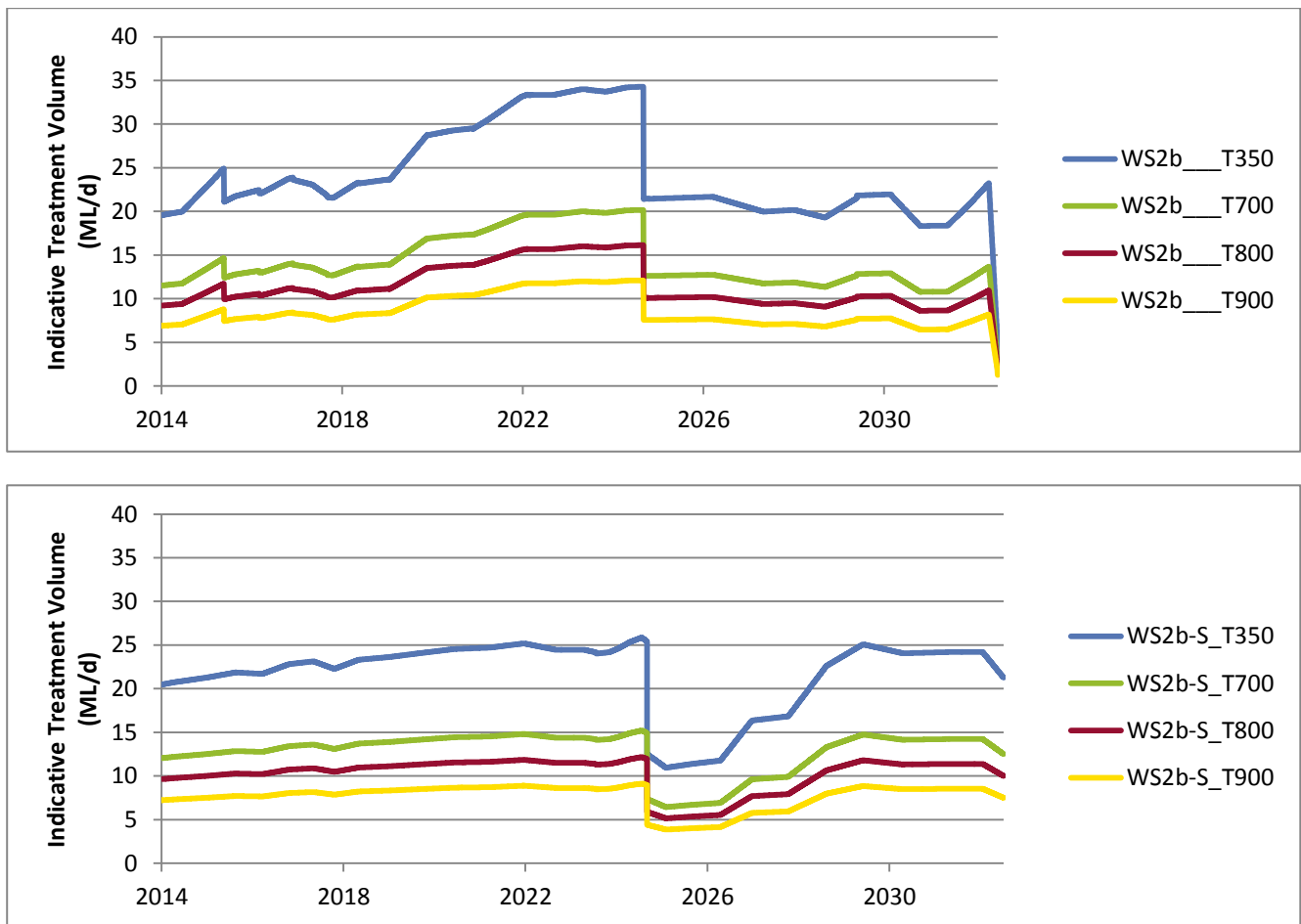


Figure 3.81 : End of Pipe Target Indicative Treatment Volume (ML/d)

Relevant assumptions include:

- no account of pre-treatment requirement
- treatment was assumed to occur instantaneously
- no account of other analytes, only salinity was considered
- assumed influent salinity from Angus Place Colliery and Springvale Mine was 804mg/L, if conversion factor is 0.67
- assumed influent salinity from Clarence was 268mg/L, if conversion factor is 0.67
- assumed effluent salinity from continuous treatment is 50mg/L
- no account of brine stream, salt was removed from model
- no account for potential dilution, albeit small, of runoff from catchment upstream of point of discharge

3.6.2 Treatment Option Scenarios

As identified above, assessment of potential Treatment Options presented in this report is limited to Water Strategy 2b (WS2b) and WS2b-S in order to reduce the complexity of this report.

The options include:

- Clarence Only

- transfer of mine water discharge from Clarence to Springvale Mine but with no discharge from Springvale Mine or Angus Place Colliery
- WS2b with Clarence
 - to assess the impact of dilution of Clarence on mine water discharge from Springvale Mine and Angus Place Colliery via Springvale LDP009
- WS2b with RO6
 - assessment of outcome of continuous treatment at 6ML/d to an assumed effluent quality of 50mg/L
- WS2b with Clarence and RO6
 - assess the outcome of dilution with Clarence and fixed continuous treatment at 6ML/d to an assumed effluent quality of 50mg/L.

3.6.3 Treatment Option Results

Concurrent Implementation

The model control files pertaining to the treatment option scenarios are:

- 002a_PRD-CLR_01a.gsm
- 002a_PRD-WS2b_CLR_02b.gsm
- 002a_PRD-WS2b_RO6_01a.gsm
- 002a_PRD-WS2b_CLR_02b_RO6.gsm
- 002a_PRD-WS2b_CLR_02b_T350uS.gsm
 - 002a_PRD-WS2b_CLR_02b_T700uS.gsm
 - 002a_PRD-WS2b_CLR_02b_T800uS.gsm
 - 002a_PRD-WS2b_CLR_02b_T900uS.gsm

Lake Wallace

Figure 3.82 presents the time-series output at Node #047 with respect to salinity. Node #047 lies immediately upstream of Lake Wallace and corresponds to location of NSW Office of Water Station No. 212045. Figure 3.83 presents time-series output at Node #047 with respect to flow. Figure 3.84 presents the distribution plot of model output, and is summarised in Table 3.47 and Table 3.48 in regard to salinity and flow respectively.

From Figure 3.82, the Clarence Only simulation indicates that discharge of Clarence mine water dominates predicted salinity in Cocks River above Lake Wallace. This is due to the volumetric discharge being 13ML/d, ranging up to 19ML/d, with an assumed salinity of 268mg/L (400µS/cm).

In Table 3.47, simulation WS2b with CLR and RO6 represents continuous treatment at a fixed rate of 6ML/d, with blending with Clarence. This simulation has a median salinity of 498mg/L, compared to NUL case of 466mg/L. From Table 3.48, median flow, however, is much higher, with WS2b with CLR and RO6 being 67.3ML/d compared to 14.2ML/d in the NUL case. The impact of higher, continuous discharge is illustrated in Figure 3.83, although is already elevated due to WS2b and WS2b-S.

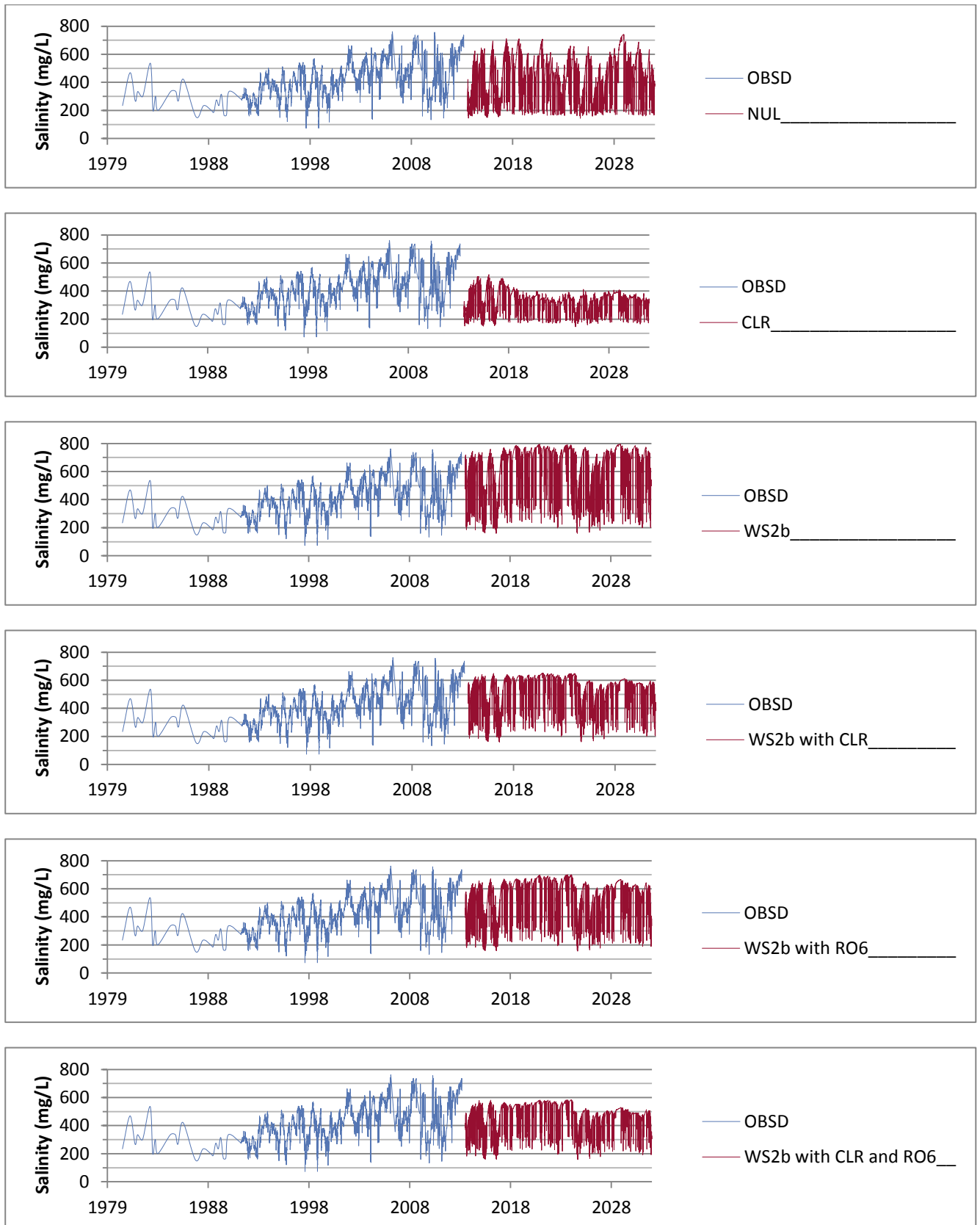


Figure 3.82 : Treatment Option Time-Series chart at #047 (Coxs River above Lake Wallace, Gauge No. 212054) – Salinity

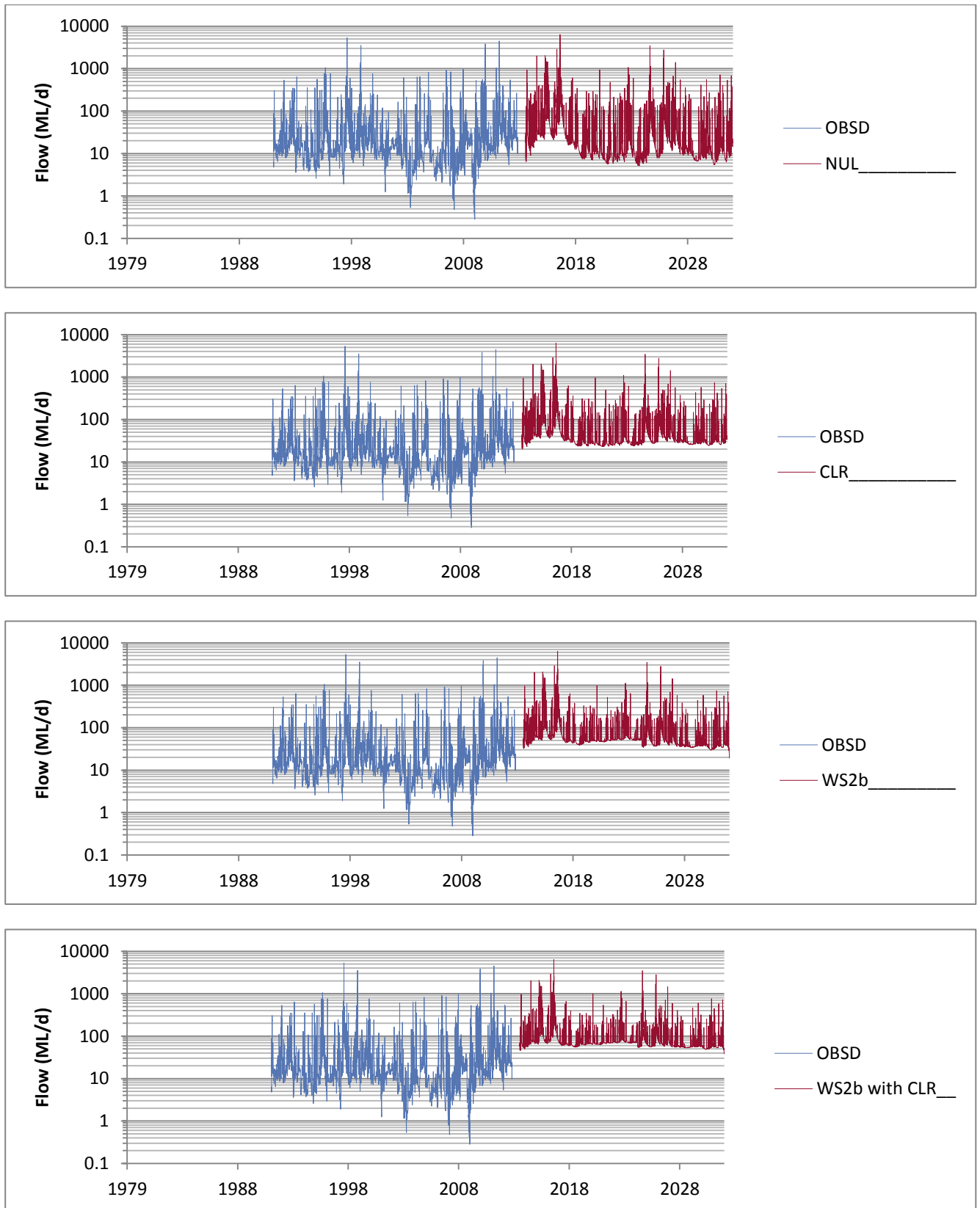


Figure 3.83 : Treatment Option Time-Series chart at #047 (Coxs River above Lake Wallace, Gauge No. 212054) – Flow

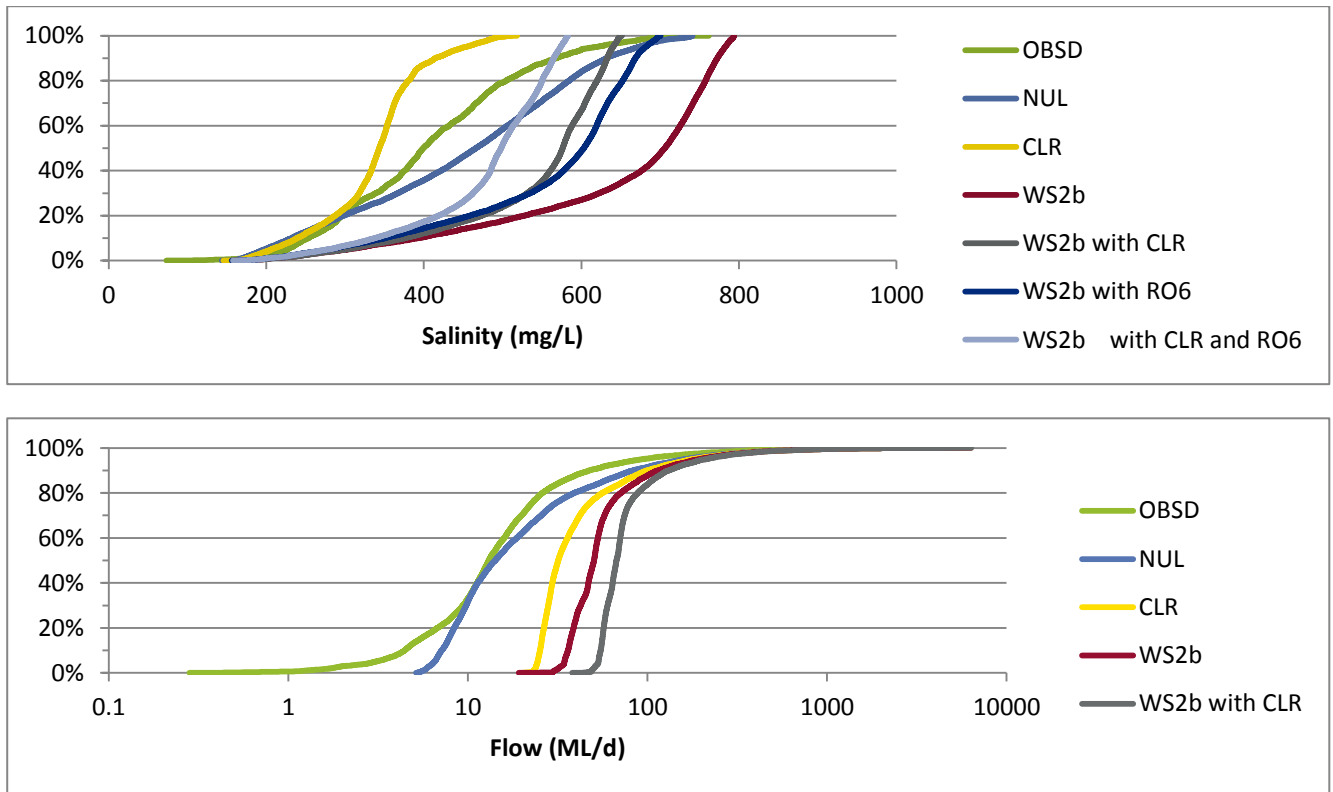


Figure 3.84 : Treatment Option Distribution Plot at #047 (Coxs River above Lake Wallace, Gauge No. 212054)

Table 3.47 : Treatment Option Daily Statistics at #047 (Coxs River above Lake Wallace) - Salinity

Percentile	Salinity (mg/L)						
	OBSD	NUL	CLR	WS2b	WS2b with CLR	WS2b with RO6	WS2b with CLR and RO6
Minimum	73	144	146	160	160	156	158
5%	227	198	206	305	302	280	279
10%	253	232	239	394	376	351	337
20%	296	298	288	528	474	459	419
50%	399	466	343	706	576	603	498
80%	504	584	380	758	620	652	550
90%	568	632	415	773	633	668	565
95%	620	673	453	783	640	681	574
Maximum	762 (n=5,280)	741	518	794	652	700	583

Table 3.48 : Treatment Option Daily Statistics at #047 (Coxs River above Lake Wallace) - Flow

Percentile	Flow (ML/d)				
	OBSD	NUL	CLR	WS2b	WS2b with CLR
Minimum	0.3	5.1	20.2	19.2	40.5
5%	3.1	6.5	24.5	34.5	53.4
10%	4.5	7.1	25.3	36.1	55.0
20%	6.8	8.4	26.6	38.8	57.1
50%	13.1	14.2	31.9	50.5	67.3
80%	26.1	39.2	56.3	71.2	88.4
90%	47.7	83.4	99.6	115.4	131.9
95%	94.7	162.5	178.5	194.7	212.9
Maximum	5,321 (n=7,906)	6,327	6,342	6,358	6,373

Lake Lyell

Figure 3.85 presents time-series model output at Node #154 with respect to flow. Node #154 is located between Lake Wallace and Lake Lyell and corresponds to location of NSW Office of Water Station No. 212058. Figure 3.86 presents the distribution plot of this output, and is summarised in Table 3.49.

From Table 3.57, predicted median flow in the NUL case is 19.0ML/d and is 53.3ML/d in WS2b and is 70.8ML/d in WS2b with CLR. It is noted that Treatment Option WS2b with RO6 and WS2b have the same flow rate, as does WS2b with CLR and WS2b with CLR and RO6, therefore only WS2b with CLR is presented in Figure 3.85 Table 3.49.

As illustrated in Figure 3.85, both proposed discharge under WS2b and Treatment Option WS2b with CLR leads to a less variable flow regime at Node #154.

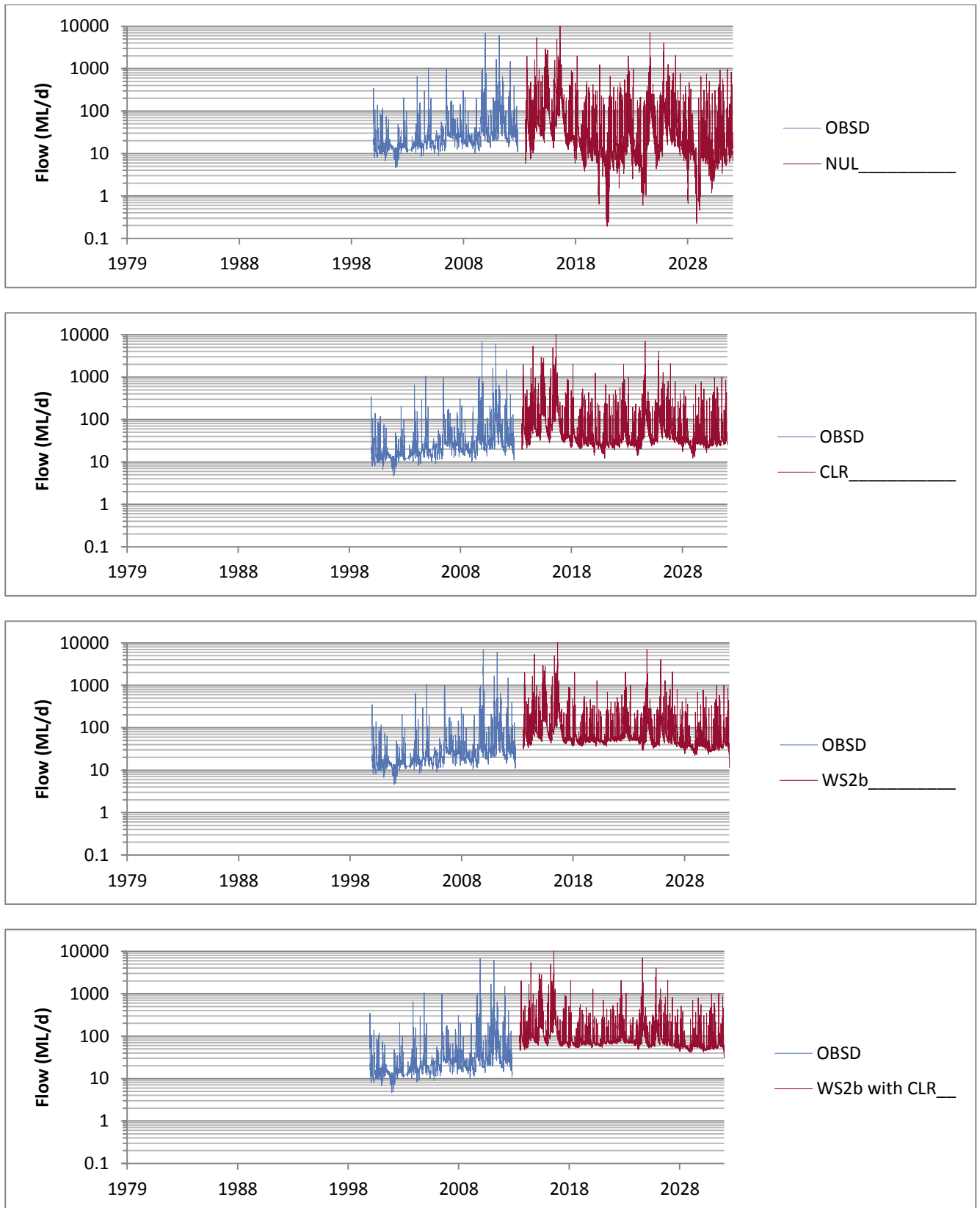


Figure 3.85 : Treatment Option Time-Series chart at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

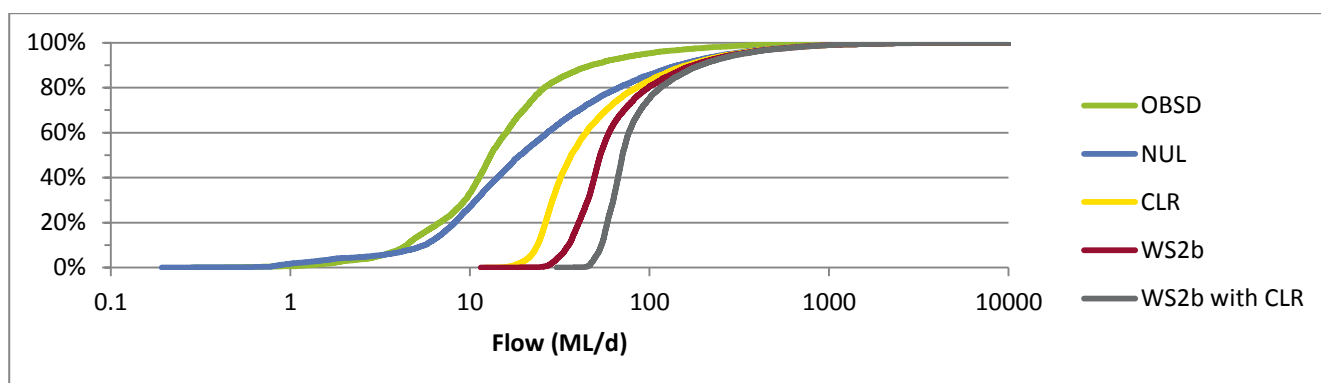


Figure 3.86 : Treatment Option Distribution Plot at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

Table 3.49 : Treatment Option Daily Statistics at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

Percentile	Flow (ML/d)				
	OBSD	NUL	CLR	WS2b	WS2b with CLR
Minimum	4.6	0.2	12.2	11.5	30.5
5%	10.5	2.7	21.7	31.6	50.3
10%	12.1	5.6	23.8	35.5	54.1
20%	14.5	8.3	26.4	40.4	58.4
50%	20.4	19.0	36.7	53.3	70.8
80%	34.7	67.3	84.9	98.5	115.6
90%	65.4	144.7	162.8	176.9	193.6
95%	112.1	280.5	295.6	310.1	326.9
Maximum	6,750 (n=4,563)	11,487	11,502	11,518	11,533

Figure 3.87 presents time-series output at Node #035 with respect to salinity. Node #035 corresponds to location of EnergyAustralia monitoring station COX5. Figure 3.88 presents the distribution plot of salinity with respect to Node #035. Table 3.50 presents a summary of Figure 3.88.

From Figure 3.87, predicted salinity in simulation WS2b as well as WS2b with CLR, WS2b with RO6 and WS2b with CLR and RO6 is less than that presented from the observation record. The higher observed salinity was due to historical discharge of Cooling Tower blowdown from Wallerawang Power Station.

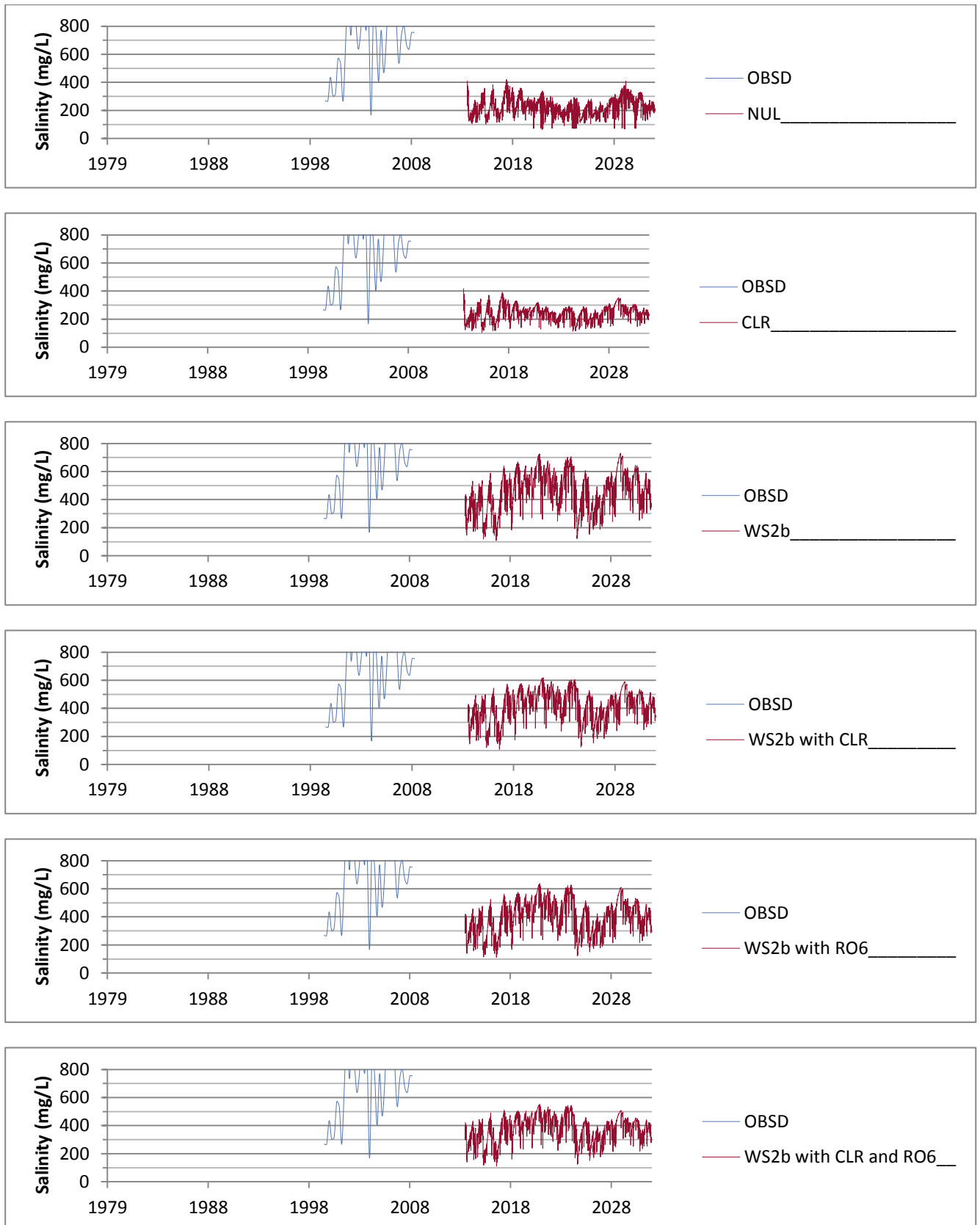


Figure 3.87 : Treatment Option Time-Series at #035 (Coxs River above Lake Lyell, at location of EnergyAustralia station COX5)

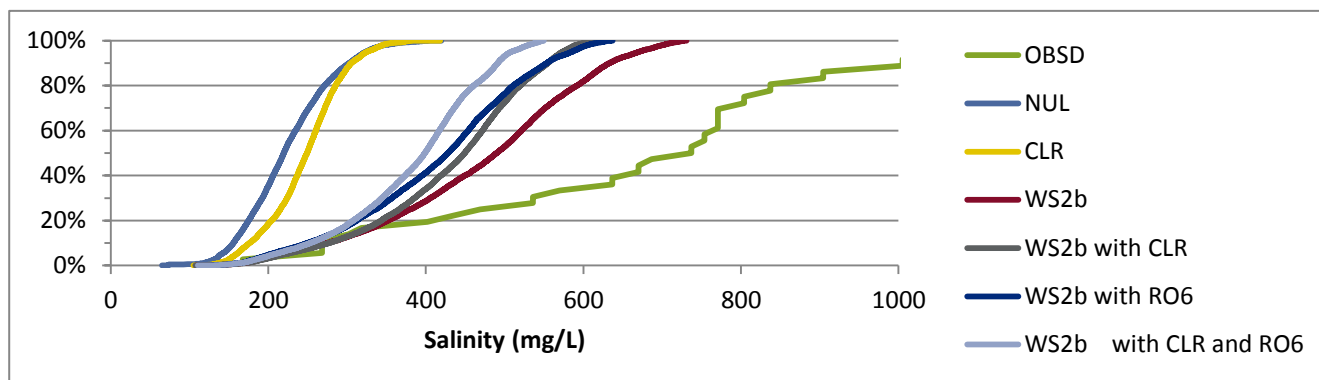


Figure 3.88 : Treatment Option Distribution at #035 (Coxs River above Lake Lyell, at location of EnergyAustralia station COX5)

Table 3.50 : Treatment Option Statistics at #035 (Coxs River above Lake Lyell, at location of EnergyAustralia station COX5)

Percentile	Salinity (mg/L)						
	OBSD	NUL	CLR	WS2b	WS2b with CLR	WS2b with RO6	WS2b with CLR and RO6
Minimum	168	65	105	108	108	111	111
5%	268	140	159	217	220	202	207
10%	285	156	176	275	277	249	253
20%	436	175	204	352	343	312	308
50%	737	220	249	490	449	428	399
80%	838	271	285	592	520	511	461
90%	1,005	303	305	633	555	554	491
95%	1,114	324	325	671	573	585	508
Maximum	1,240 (n=36)	411	395	729	617	637	550

Figure 3.89 presents the time-series output at Lake Lyell (Node #174). Figure 3.90 presents the distribution of modelled salinity and Table 3.51 presents a summary.

From Figure 3.89, predicted peak salinity is 440mg/L (655 μ S/cm) in simulation WS2b with CLR and RO6. This is essentially equivalent to the predicted peak salinity presented in Figure 3.75, with respect to End of Pipe target at 900 μ S/cm.

From Table 3.65, predicted median salinity in simulation WS2b with CLR and RO6 is 352mg/L and is comparable to median salinity from the observation record of 295mg/L. Predicted peak salinity in WS2b with CLR and RO6 is 459mg/L, compared to 634mg/L from the observation record.

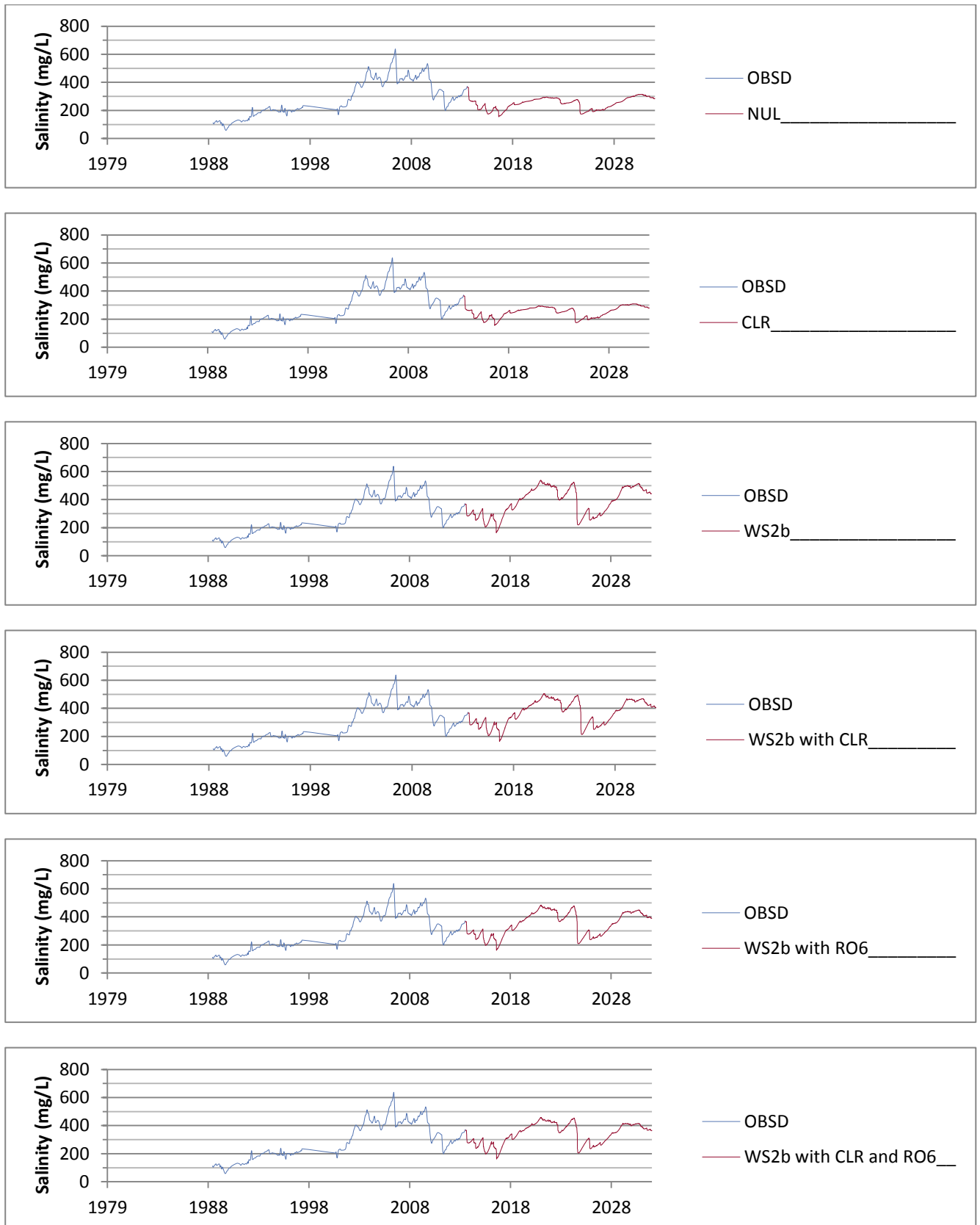


Figure 3.89 : Treatment Option Time-Series chart at #174 (Lake Lyell)

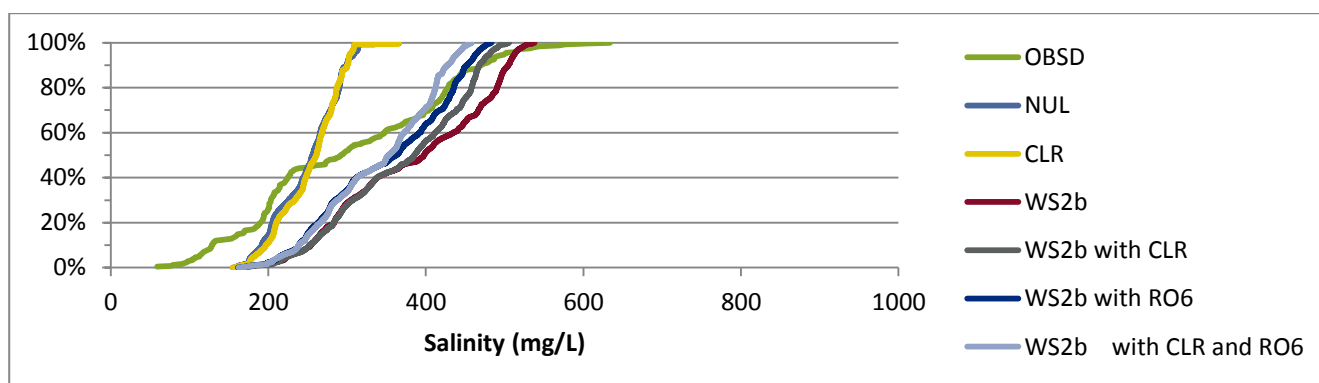


Figure 3.90 : Treatment Option Distribution Plot at #174 (Lake Lyell)

Table 3.51 : Treatment Option Daily Statistics at #174 (Lake Lyell)

Percentile	Salinity (mg/L)						
	OBSD	NUL	CLR	WS2b	WS2b with CLR	WS2b with RO6	WS2b with CLR and RO6
Minimum	59	155	155	164	164	161	162
5%	114	179	182	225	225	215	216
10%	129	192	197	254	252	239	238
20%	192	205	210	283	283	263	266
50%	295	256	261	398	385	362	352
80%	428	290	287	490	458	436	412
90%	471	300	300	505	468	452	427
95%	500	309	304	513	481	464	439
Maximum	634 (n=242)	366	366	538	506	483	459

Lake Burragarang

Figure 3.91 presents predicted salinity at Node #225, which is the last sub-catchment on the Coxs River above Lake Burragarang in the water quality model. Figure 3.92 presents the equivalent chart with respect to flow. Figure 3.93 presents the distribution plot of model output, and is summarised in Table 3.52 and Table 3.53.

From Figure 3.91, predicted salinity in the Coxs River above Lake Burragarang is higher in each Treatment Option scenario compared to the NUL case, however, median salinity in Table 3.52 is 159mg/L in WS2b with CLR and RO6 and therefore less than the ANZECC default trigger value of 234mg/L (350 μ S/cm). As such, whilst the Proposal leads to salinity above the historical range at this location, it is not considered significant.

From Figure 3.92 and Table 3.53, predicted flow in WS2b with CLR and RO6 of 221.6ML/d is not significantly different to predicted median flow in the NUL case of 190.0ML/d.

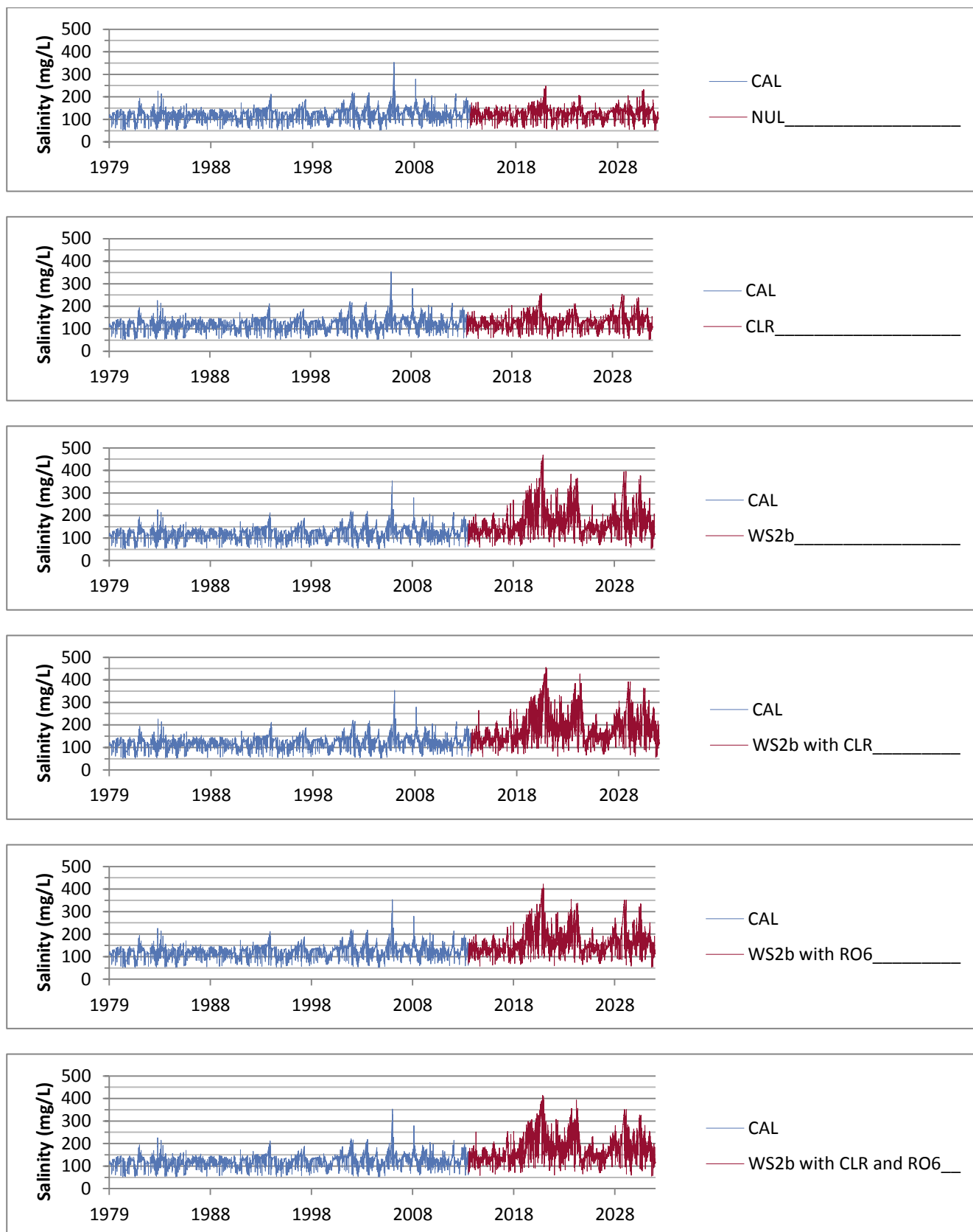


Figure 3.91 : Treatment Option Time-Series chart at #225 (Coxs River above Lake Burragorang) – Salinity

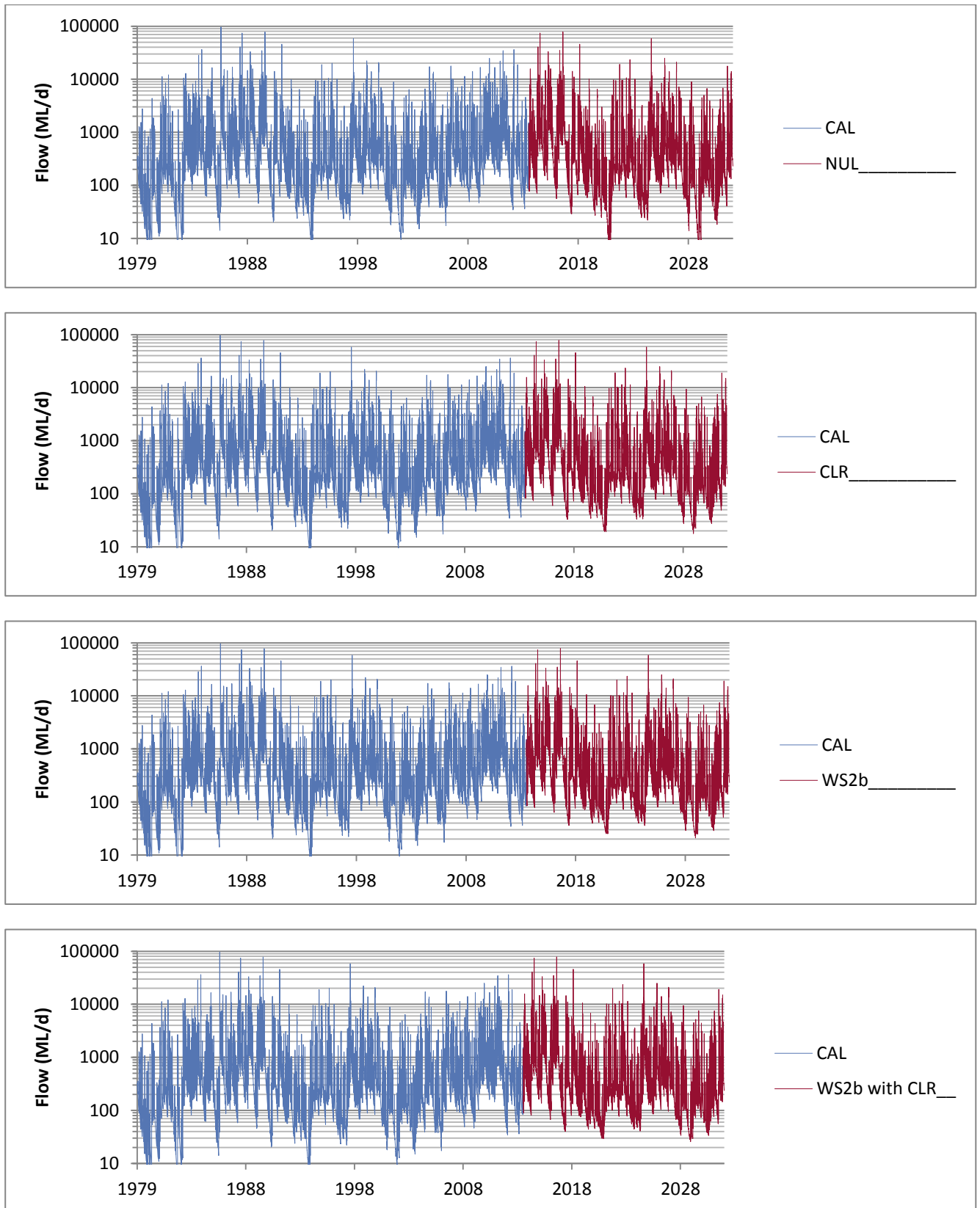


Figure 3.92 : Treatment Option Time-Series chart at #225 (Coxs River above Lake Burragorang) – Flow

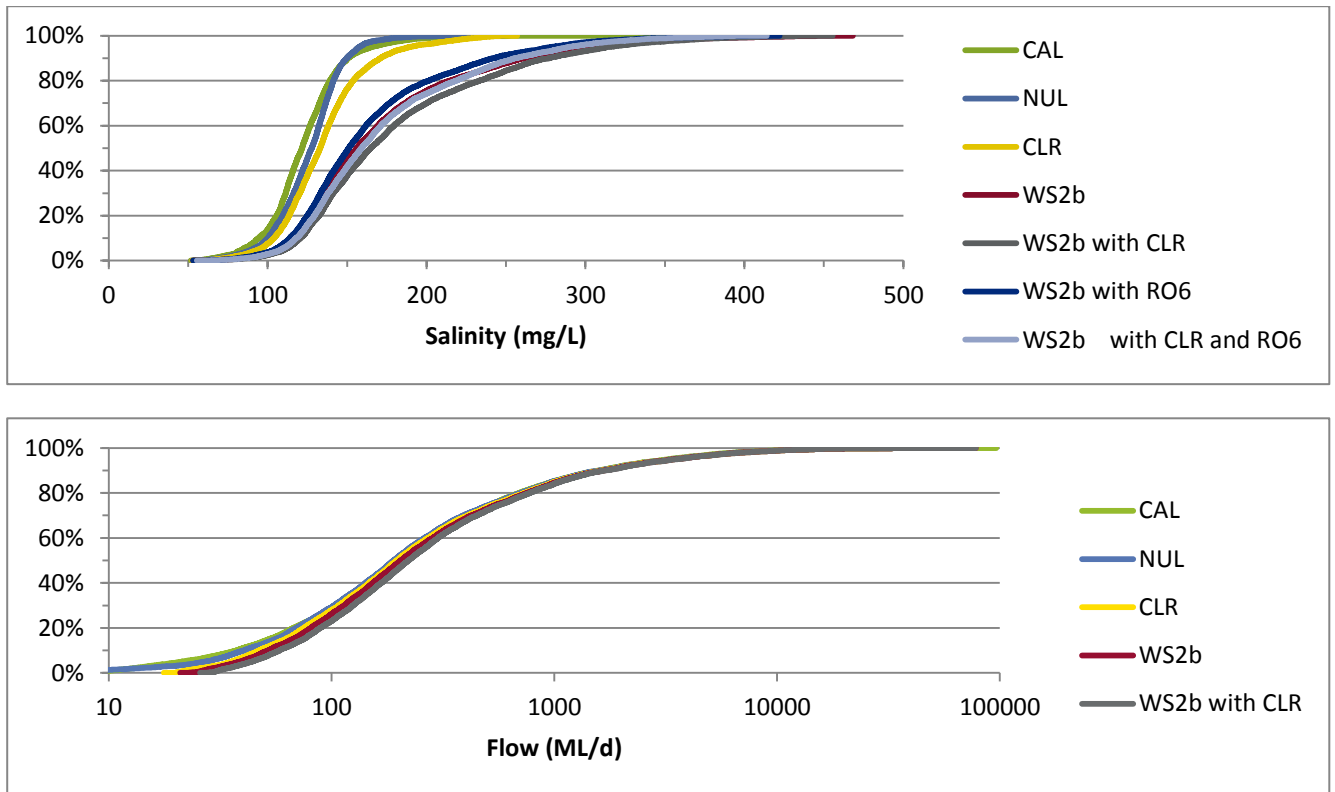


Figure 3.93 : Treatment Option Distribution Plot at #225 (Coxs River above Lake Burragorang)

Table 3.52 : Treatment Option Daily Statistics at #225 (Coxs River above Lake Burragorang) - Salinity

Percentile	Salinity (mg/L)						
	OBSD	NUL	CLR	WS2b	WS2b with CLR	WS2b with RO6	WS2b with CLR and RO6
Minimum	74	52	52	53	56	53	55
5%	75	90	95	107	111	105	109
10%	82	100	104	116	121	114	118
20%	91	110	113	128	132	125	129
50%	111	128	133	156	165	151	159
80%	142	141	154	215	233	202	219
90%	159	150	171	261	277	242	256
95%	280	158	190	304	315	279	290
Maximum	704 (n=25)	249	257	468	456	422	414

Table 3.53 : Treatment Option Daily Statistics at #225 (Coxs River above Lake Burragorang) - Flow

Percentile	Flow (ML/d)				
	CAL	NUL	CLR	WS2b	WS2b with CLR
Minimum	4.9	5.6	17.7	20.9	25.7
5%	21.4	27.1	35.4	38.8	43.9
10%	37.5	40.5	47.5	52.0	58.7
20%	67.7	69.7	75.3	81.0	89.1
50%	199.5	190.0	196.9	205.0	221.6
80%	697.2	710.7	737.2	757.7	778.6
90%	1,601	1,601	1,645.2	1,676	1,703
95%	3,285	3,380	3,412.5	3,470	3,524
Maximum	96,638	78,103	78,118	78,134	78,149

Figure 3.94 presents the time-series predicted salinity in Lake Burragorang (Node #280), including output from the calibration model, since there is observation data for Lake Burragorang. Figure 3.95 presents a distribution plot of Figure 3.94 and is summarised in Table 3.54.

From Table 3.54, predicted median salinity in WS2b with CLR and RO6 is 104mg/L, compared to 98mg/L in the NUL case. In comparison, predicted median salinity in WS2b is 104mg/L. The increase in salinity in Lake Burragorang is 6% and therefore is considered to have a neutral effect on water quality since the predicted change in salinity is small.

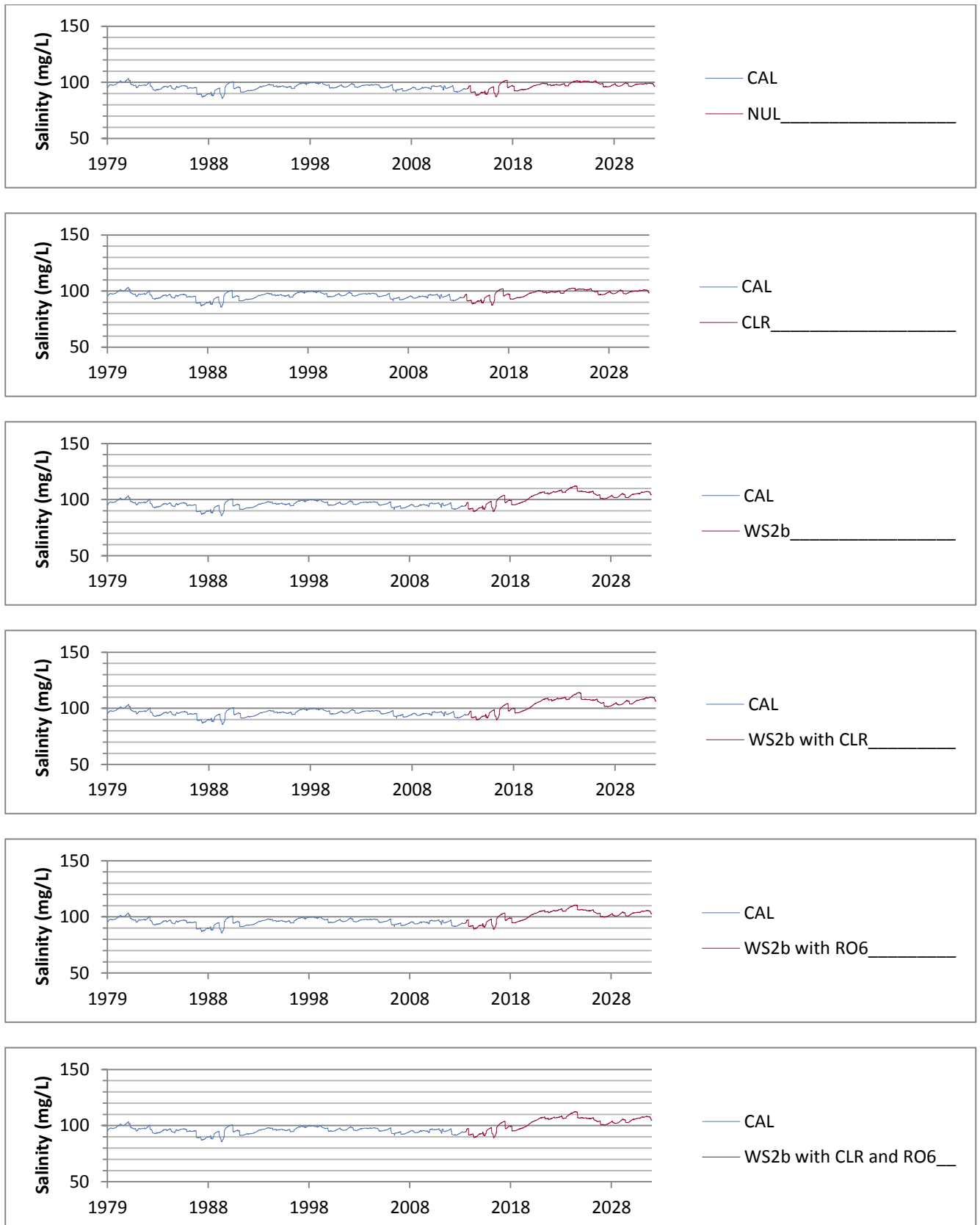


Figure 3.94 : Treatment Option Time-Series chart at #280 (Lake Burragorang)

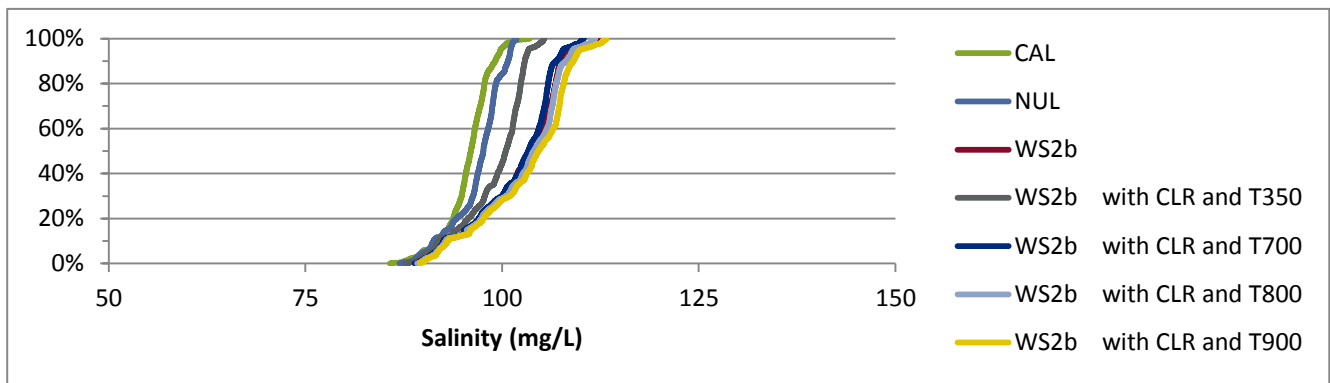


Figure 3.95 : Treatment Option Distribution Plot at #280 (Lake Burragorang)

Table 3.54 : Treatment Option Daily Statistics at #280 (Lake Burragorang)

Percentile	Salinity (mg/L)						
	CAL	NUL	CLR	WS2b	WS2b with CLR	WS2b with RO6	WS2b with CLR and RO6
Minimum	86	87	87	89	90	89	89
5%	90	90	90	92	92	91	92
10%	92	91	91	93	93	92	93
20%	94	94	95	97	98	97	97
50%	96	98	99	104	105	103	104
80%	98	99	101	107	108	105	107
90%	99	101	102	107	109	106	108
95%	100	101	102	109	111	108	109
Maximum	104	102	103	112	114	111	112

Sequential Implementation

The model control files pertaining to the treatment option scenarios are:

- 002a_PRD-WS2b-S_CLR_01a.gsm
- 002a_PRD-WS2b-S_RO6_01a.gsm
- 002a_PRD-WS2b-S_CLR_01a_RO6.gsm

Lake Wallace

Figure 3.96 presents time-series model output for salinity at Node #047, which is located immediately upstream of Lake Wallace. Figure 3.97 presents equivalent output at this node with respect to flow. Figure 3.98 presents a distribution plot of model output, and is summarised in Table 3.55 and Table 3.56.

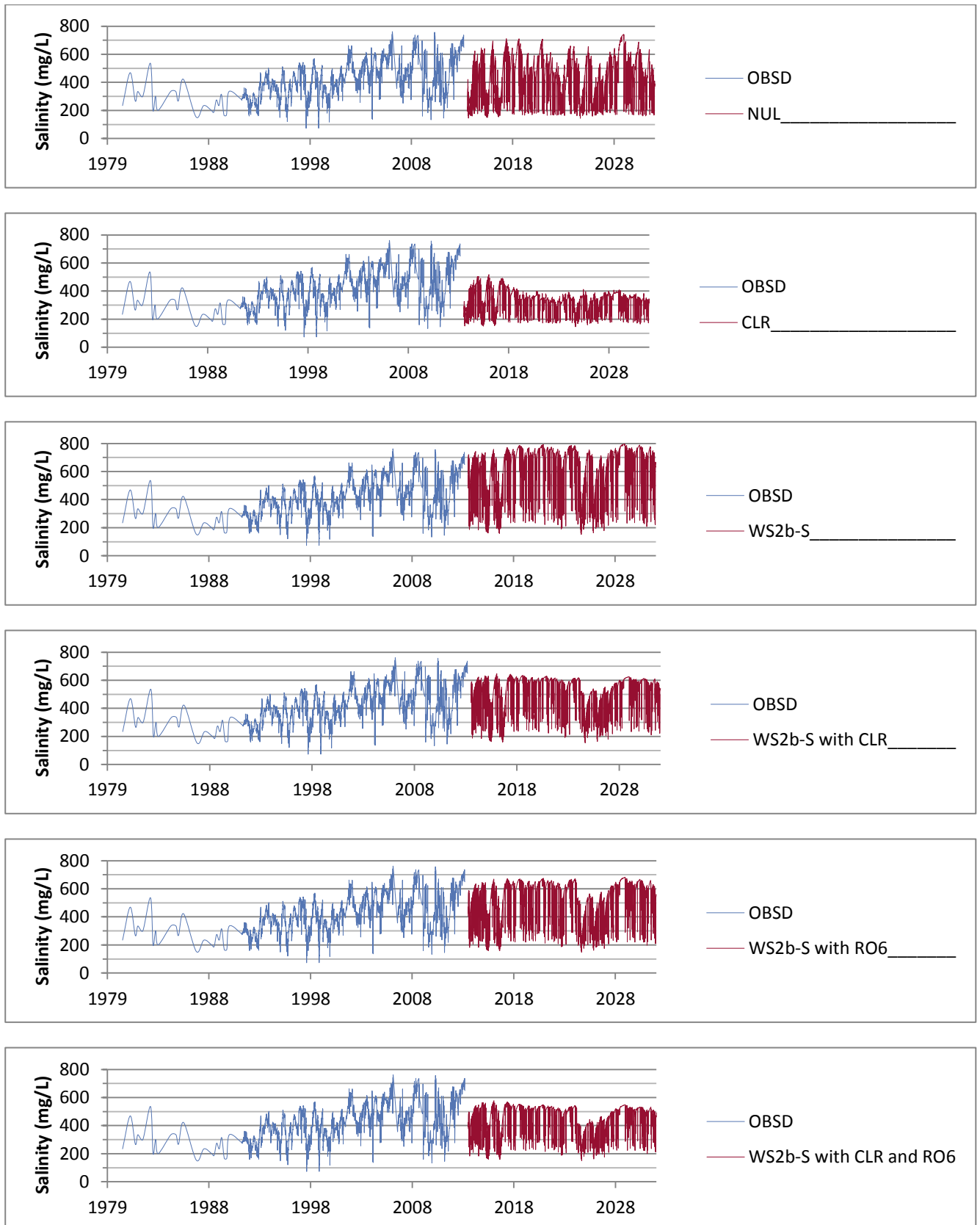


Figure 3.96 : Treatment Option Time-Series chart at #047 (Coxs River above Lake Wallace, Gauge No. 212054) – Salinity

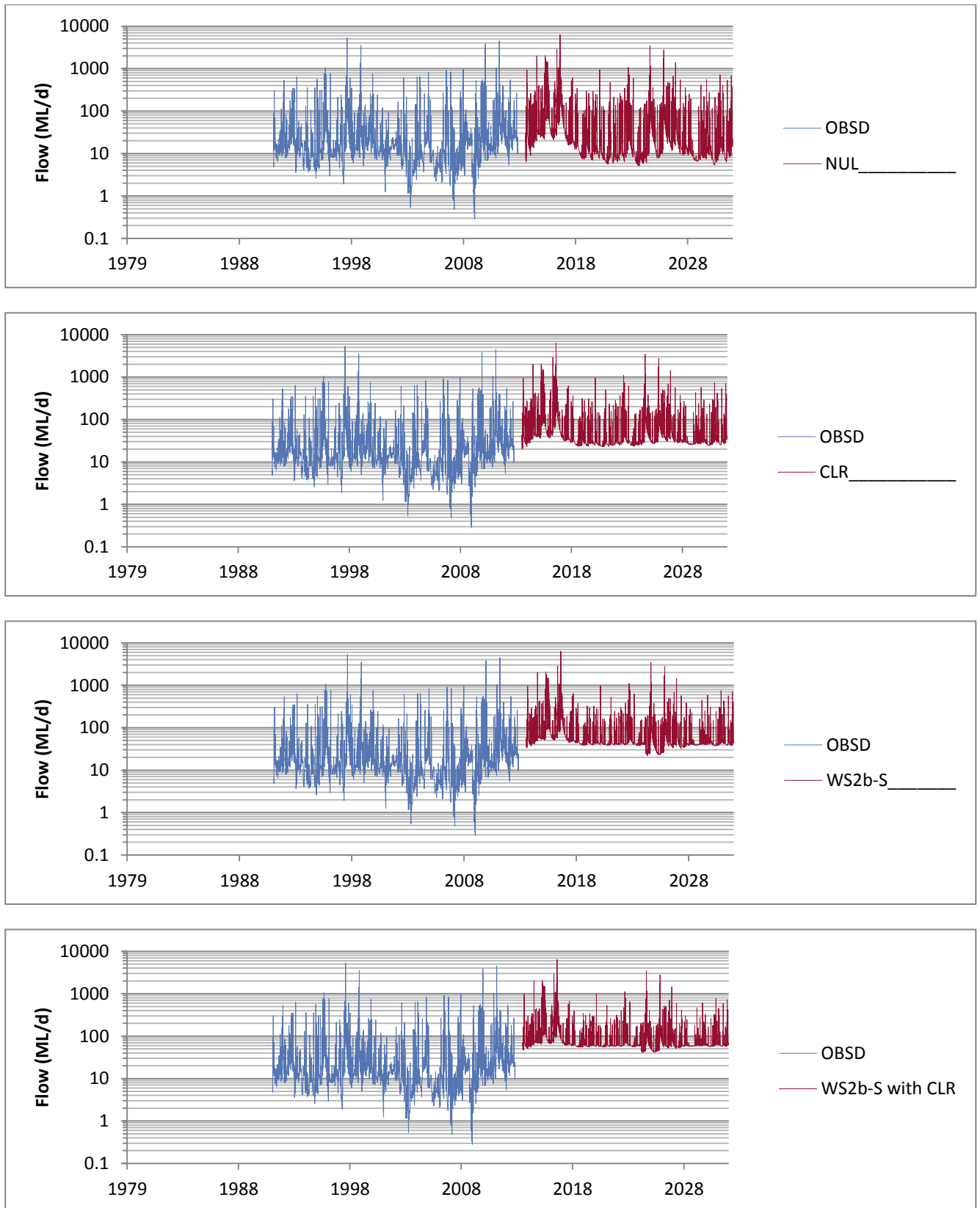


Figure 3.97 : Treatment Option Time-Series chart at #047 (Coxs River above Lake Wallace, Gauge No. 212054) – Flow

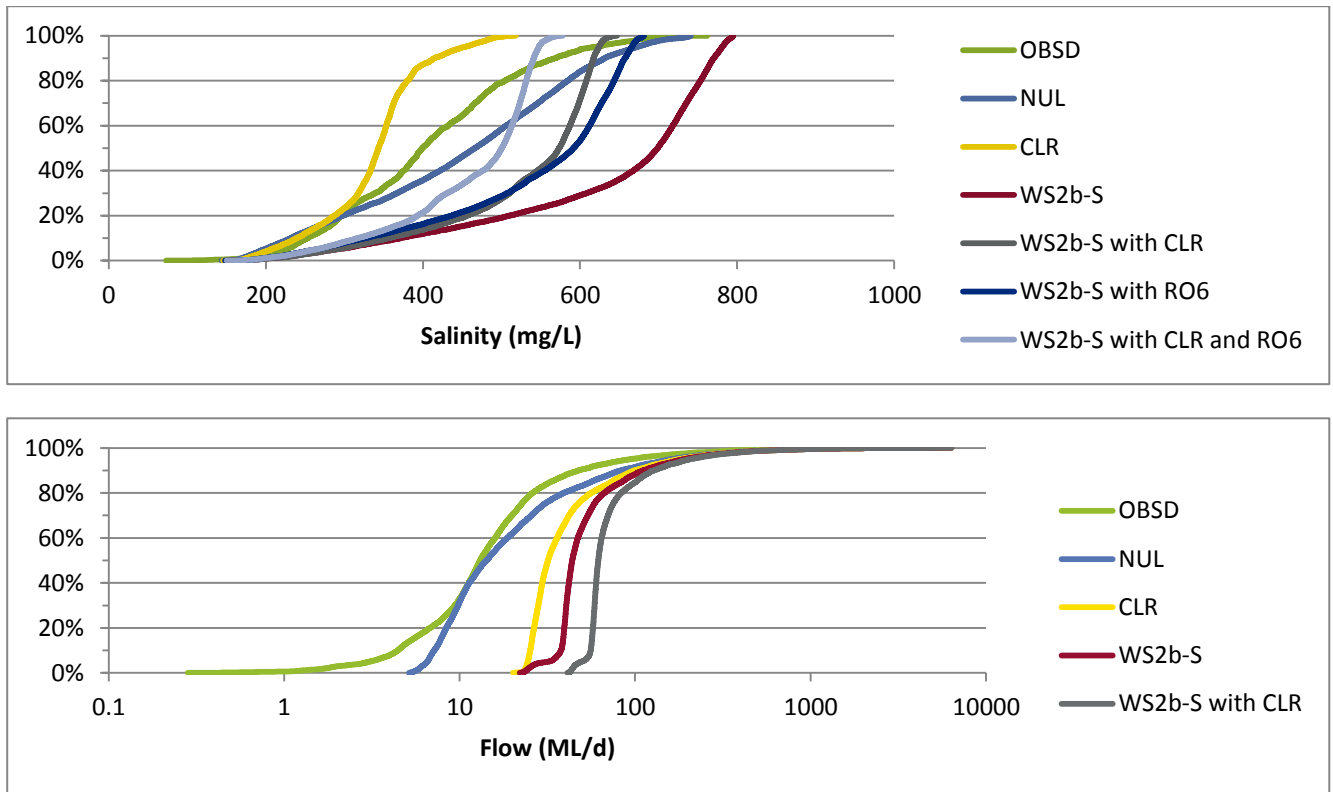


Figure 3.98 : Treatment Option Distribution Plot at #047 (Coxs River above Lake Wallace, Gauge No. 212054)

Table 3.55 : Treatment Option Daily Statistics at #047 (Coxs River above Lake Wallace) - Salinity

Percentile	Salinity (mg/L)						
	OBSD	NUL	CLR	WS2b-S	WS2b-S with CLR	WS2b-S with RO6	WS2b-S with CLR and RO6
Minimum	73	144	146	152	154	148	150
5%	227	198	206	290	289	265	265
10%	253	232	239	371	357	327	317
20%	296	298	288	510	456	437	393
50%	399	466	343	699	573	592	500
80%	504	584	380	754	608	643	532
90%	568	632	415	770	617	657	541
95%	620	673	453	781	624	666	547
Maximum	762 (n=5,280)	741	518	795	647	681	578

Table 3.56 : Treatment Option Daily Statistics at #047 (Coxs River above Lake Wallace) - Flow

Percentile	Flow (ML/d)				
	OBSD	NUL	CLR	WS2b-S	WS2b-S with CLR
Minimum	0.3	5.1	20.2	22.0	41.1
5%	3.1	6.5	24.5	32.0	49.5
10%	4.5	7.1	25.3	37.8	55.8
20%	6.8	8.4	26.6	39.5	57.5
50%	13.1	14.2	31.9	43.8	61.7
80%	26.1	39.2	56.3	67.0	83.6
90%	47.7	83.4	99.6	111.2	127.8
95%	94.7	162.5	178.5	190.8	205.7
Maximum	5,321 (n=7,906)	6,327	6,342	6,358	6,373

From Table 3.55, predicted median salinity in WS2b-S with CLR and RO6 is 500mg/L and is comparable to predicted median salinity in the NUL case of 466mg/L. Predicted maximum salinity is 578mg/L in WS2b-S with CLR and RO6, compared to 741mg/L. This is due to the magnitude of mine water discharge in the Coxs River at this location.

Lake Lyell

Figure 3.99 presents the time-series output with respect to flow at Node #154. Node #154 corresponds with the location of NSW Office of Water Station No. 212058 which is located between Lake Wallace and Lake Lyell. Figure 3.100 presents a distribution plot of Figure 3.99, with a summary presented in Table 3.57.

From Table 3.57, predicted median flow at this Node is 48.2ML/d in WS2b-S and is 65.7ML/d in WS2b-S with CLR. It is noted that Treatment Option WS2b-S with RO6 and WS2b-S have the same flow rate, as does WS2b-S with CLR and WS2b-S with CLR and RO6, therefore only WS2b-S with CLR is presented in Figure 3.99 and Table 3.57.

From Figure 3.99, WS2b-S and WS2b-S with CLR lead to a less variable flow regime at Node #154.

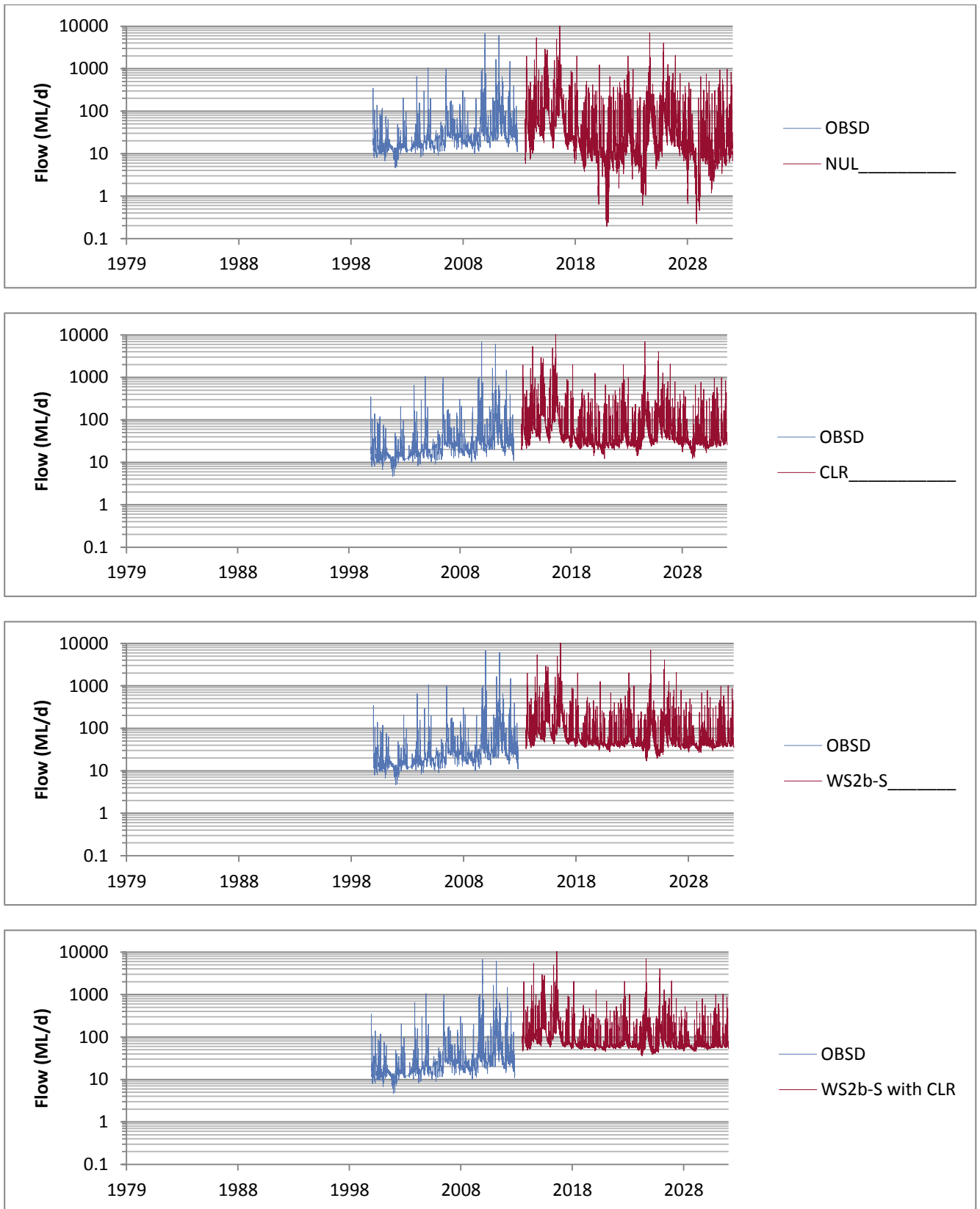


Figure 3.99 : Treatment Option Time-Series chart at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

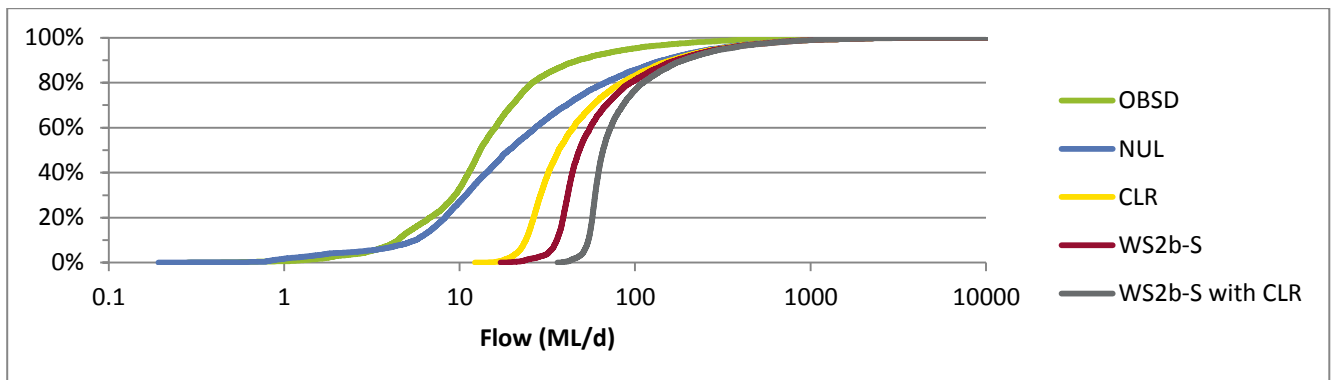


Figure 3.100 : Treatment Option Distribution Plot at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

Table 3.57 : Treatment Option Daily Statistics at #154 (Coxs River above Lake Lyell, Gauge No. 212058)

Percentile	Flow (ML/d)				
	OBSD	NUL	CLR	WS2b-S	WS2b-S with CLR
Minimum	4.6	0.2	12.2	17.1	36.2
5%	10.5	2.7	21.7	32.7	51.1
10%	12.1	5.6	23.8	35.8	54.2
20%	14.5	8.3	26.4	38.9	57.1
50%	20.4	19.0	36.7	48.2	65.7
80%	34.7	67.3	84.9	94.4	111.6
90%	65.4	144.7	162.8	172.5	188.9
95%	112.1	280.5	295.6	306.8	323.2
Maximum	6,750 (n=4,563)	11,487	11,502	11,518	11,533

Figure 3.101 presents time-series output with respect to salinity at Node #035. Figure 3.102 presents a distribution plot of model output, and is summarised in Table 3.58.

From Table 3.58, modelled median salinity in WS2b-S is 473mg/L, and is 387mg/L in WS2b-S with CLR and RO6. Modelled median salinity from the observation record is 737mg/L at this location. As noted above, this is due to historical discharge of Cooling Tower blowdown from Wallerawang Power Station.

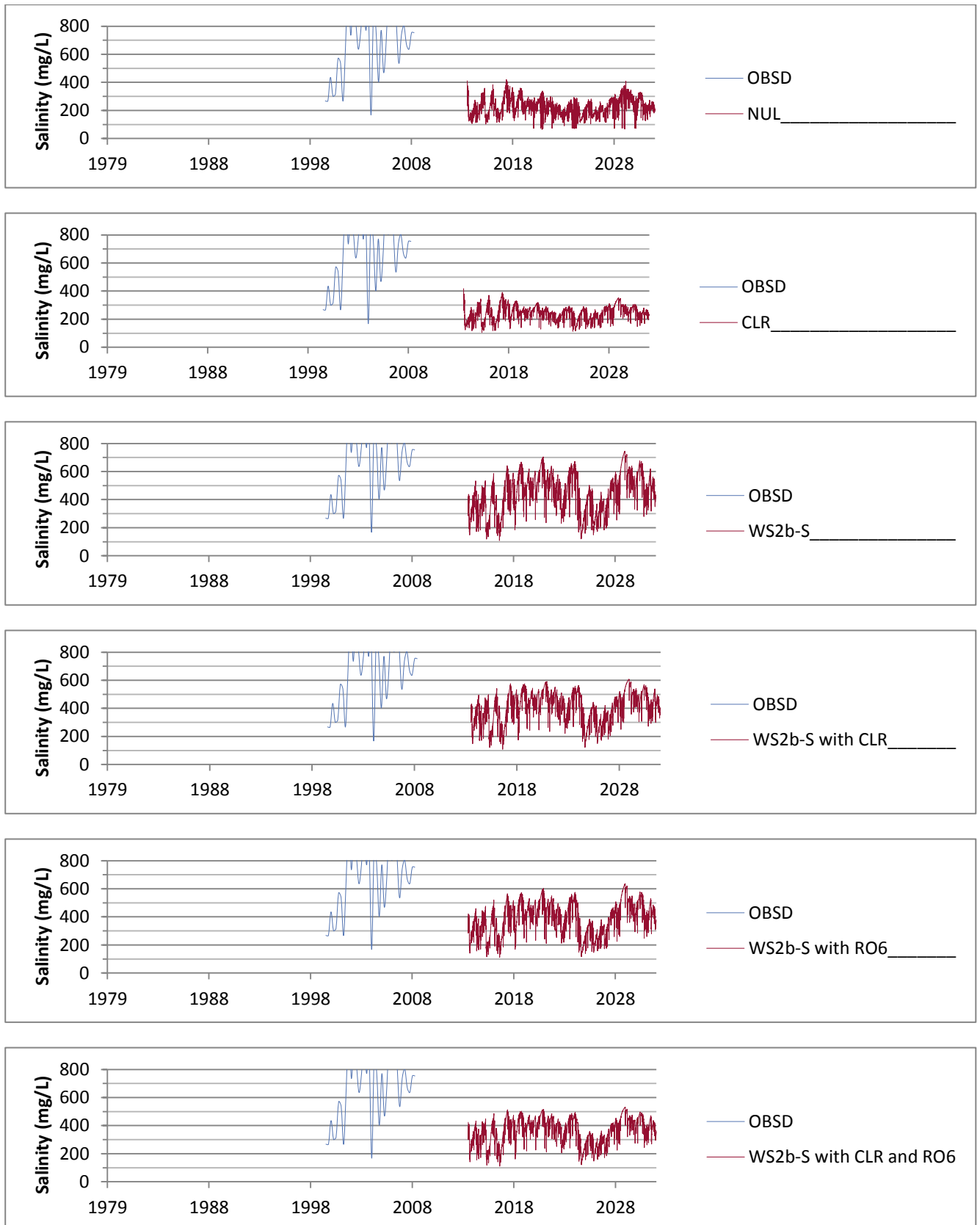


Figure 3.101 : Treatment Option Time-Series at #035 (Coxs River above Lake Lyell, at location of EnergyAustralia station COX5)

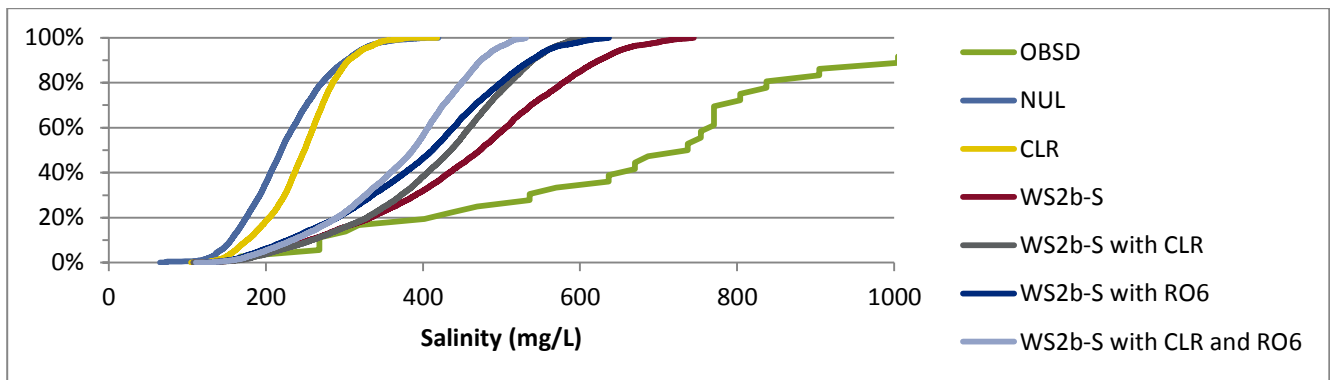


Figure 3.102 : Treatment Option Distribution at #035 (Coxs River above Lake Lyell, at location of EnergyAustralia station COX5)

Table 3.58 : Treatment Option Statistics at #035 (Coxs River above Lake Lyell, at location of EnergyAustralia station COX5)

Percentile	Salinity (mg/L)						
	OBSD	NUL	CLR	WS2b-S	WS2b-S with CLR	WS2b-S with RO6	WS2b-S with CLR and RO6
Minimum	168	65	105	108	108	111	111
5%	268	140	159	206	212	191	198
10%	285	156	176	255	259	228	234
20%	436	175	204	334	329	291	290
50%	737	220	249	473	436	412	387
80%	838	271	285	579	510	499	449
90%	1,005	303	305	625	540	537	474
95%	1,114	324	325	656	562	562	493
Maximum	1,240 (n=36)	411	395	744	607	636	531

Figure 3.103 presents time-series model output at Lake Lyell (Node #174). Figure 3.104 presents the distribution of that model output, and is summarised in Table 3.59.

From Table 3.59, modelled median salinity in WS2b-S with CLR and RO6 is 340mg/L and is comparable to the observation record where modelled median salinity is 295mg/L. Predicted peak salinity in WS2b-S with CLR and RO6 is 437mg/L (650µS/cm) compared to 634mg/L (950µS/cm) from the observation record.

From Figure 3.103, time-series output for WS2b-S with CLR and RO6 is equivalent to WSb2-S_T900 presented in Figure 3.76.

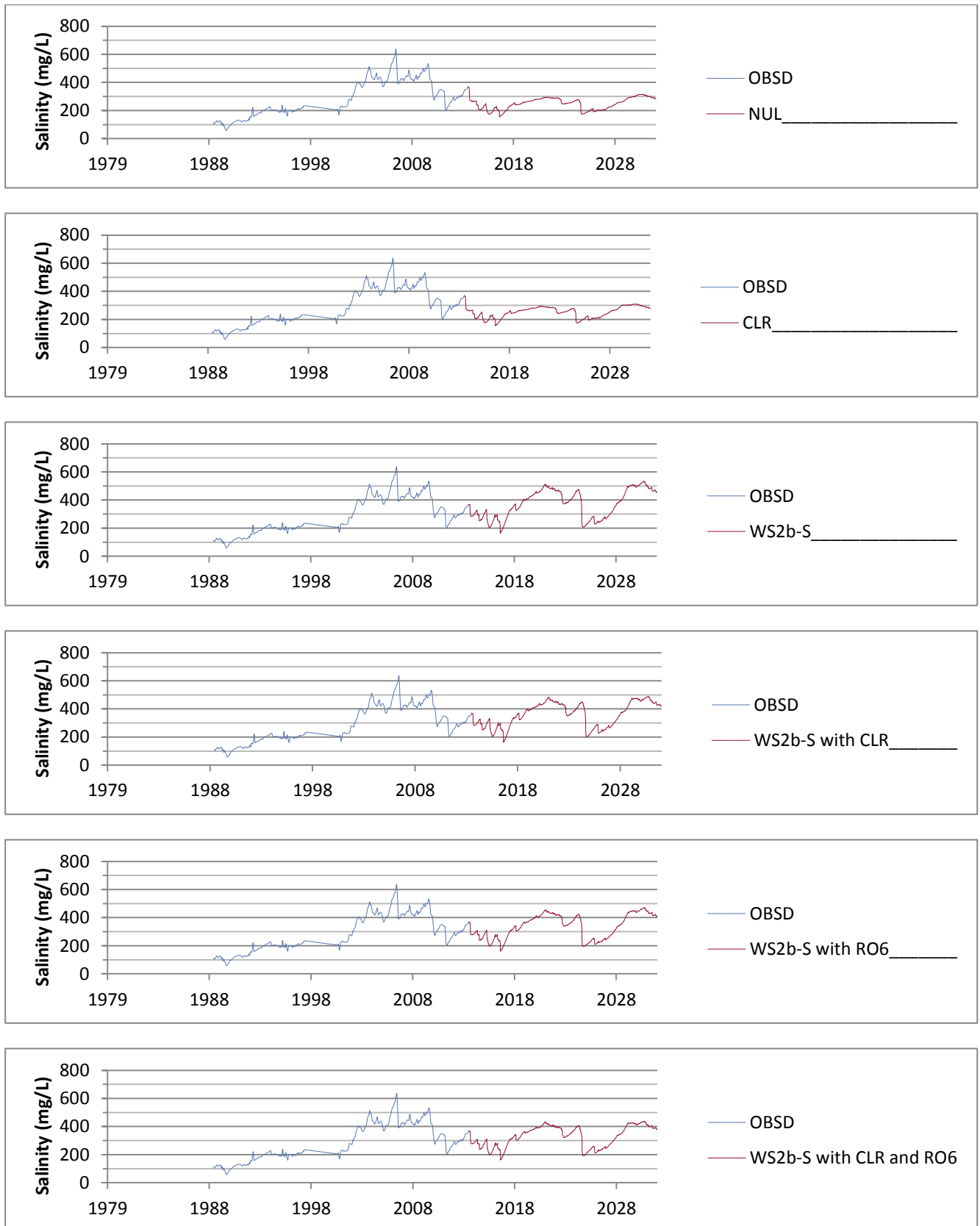


Figure 3.103 : Treatment Option Time-Series chart at #174 (Lake Lyell)

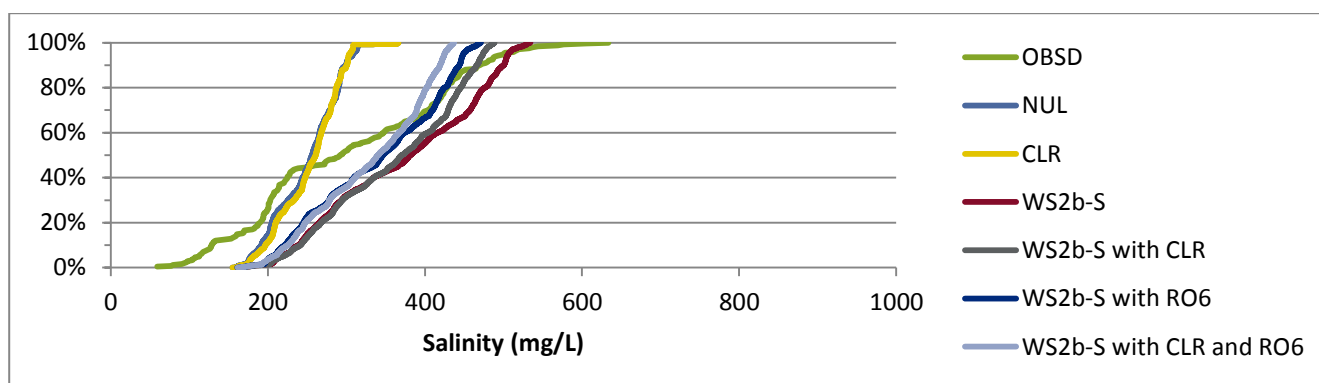


Figure 3.104 : Treatment Option Distribution Plot at #174 (Lake Lyell)

Table 3.59 : Treatment Option Daily Statistics at #174 (Lake Lyell)

Percentile	Salinity (mg/L)						
	OBSD	NUL	CLR	WS2b-S	WS2b-S with CLR	WS2b-S with RO6	WS2b-S with CLR and RO6
Minimum	59	155	155	163	163	161	161
5%	114	179	182	218	219	205	207
10%	129	192	197	239	242	222	226
20%	192	205	210	266	268	246	248
50%	295	256	261	381	370	347	340
80%	428	290	287	476	446	425	402
90%	471	300	300	500	466	444	419
95%	500	309	304	506	474	449	425
Maximum	634 (n=242)	366	366	534	489	471	437

Figure 3.105 and Figure 3.106 presents time-series model output with respect to salinity and flow at Node #225. Node #225 lies immediately upstream of Lake Burragorang and is the last sub-catchment of the Coxs River in the water quality model. Figure 3.107 presents a distribution plot of model output, and is summarised in Table 3.60 and Table 3.61 with respect to salinity and flow respectively.

From Figure 3.105, predicted time-series salinity exceeds the NUL case in WS2b-S and in each treatment option. As noted above, predicted median salinity from Table 3.60 of 155mg/L (230 μ S/cm) in WS2b-S with CLR and RO6 is; however, lower than the ANZECC default trigger value of 234mg/L (350 μ S/cm). Model predictions are higher than the observation record, if the spike in salinity in 1988 that is attributed to a transcription error is ignored.

From Figure 3.106, predicted impact to flow at this location in the Coxs River catchment is minimal. Median flow from Table 3.61 is 190.0ML/d in the NUL case compared to 216.4ML/d in WS2b-S with CLR. The results of WS2b-S with CLR are essentially equivalent to that from WS2b with CLR.

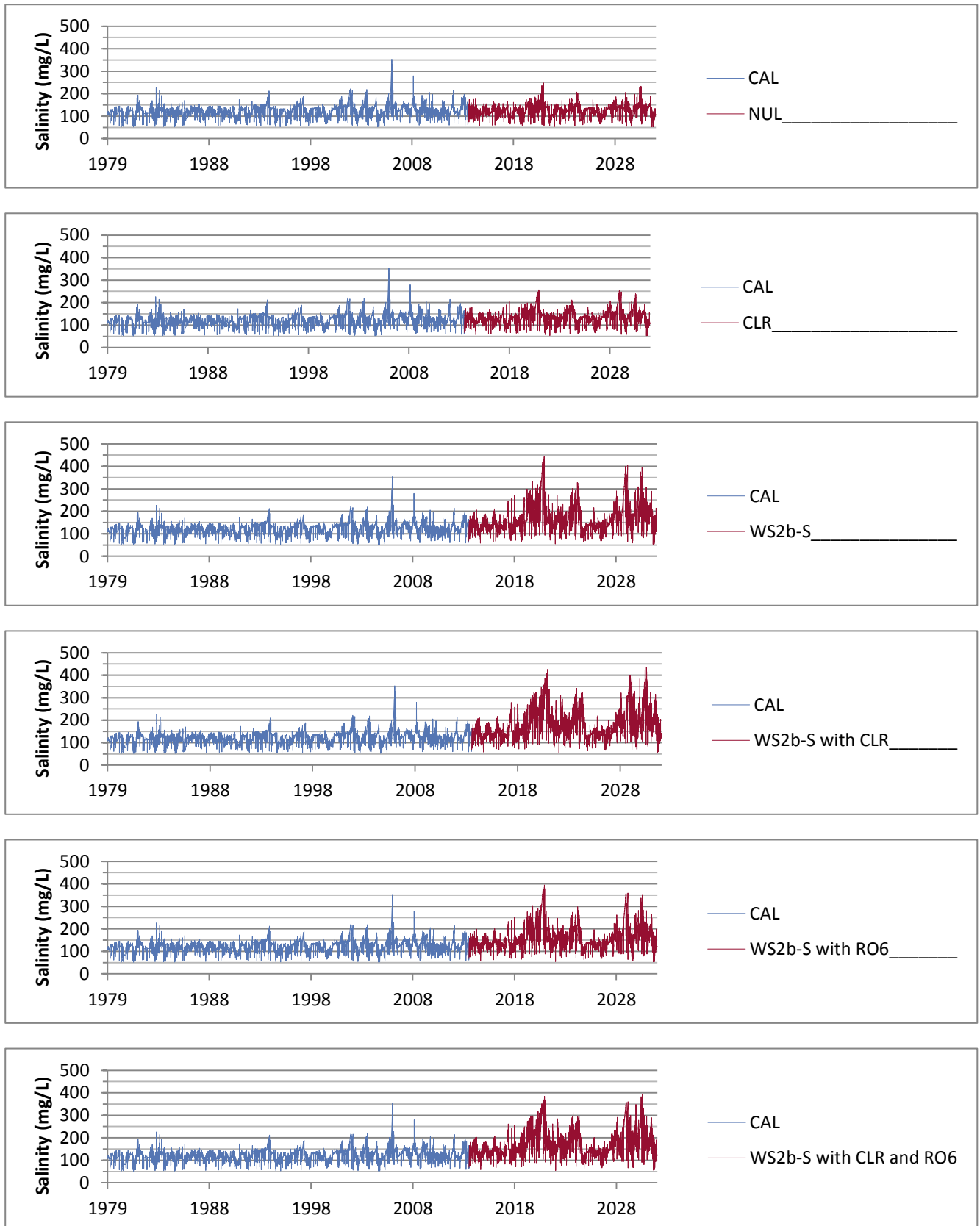


Figure 3.105 : Treatment Option Time-Series chart at #225 (Coxs River above Lake Burragorang) - Salinity

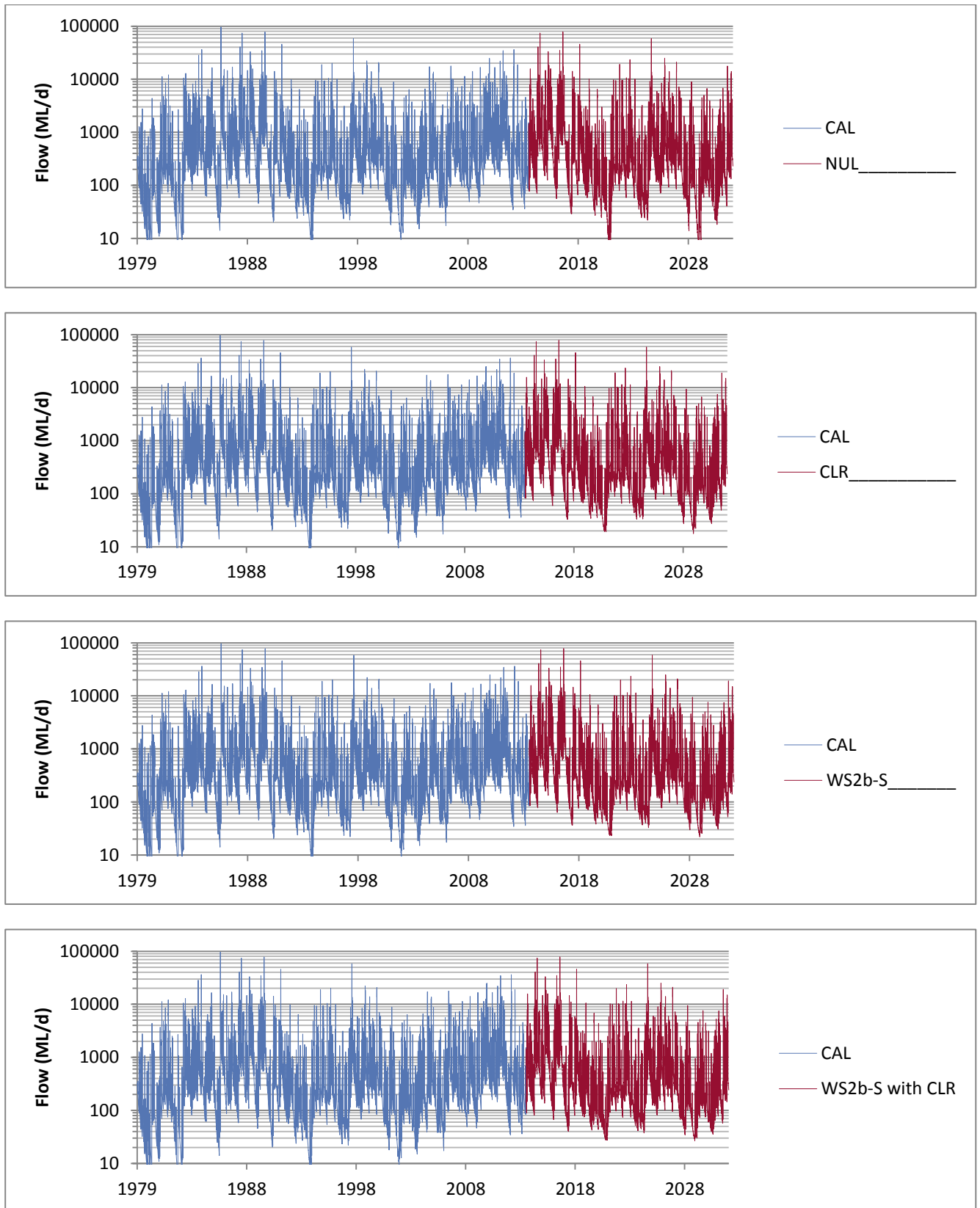


Figure 3.106 : Treatment Option Time-Series chart at #225 (Coxs River above Lake Burragorang) - Flow

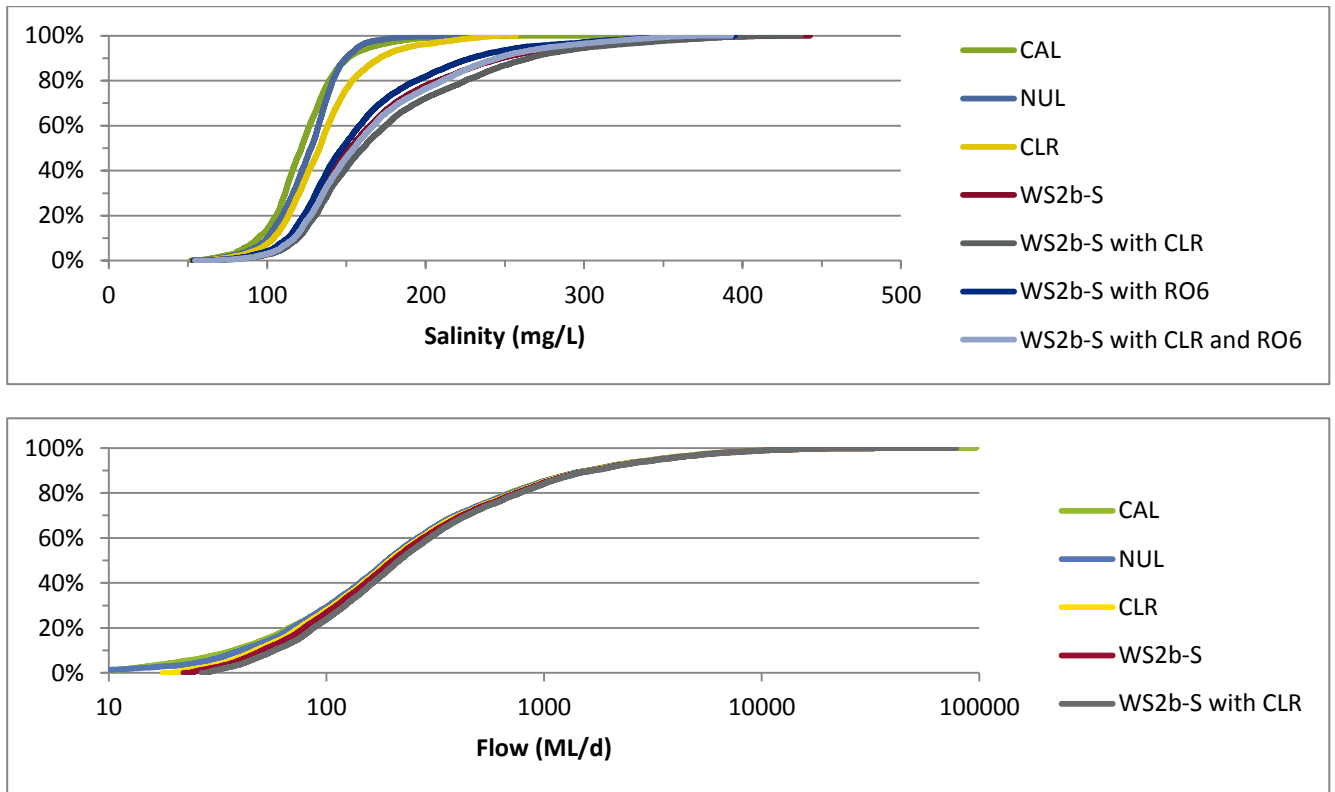


Figure 3.107 : Treatment Option Distribution Plot at #225 (Coxs River above Lake Burragorang)

Table 3.60 : Treatment Option Daily Statistics at #225 (Coxs River above Lake Burragorang) - Salinity

Percentile	Salinity (mg/L)						
	OBSD	NUL	CLR	WS2b-S	WS2b-S with CLR	WS2b-S with RO6	WS2b-S with CLR and RO6
Minimum	74	52	52	53	55	53	54
5%	75	90	95	105	110	103	107
10%	82	100	104	115	119	113	117
20%	91	110	113	126	130	123	127
50%	111	128	133	152	161	147	155
80%	142	141	154	208	225	194	210
90%	159	150	171	248	265	229	245
95%	280	158	190	288	305	262	279
Maximum	704 (n=25)	249	257	443	437	395	393

Table 3.61 : Treatment Option Daily Statistics at #225 (Coxs River above Lake Burragorang) - Flow

Percentile	Flow (ML/d)				
	CAL	NUL	CLR	WS2b-S	WS2b-S with CLR
Minimum	4.9	5.6	17.7	22.0	26.7
5%	21.4	27.1	35.4	38.7	43.6
10%	37.5	40.5	47.5	50.8	57.6
20%	67.7	69.7	75.3	79.1	87.3
50%	199.5	190.0	196.9	202.9	216.4
80%	697.2	710.7	737.2	748.1	775.9
90%	1,601	1,601	1,645.2	1,666	1,697
95%	3,285	3,380	3,412.5	3,477	3,560
Maximum	96,638	78,103	78,118	78,133	78,149

Figure 3.108 presents time-series output in Lake Burragorang (Node #280). Figure 3.109 presents a distribution plot of model output, and is summarised in Table 3.62.

From Figure 3.108, WS2b-S and each treatment option leads to predicted time-series salinity that exceeds the range from the CAL model. As presented in Table 3.62, modelled median salinity in WS2b-S with CLR and RO6 is 103mg/L, and is compared to 98mg/L in the NUL case. Modelled peak salinity in WS2b-S with CLR and RO6 is 110mg/L compared to modelled peak of 102mg/L from the NUL case. The increase in salinity in Lake Burragorang is 5% and therefore is considered to have a neutral effect on water quality since the predicted change in salinity is small.

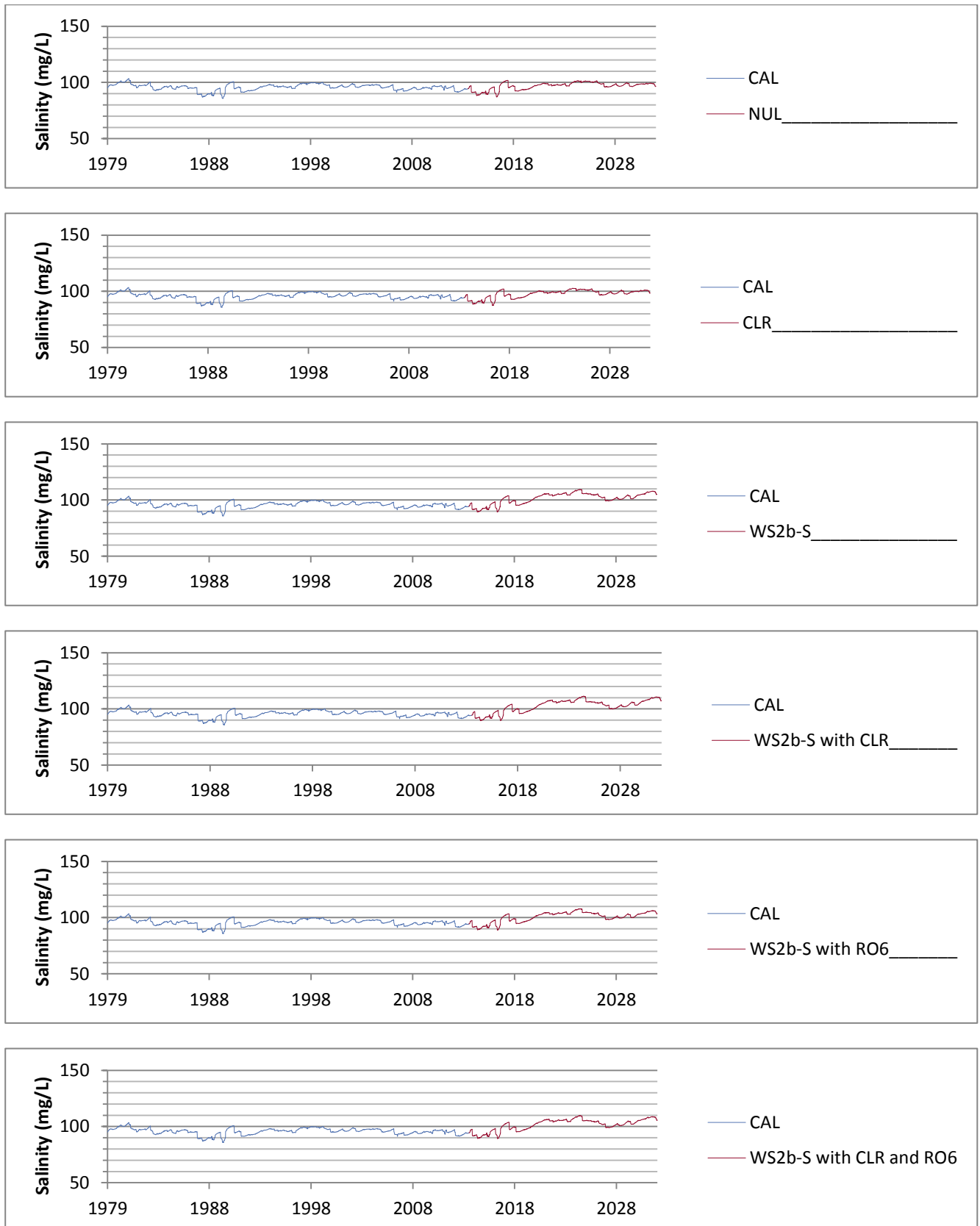


Figure 3.108 : Treatment Option Time-Series chart at #280 (Lake Burragorang)

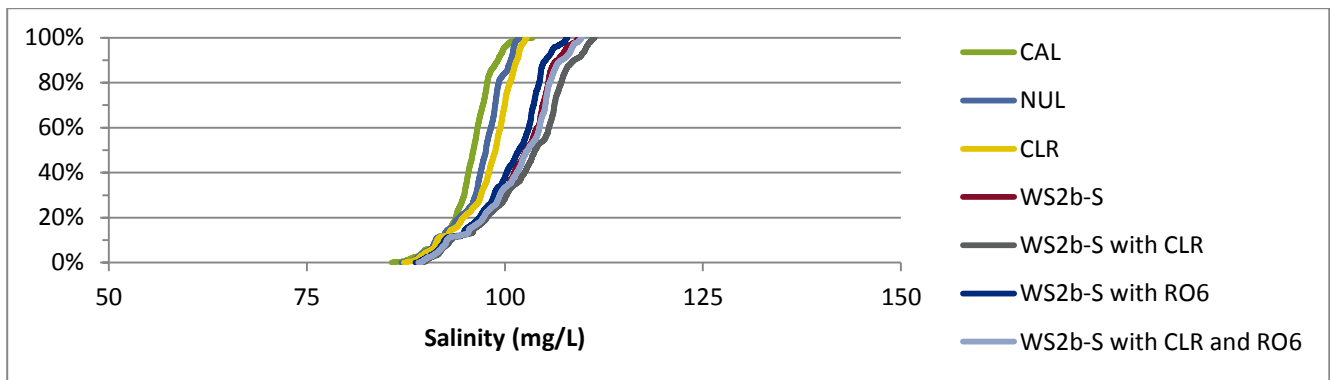


Figure 3.109 : Treatment Option Distribution Plot at #280 (Lake Burragorang)

Table 3.62 : Treatment Option Daily Statistics at #280 (Lake Burragorang)

Percentile	Salinity (mg/L)						
	CAL	NUL	CLR	WS2b-S	WS2b-S with CLR	WS2b-S with RO6	WS2b-S with CLR and RO6
Minimum	86	87	87	89	90	89	89
5%	90	90	90	92	92	91	92
10%	92	91	91	93	93	92	93
20%	94	94	95	97	98	97	97
50%	96	98	99	103	104	102	103
80%	98	99	101	105	107	104	106
90%	99	101	102	107	109	105	107
95%	100	101	102	108	110	106	108
Maximum	104	102	103	109	111	108	110

3.7 End of Pipe Targets with Clarence

3.7.1 End of Pipe Target with Clarence Setup

These simulations were prepared based on the WS2b and WS2b-S simulations presented above.

The methodology adopted comprised calibration of level of treatment of mine water required such that resultant discharge, following blending with Clarence, met specified target. Relevant assumptions include:

- no account of pre-treatment requirement
- treatment was assumed to occur instantaneously
- no account of other analytes, only salinity was considered
- assumed influent salinity from Angus Place Colliery and Springvale Mine was 804mg/L, if conversion factor is 0.67
- assumed effluent salinity from continuous treatment is 50mg/L
- no account of brine stream, salt was removed from model
- no account for potential dilution, albeit small, of runoff from catchment upstream of point of discharge
- mine water discharge instantaneously and completely blended with discharge from Clarence

It is noted prediction treatment volumes presented here are indicative, being based on simple mass balance and do not take into account the pre-treatment and other water treatment process requirements. Expected accuracy of predictions is therefore +/-15%. Further detail on treatment requirements are contained in the treatment option assessment, presented elsewhere.

3.7.2 End of Pipe Target with Clarence Scenarios

An assessment of potential End of Pipe target salinities, following blending with Clarence, is presented with respect to predicted salinity in:

- Node #047 (Coxs River above Lake Wallace, corresponding to location of NSW Office of Water Station No. 212054)
- Node #174 (Lake Lyell)
- Node #280 (Lake Burragorang)

The End of Pipe targets, following blending with Clarence, consist:

- 350µS/cm, default ANZECC trigger value for SE Australia upland watercourses (equivalent to 234mg/L)
- 700µS/cm (equivalent to 469mg/L)
- 800µS/cm (equivalent to 536mg/L)
- 900µS/cm (equivalent to 603mg/L)

Current assumed salinity of mine water discharge from Angus Place Colliery and Springvale Mine is 1,200µS/cm and is 400µS/cm from Clarence.

3.7.3 End of Pipe Target with Clarence Results

Concurrent Implementation

The model control files pertaining to the scenarios are:

- 002a_PRD-WS2b_CLR_02b_T350uS.gsm
- 002a_PRD-WS2b_CLR_02b_T700uS.gsm
- 002a_PRD-WS2b_CLR_02b_T800uS.gsm
- 002a_PRD-WS2b_CLR_02b_T900uS.gsm

Sequential Implementation

The model control files pertaining to the treatment option scenarios are:

- 002a_PRD-WS2b-S_CLR_01a_T350uS.gsm
- 002a_PRD-WS2b-S_CLR_01a_T700uS.gsm
- 002a_PRD-WS2b-S_CLR_01a_T800uS.gsm
- 002a_PRD-WS2b-S_CLR_01a_T900uS.gsm

Lake Wallace

Figure 3.110 and Figure 3.111 presents time-series model output at Node #047. Node #047 resides immediately upstream of Lake Wallace and is the location of NSW Office of Water Station No. 212054. Figure 3.112 presents a distribution plot of the model output, and is summarised in Table 3.63 and Table 3.64.

From Figure 3.110 and Figure 3.111 predicted salinity at Node #047 with respect to an End of Pipe target of 350µS/cm is considerably lower than the historical record. Predicted salinity, including Clarence, is equivalent

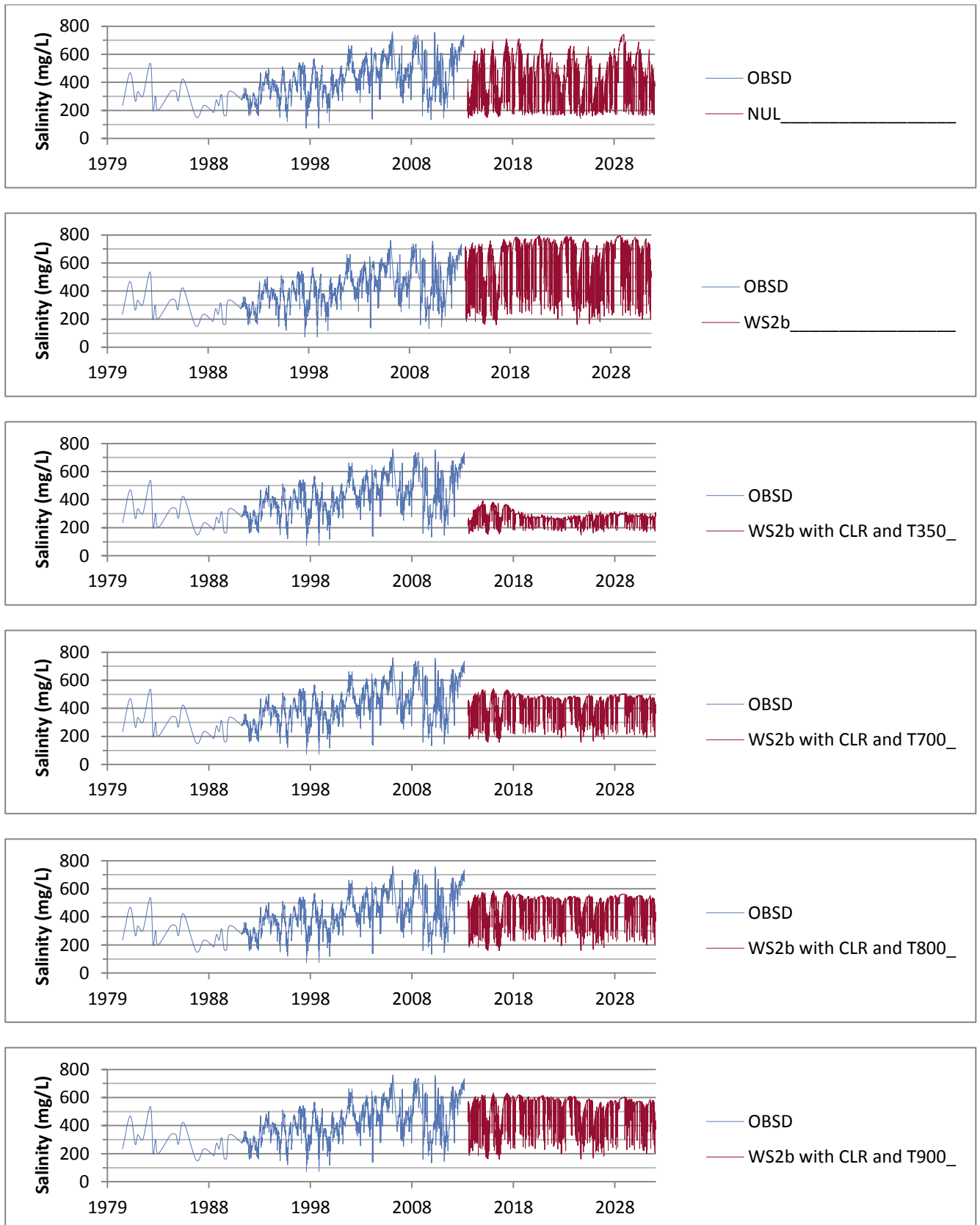


Figure 3.110 : End of Pipe Target with Clarence Time-Series at #047 (Coxs River above Lake Wallace) - Concurrent

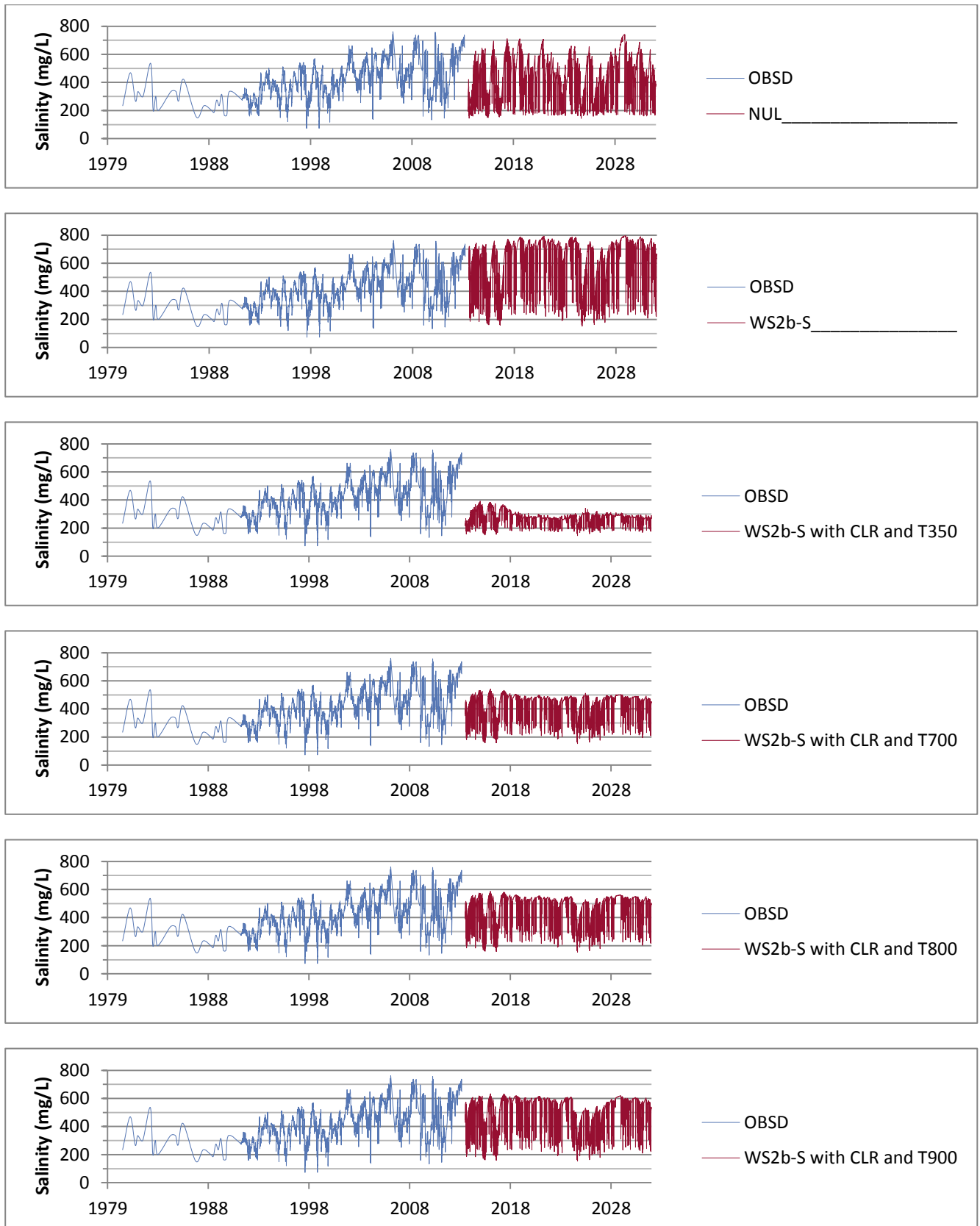


Figure 3.111 : End of Pipe Target with Clarence Time-Series at #047 (Coxs River above Lake Wallace) – Sequential

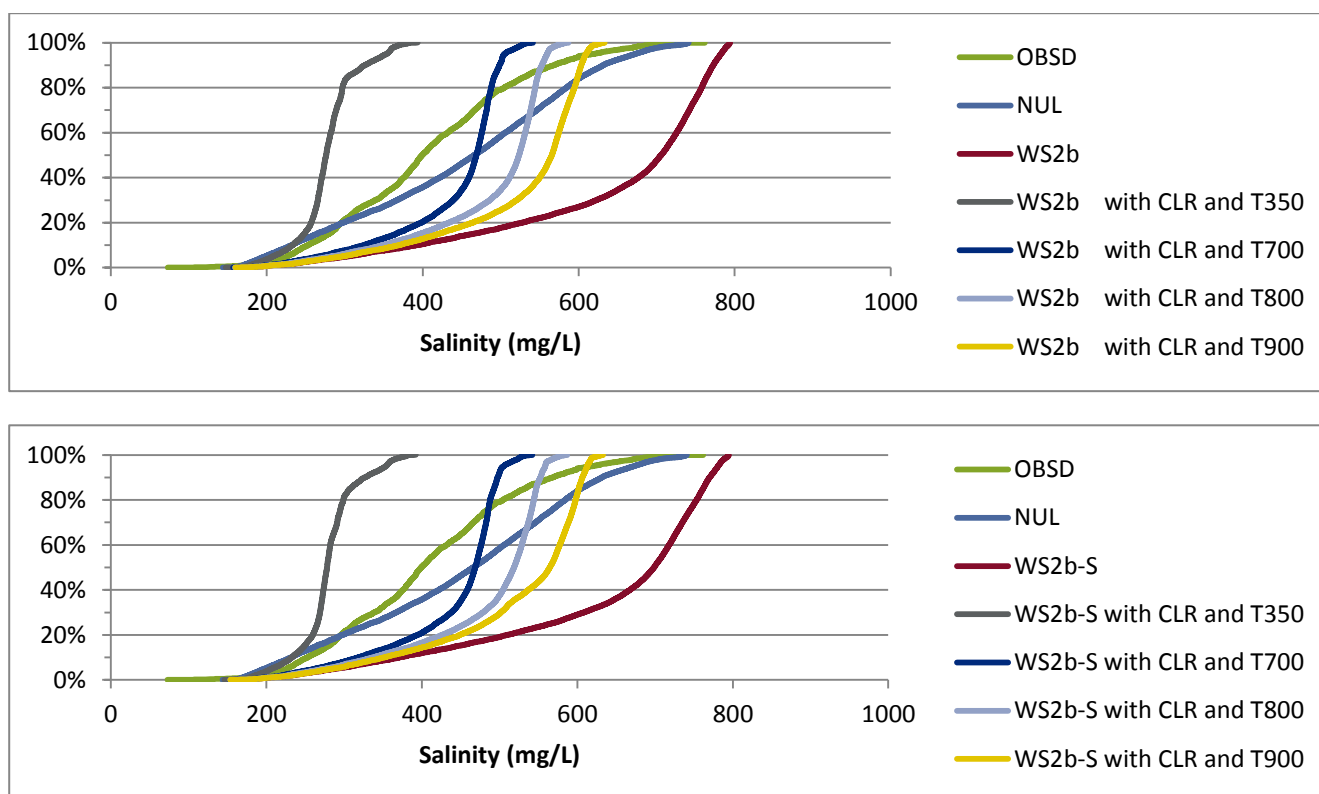


Figure 3.112 : End of Pipe Target with Clarence Distribution Plot at #047 (Coxs River above Lake Wallace, Gauge No. 212054)

Table 3.63 : End of Pipe Target with Clarence Daily Statistics at #047 (Coxs River above Lake Wallace) - Concurrent

Percentile	Salinity (mg/L)						
	OBSD	NUL	WS2b	WS2b_T350 with CLR	WS2b_T700 with CLR	WS2b_T800 with CLR	WS2b_T900 with CLR
Minimum	73	145	160	147	157	159	160
5%	227	198	305	208	267	283	298
10%	253	232	394	233	325	349	370
20%	296	298	528	257	398	434	464
50%	399	466	706	276	469	524	566
80%	504	584	758	297	488	544	595
90%	568	632	773	326	498	553	603
95%	620	673	783	354	505	560	609
Maximum	762 (n=5,280)	741	794	394	541	587	633

to simulations presented in **Error! Reference source not found.** and Figure 3.73. The benefit of including Clarence is reduced modelled treatment volume.

From Table 3.63, predicted median salinity in WS2b with CLR is 566mg/L, at an End of Pipe target of 900µS/cm. Predicted median salinity in WS2b-S with CLR from Table 3.64 is 565mg/L, for an equivalent target. The predicted salinity in WS2b without Clarence at an equivalent End of Pipe target is 567mg/L from Table 3.41 and is 564mg/L from Table 3.42.

Table 3.64 : End of Pipe Target with Clarence Daily Statistics at #047 (Coxs River above Lake Wallace) - Sequential

Percentile	Salinity (mg/L)						
	OBSD	NUL	WS2b-S	WS2b-S_T350 with CLR	WS2b-S_T700 with CLR	WS2b-S_T800 with CLR	WS2b-S_T900 with CLR
Minimum	73	145	145	146	153	153	154
5%	227	198	198	207	263	276	286
10%	253	232	232	233	319	338	352
20%	296	298	298	260	395	426	449
50%	399	466	466	278	469	519	565
80%	504	584	584	299	488	544	598
90%	568	632	632	327	498	553	607
95%	620	673	673	354	505	559	613
Maximum	762 (n=5,280)	741	741	392	542	587	633

Lake Lyell

Figure 3.113 and Figure 3.114 present the time output at Lake Lyell (Node #174) with respect to salinity. The observation record at Lake Lyell is also presented in Figure 3.113 and Figure 3.114, for the purpose of comparison. Figure 3.115 presents the distribution plot of model output, and is summarised in Table 3.65 and Table 3.66 for concurrent and sequential implementation cases.

From Figure 3.113 and Figure 3.114, each of the simulations considering End of Pipe targets lie within the historical range. For an End of Pipe Target at 900 μ S/cm, predicted salinity is less than 460mg/L (685 μ S/cm), in both the concurrent implementation and sequential implementation cases.

From Figure 3.113 and Figure 3.114, the simulation of End of Pipe target at 350 μ S/cm with CLR, is lower than the predicted salinity in the NUL case.

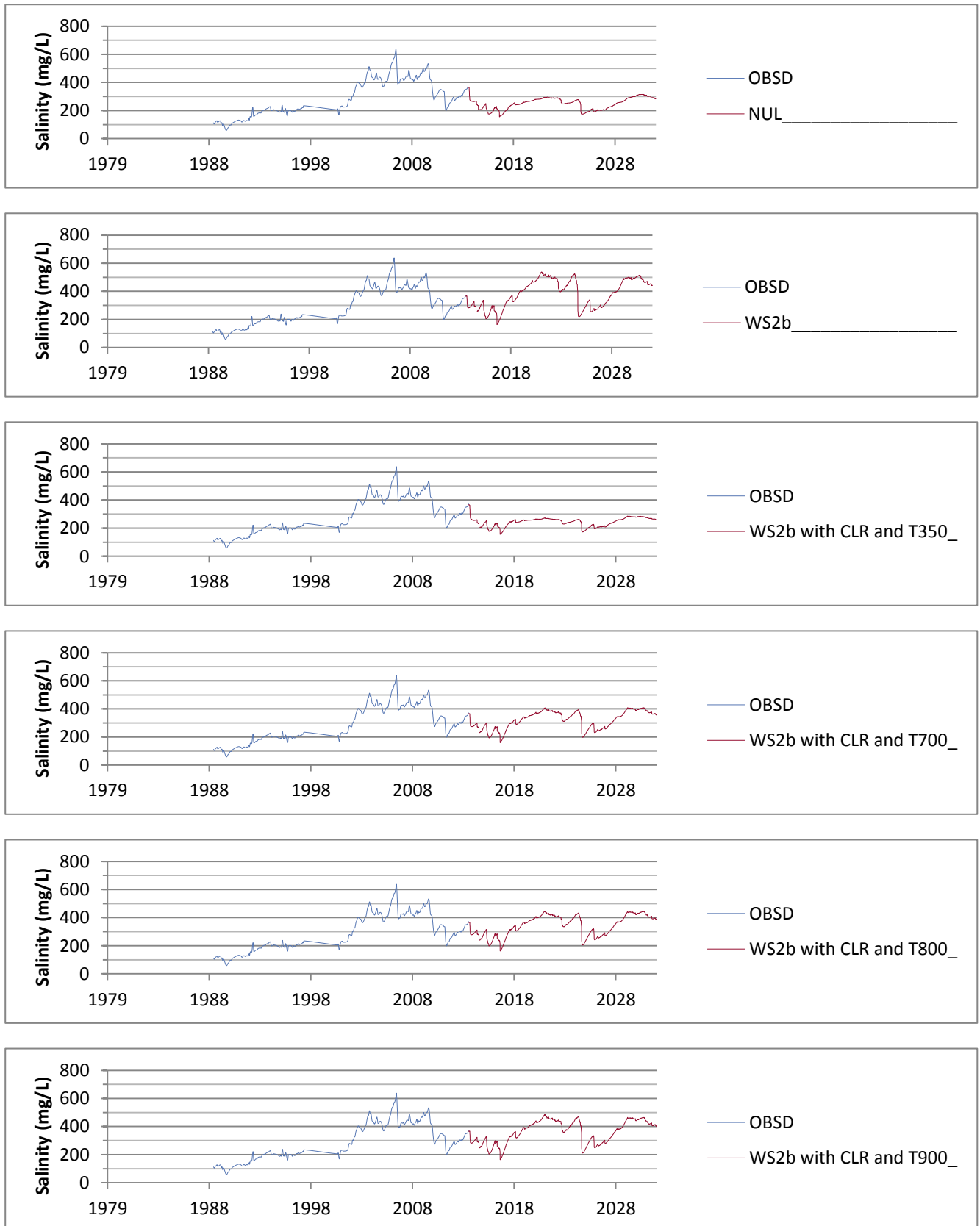


Figure 3.113 : End of Pipe Target with Clarence Time-Series chart at #174 (Lake Lyell) – Concurrent

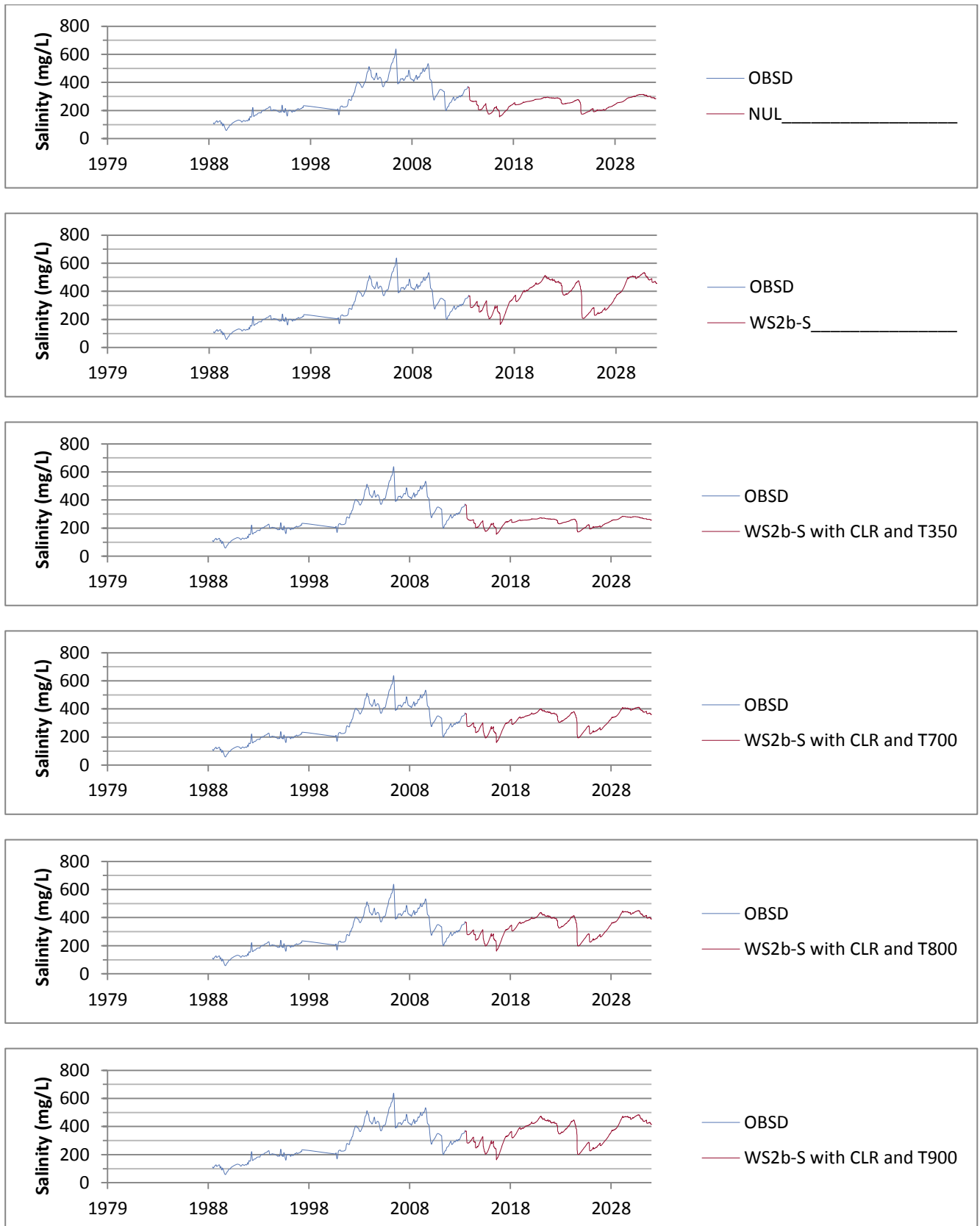


Figure 3.114 : End of Pipe Target with Clarence Time-Series chart at #174 (Lake Lyell) – Sequential

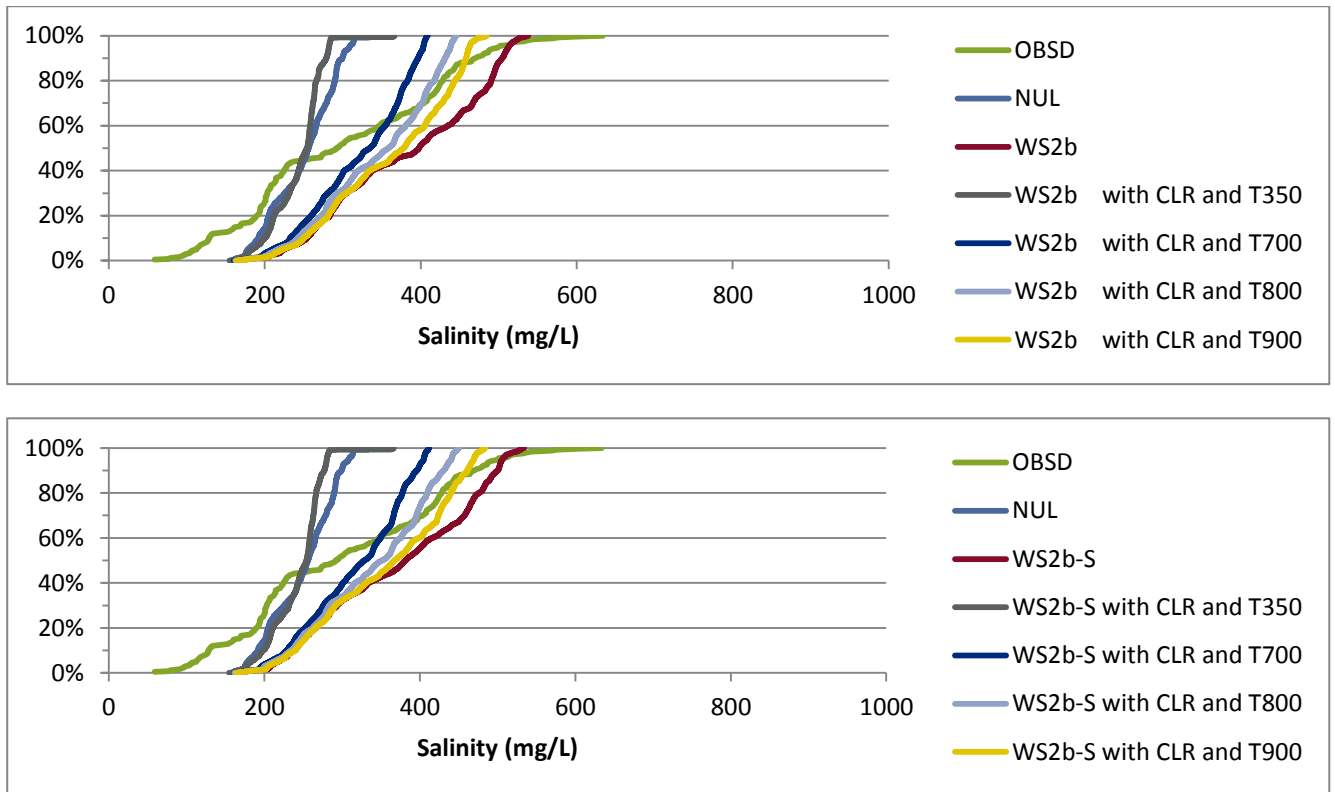


Figure 3.115 : End of Pipe Target with Clarence Distribution Plot at #174 (Lake Lyell)

Table 3.65 : End of Pipe Target with Clarence Daily Statistics at #174 (Lake Lyell) - Concurrent

Percentile	Salinity (mg/L)						
	OBSD	NUL	WS2b	WS2b_T350 with CLR	WS2b_T700 with CLR	WS2b_T800 with CLR	WS2b_T900 with CLR
Minimum	59	155	164	155	160	162	164
5%	114	179	225	184	210	217	223
10%	129	192	254	200	233	242	250
20%	192	205	284	212	260	272	281
50%	295	256	398	254	335	358	378
80%	428	290	490	266	383	417	444
90%	471	300	505	279	397	431	458
95%	500	309	513	282	403	438	462
Maximum	634 (n=242)	366	538	366	409	446	485

Table 3.66 : End of Pipe Target with Clarence Daily Statistics at #174 (Lake Lyell) - Sequential

Percentile	Salinity (mg/L)						
	OBSD	NUL	WS2b-S	WS2b-S_T350 with CLR	WS2b-S_T700 with CLR	WS2b-S_T800 with CLR	WS2b-S_T900 with CLR
Minimum	59	155	155	155	161	162	164
5%	114	179	179	183	207	213	218
10%	129	192	192	199	229	234	240
20%	192	205	205	211	252	263	266
50%	295	256	256	254	329	351	367
80%	428	290	290	267	378	410	440
90%	471	300	300	277	396	431	461
95%	500	309	309	281	405	441	470
Maximum	634 (n=242)	366	366	366	412	451	484

Lake Burragorang

Figure 3.116 and Figure 3.117 present time-series output of salinity at Node #280 (Lake Burragorang), together with the calibration model output. Figure 3.118 presents the distribution plot of model output, and is summarised in Table 3.67 and Table 3.68 with respect to concurrent implementation and sequential implementation cases.

From Table 3.67, predicted median salinity in Lake Burragorang for End of Pipe target of 350µS/cm simulation is 100mg/L and is 105mg/L in the End of Pipe target of 900µS/cm. Median salinity in the NUL case is 98mg/L.

From Table 3.68, predicted median salinity in Lake Burragorang is 100mg/L for an End of Pipe target of 350µS/cm and is 104mg/L when End of Pipe target is 900µS/cm.

The maximum modelled salinity in Lake Burragorang is 102mg/L in the NUL case. From Table 3.67, maximum modelled salinity for an End of Pipe target of 900µS/cm is 113mg/L and is 111mg/L for the equivalent target from Table 3.68.

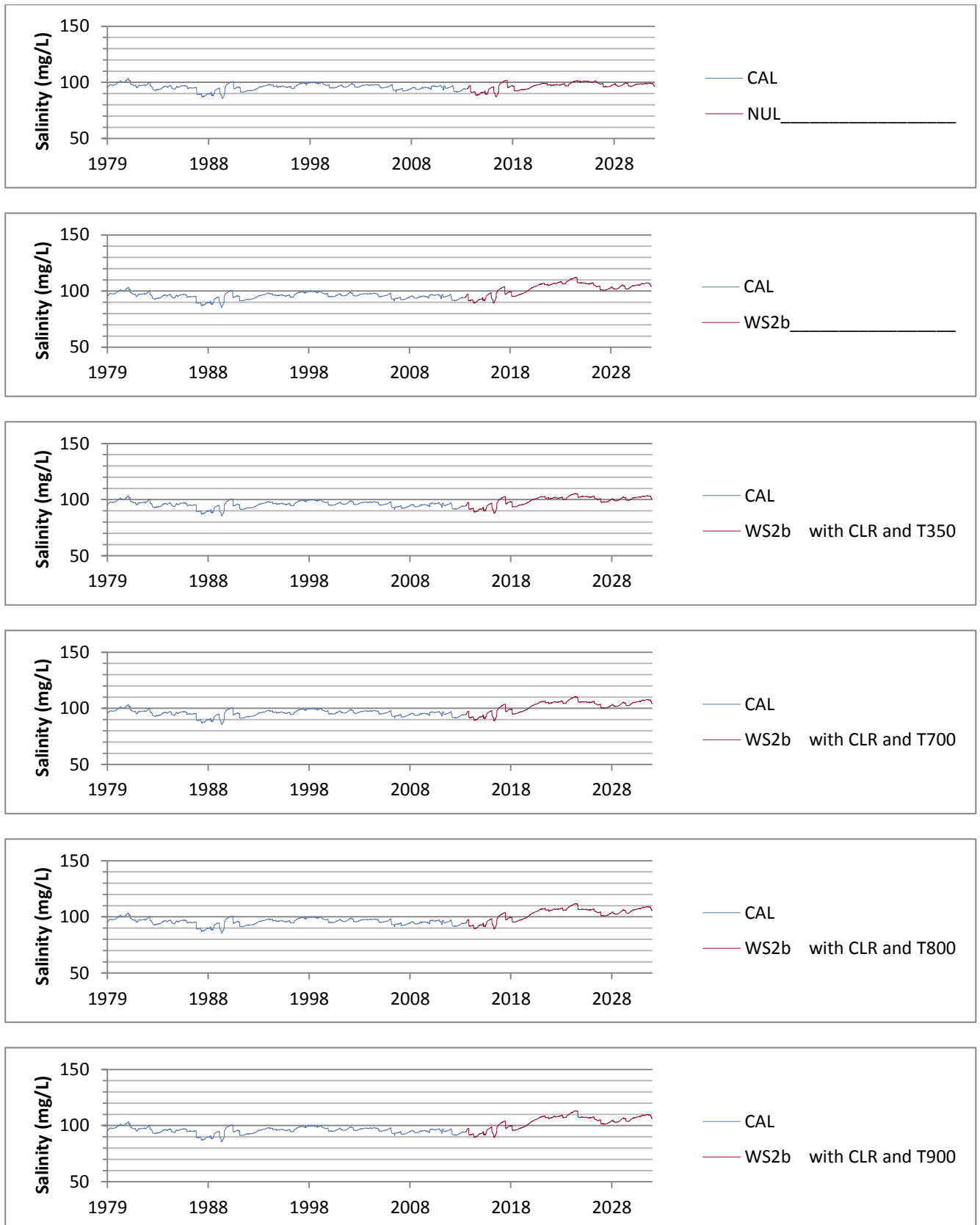


Figure 3.116 : End of Pipe Target with Clarence Time-Series chart at #280 (Lake Burragorang) – Concurrent

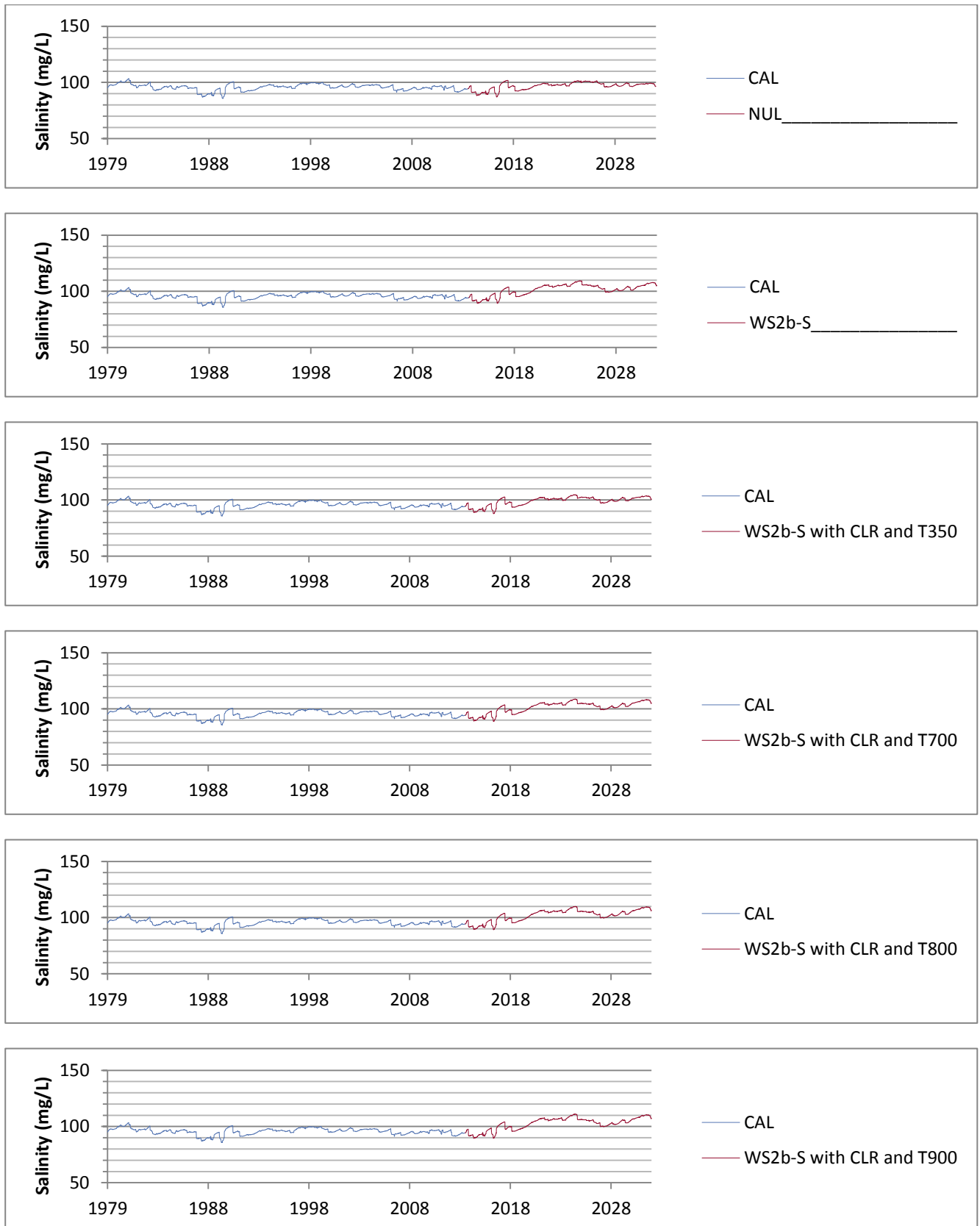


Figure 3.117 : End of Pipe Target with Clarence Time-Series chart at #280 (Lake Burragorang) - Sequential

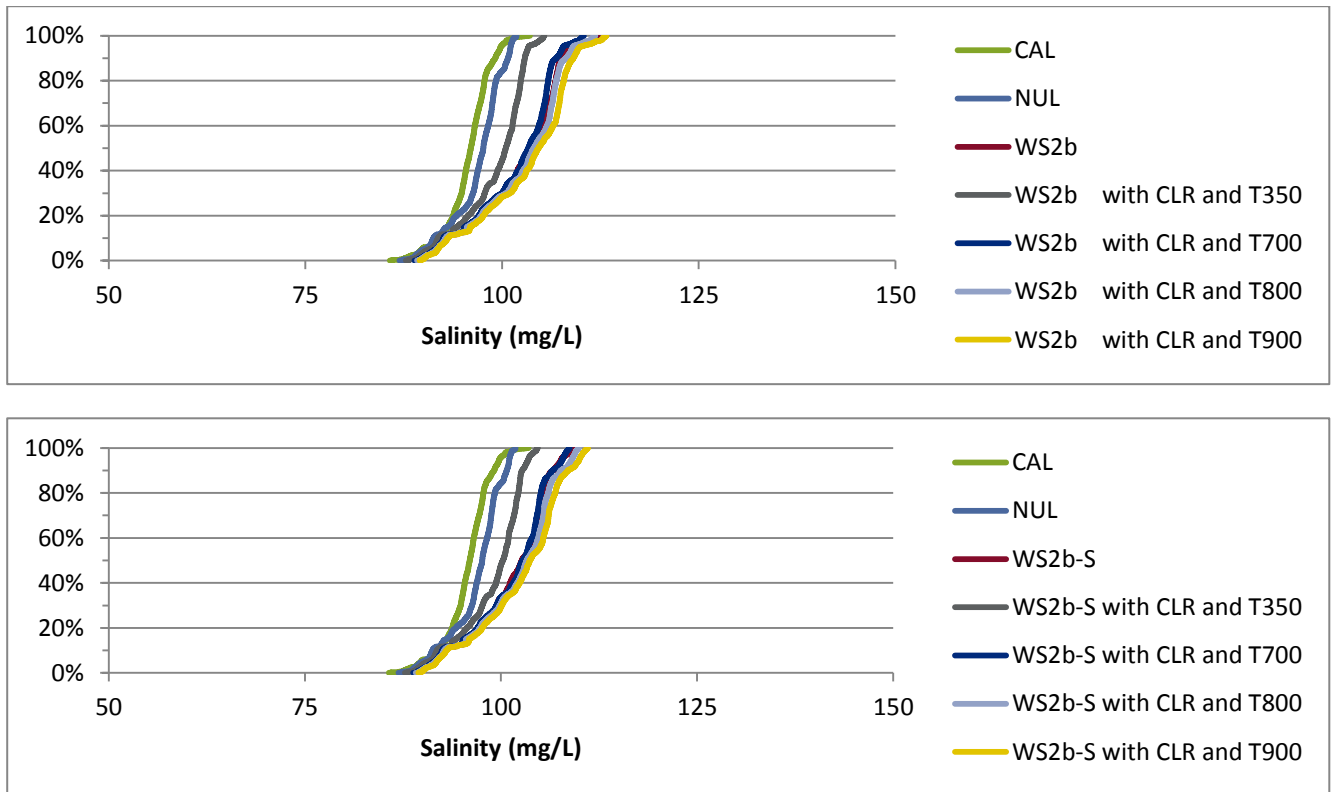


Figure 3.118 : End of Pipe Target with Clarence Distribution Plot at #280 (Lake Burragarang)

Table 3.67 : End of Pipe Target Daily Statistics at #280 (Lake Burragarang) - Concurrent

Percentile	Salinity (mg/L)						
	CAL	NUL	WS2b	WS2b_T350 with CLR	WS2b_T700 with CLR	WS2b_T800 with CLR	WS2b_T900 with CLR
Minimum	86	87	89	88	89	89	89
5%	90	90	92	91	92	92	92
10%	92	91	93	92	93	93	93
20%	94	94	97	96	97	97	98
50%	96	98	104	100	103	104	105
80%	98	99	107	102	106	107	108
90%	99	101	107	103	107	108	109
95%	100	101	109	103	108	109	110
Maximum	104	102	112	105	110	112	113

Table 3.68 : End of Pipe Target Daily Statistics at #280 (Lake Burragorang) - Sequential

Percentile	Salinity (mg/L)						
	CAL	NUL	WS2b-S	WS2b-S_T350 with CLR	WS2b-S_T700 with CLR	WS2b-S_T800 with CLR	WS2b-S_T900 with CLR
Minimum	86	87	87	88	89	89	89
5%	90	90	90	91	92	92	92
10%	92	91	91	92	93	93	93
20%	94	94	94	96	97	97	98
50%	96	98	98	100	103	103	104
80%	98	99	99	102	105	106	107
90%	99	101	101	103	107	108	109
95%	100	101	101	104	108	109	110
Maximum	104	102	102	105	109	110	111

Treatment Volumes

Figure 3.119 presents the modelled treatment volume considering discharge of Clarence to the Coxs River via Springvale LDP009 and concurrent implementation and sequential implementation of extensions at Angus Place Colliery and Springvale Mine.

It is highlighted that prediction treatment volumes are indicative, being based on simple mass balance and do not take into account pre-treatment and / or other water treatment process requirements; although, the expected accuracy is +/- 15%. Further detail on model assumptions is presented in Section 3.5.1 above.

From Figure 3.119, modelled volumetric treatment requirement is up to 35.1ML/d in 2023 in the concurrent implementation with an End of Pipe target of 350 μ S/cm, including Clarence. This treatment requirement is essentially the same as the non-Clarence simulation presented in Figure 3.81, since assumed salinity of mine water discharge at Clarence is 268mg/L (400 μ S/cm). For the sequential implementation case, modelled volumetric requirement with an End of Pipe target of 350 μ S/cm, including Clarence, is 26.7ML/d.

The treatment requirement with an End of Pipe target of 900 μ S/cm is 3.9ML/d and is 1.4ML/d in 2023 for concurrent implementation and sequential implementation scenarios respectively. From Figure 3.81, equivalent treatment requirement was 12.1ML/d and 9.1ML/d respectively.

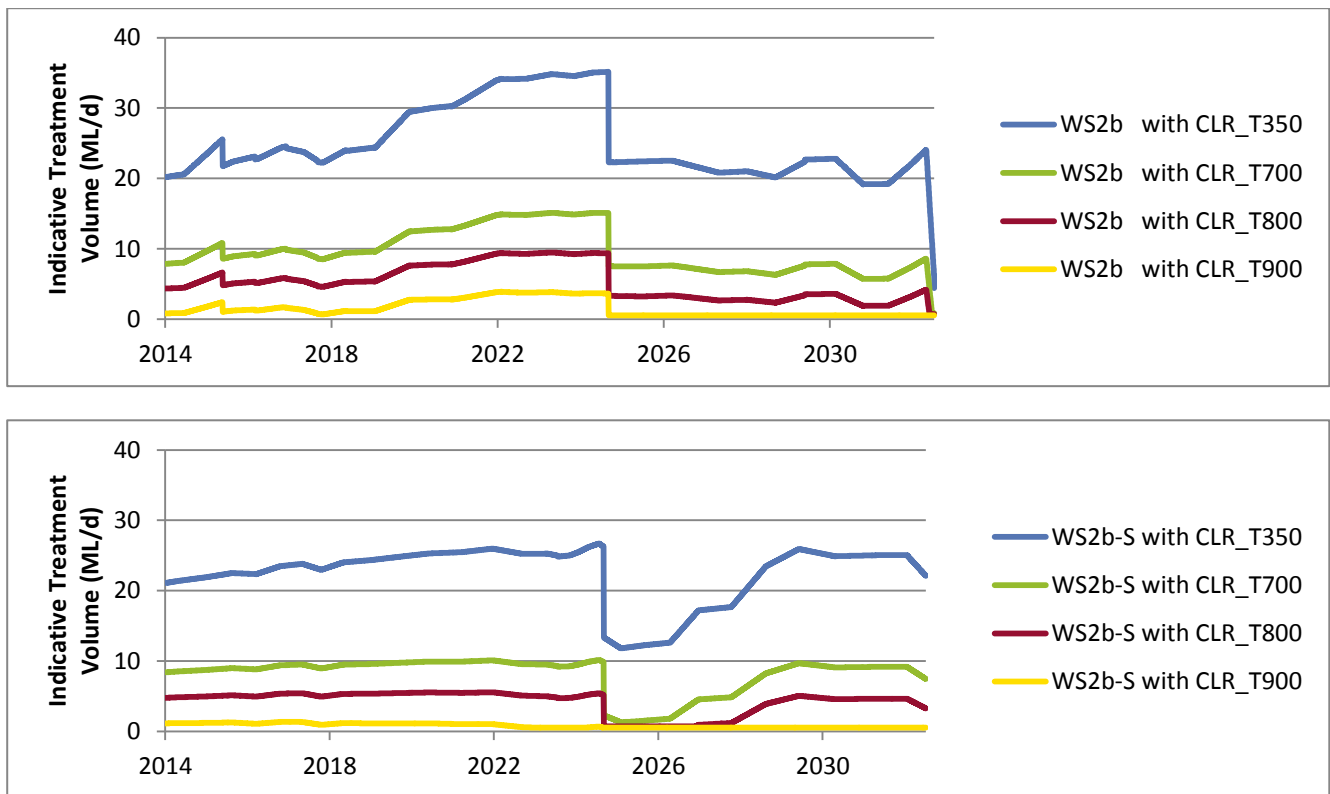


Figure 3.119 : End of Pipe Target with Clarence Indicative Treatment Volume (ML/d)

3.8 Uncertainty Analysis

In the previous version of the RWQIAM the uncertainty analysis conditions considered were in regard to climatic scenarios. To address comments received from the NSW Office of Environment and Heritage (NSW EPA, 2014), additional uncertainty analysis conditions have been prepared.

Uncertainty conditions comprise:

- Climatic Scenarios (Low and High Rainfall Conditions)
- Change to Assumed Land-Use Class Salinity
- Change to Assumed Average Soil Storage Capacity
- Change to Assumed Baseflow Index, BFI.

To reduce the complexity of this report the uncertainty analysis simulations of WS2b and WS2b-S as well are presented, rather than including WS1, WS1-S, WS2a and WS2a-S since conclusions on predictive uncertainty will be able to be inferred.

Results of uncertainty analysis are presented with respect to:

- Node #047 (Coxs River above Lake Wallace, corresponding to location of NSW Office of Water Station No. 212054)
- Node #174 (Lake Lyell)
- Node #280 (Lake Burragorang)

It is noted that the NUL case is presented with respect to each uncertainty analysis scenario for the purpose of comparison.

3.8.1 Climatic Scenarios

The general methodology of this uncertainty analysis condition is the same as that presented in RPS (2014a), with a continuous period of low and high rainfall being selected from the climatic record. The daily rainfall and evaporation record from that selected period was then applied to a copy of the prediction simulation. Further detail on the method for selecting respective rainfall periods is presented in Section 3.4.1.

The model control files for these simulations were:

- 002a_UNC_HighRf-WS2b_01a.gsm
- 002a_UNC_HighRf-WS2b-S_01a.gsm
- 002a_UNC_HighRf-WS2b_01a_NUL.gsm
- 002a_UNC_LowRf-WS2b_01a.gsm
- 002a_UNC_LowRf-WS2b-S_01a.gsm
- 002a_UNC_LowRf-WS2b_01a_NUL.gsm

Lake Wallace

Figure 3.120 presents distribution plot with respect to low and high rainfall conditions at Node #047 for the concurrent and sequential implementation cases. The base prediction case, WS2b and WS2b-S respectively, is also presented in the above figures for the purpose of comparison.

From Figure 3.120 there is not a significant difference in predicted salinity due to well below or well above rainfall conditions. The uncertainty analysis indicates that model predictions with respect to salinity at this location are not particularly sensitive to assumed climatic condition. From Figure 3.120, there is also not a particularly large impact to model predictions with respect to flow, up to the median (50th percentile), due to assumed climatic condition.

From Figure 3.120, median salinity in the High Rainfall scenario is 698mg/L in WS2b and is 687mg/L in WS2b-S. This is compared to 706mg/L and 699mg/L in the base prediction (Table 3.33). For the Low Rainfall scenario, prediction median salinity is 716mg/L and 710mg/L for WS2b and WS2b-S respectively.

Lake Lyell

Figure 3.121 presents the distribution plot of climate scenarios in Lake Lyell (Node #174) for the concurrent and sequential implementation cases with respect to salinity. The base prediction cases, WS2b and WS2b-S, as well as the null case are also presented in Figure 3.121.

From Figure 3.121, median salinity in the High Rainfall scenario is 368mg/L and 356mg/L for WS2b and WS2b-S respectively. The median salinity of the equivalent NUL case is 255mg/L. For comparison, in the base prediction simulations, median salinity is 398 and 381mg/L for WS2b and WS2b-S, with the NUL case being 256mg/L. From Figure 3.121, median salinity in the Low Rainfall scenario is 425mg/L and 412 mg/L for WS2b and WS2b-S, and is 279mg/L in the equivalent NUL case.

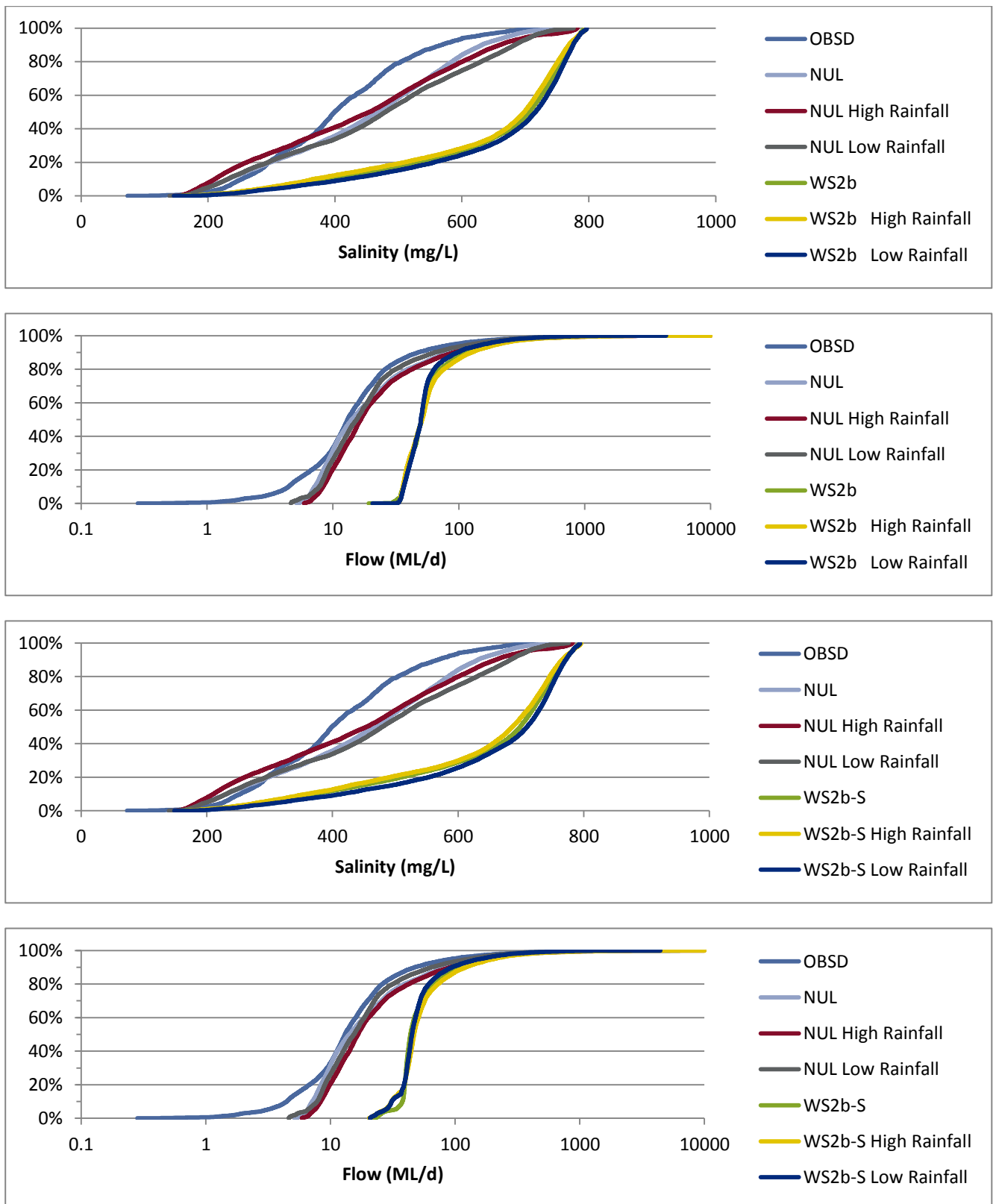


Figure 3.120 : Uncertainty Analysis (Climatic Conditions) Distribution Plot at #047 (Coxs River above Lake Wallace)

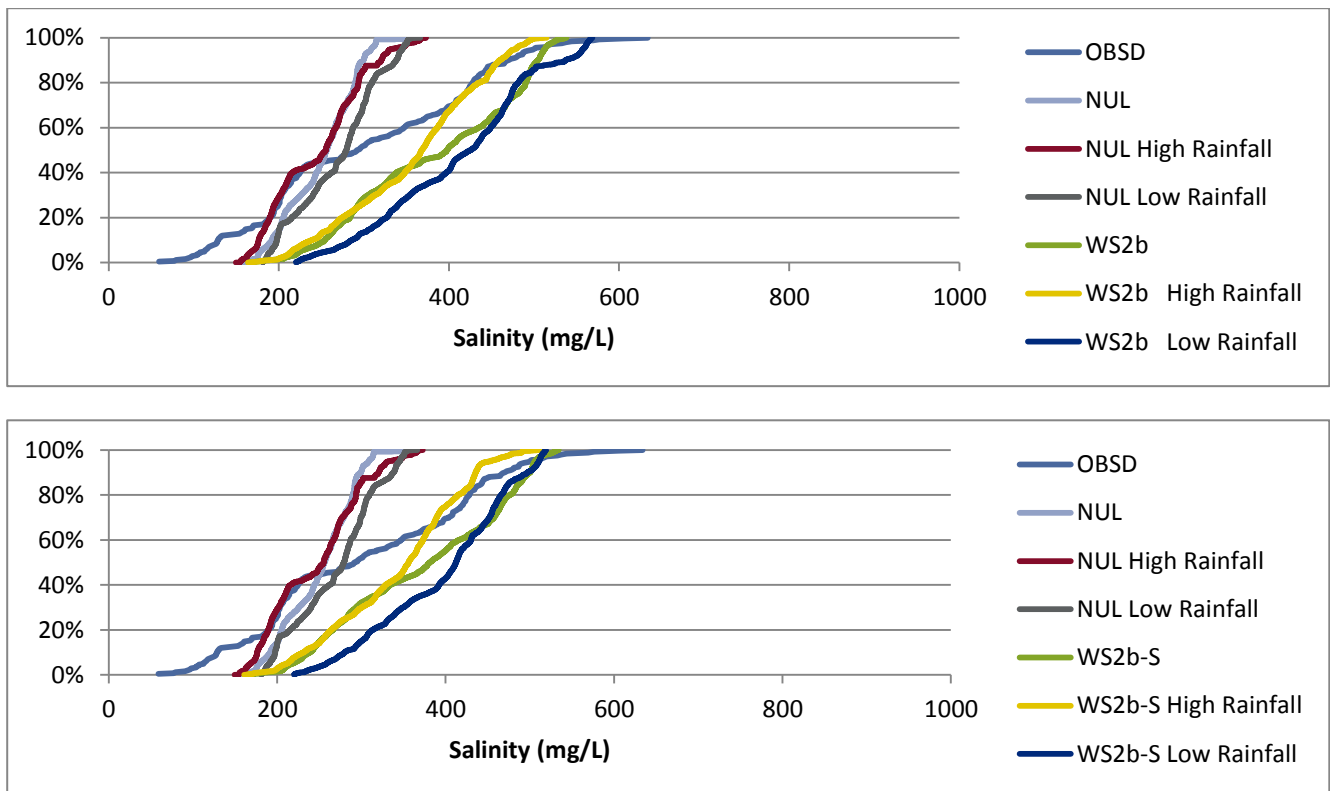


Figure 3.121 : Uncertainty Analysis (Climatic Conditions) Distribution Plot at #174 (Lake Lyell)

Lake Burragorang

Figure 3.122 presents the distribution plot of the climatic uncertainty condition at Lake Burragorang with respect to salinity. It is noted that the calibration simulation, CAL was also included in this plot, since there were no observations available for Lake Burragorang.

From Figure 3.122, predicted median salinity in WS2b and WS2b-S was 101 and 100mg/L respectively for the High Rainfall condition. The median salinity of the equivalent NUL case was 96mg/L. For comparison, the median salinity in the base prediction case (Table 3.40) was 104mg/L and 103mg/L for WS2b and WS2b-S, and the NUL case was 98mg/L. For the Low Rainfall condition, from Figure 3.122, predicted median salinity for WS2b was 100mg/L and was 98mg/L for WS2b-S, with the median salinity from the equivalent NUL case being 93mg/L.

3.8.2 Change to Land-Use Class Salinity

This uncertainty analysis simulation comprised an increase and decrease of assumed land-use salinity for each land-use class. The assumed land-use salinities are presented in Table 3.17. It is noted that initial conditions for these uncertainty analysis simulations were obtained from the relevant sensitivity analysis simulation presented in Section 3.3.

The model control files for these simulations were:

- 002a_UNC-SALu-WS2b_01a.gsm
- 002a_UNC-SALu-WS2b-S_01a.gsm
- 002a_UNC-SALu-WS2b_01a_NUL.gsm
- 002a_UNC-SALd-WS2b_01a.gsm

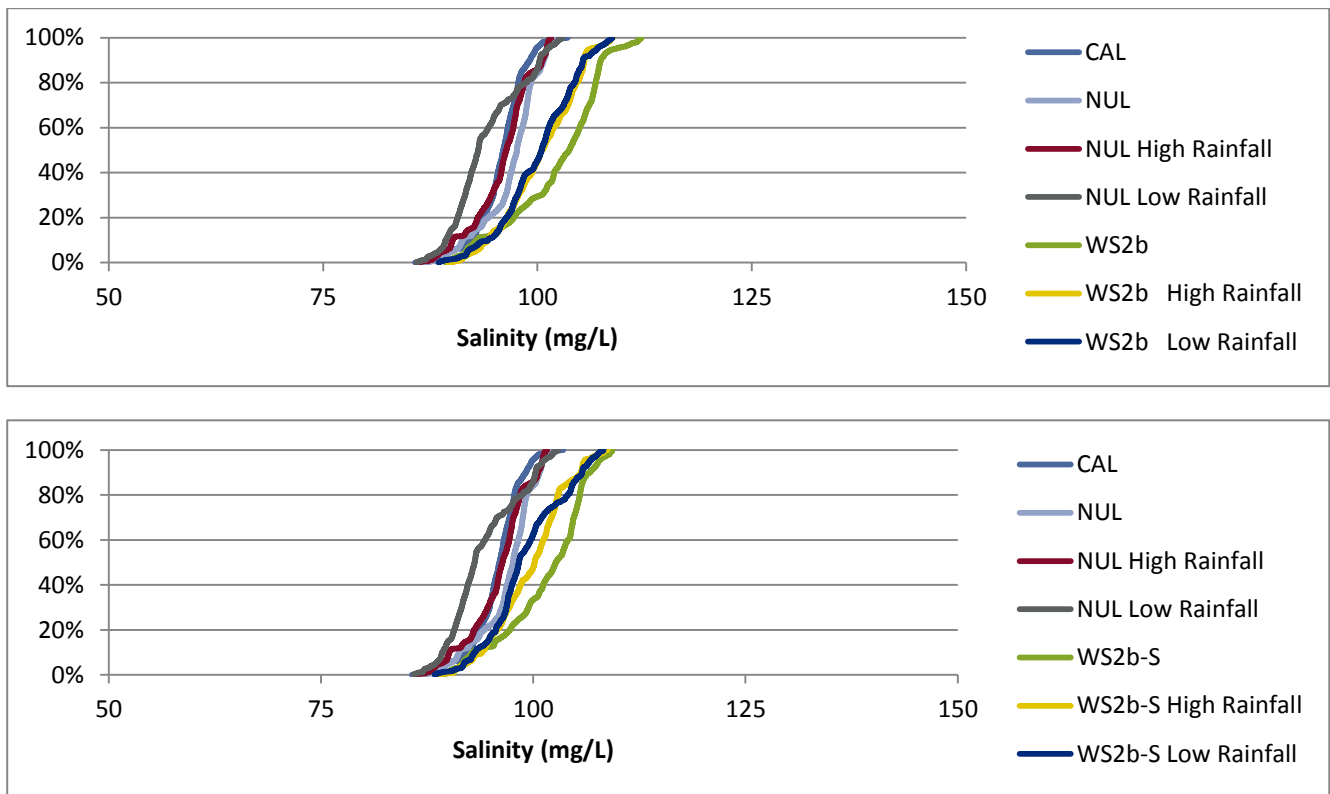


Figure 3.122 : Uncertainty Analysis (Climatic Conditions) Distribution Plot at #280 (Lake Burragarang)

- 002a UNC-SALd-WS2b-S_01a.gsm
- 002a UNC-SALd-WS2b_01a_NUL.gsm

Lake Wallace

Figure 3.123 presents the distribution plot of model output for the Land-Use Salinity uncertainty condition at Node #147 (upstream of Lake Wallace). The observation record, OBSD, as well as the base prediction simulation results, WS2b and WS2b-S, is also presented, including the NUL case.

It is noted that assumed Land-Use salinity does not affect the flow regime; therefore the distribution of model output with respect to salinity is presented in Figure 3.123 only.

From Figure 3.123, there is limited impact on predicted salinity distribution in the Coxs River above Lake Wallace. This is due to the significance of mine water discharge in median flows at this location.

From Figure 3.123, median salinity under the Land-Use Salinity +20% condition is 712 and 705mg/L for WS2b and WS2b-S respectively. The equivalent NUL case is 487mg/L. For Land-Use Salinity -20% condition, predicted median salinity is 700 and 692mg/L and is 445mg/L in the NUL case. For comparison, median salinity for the base predictions (Table 3.33) is 706 and 699mg/L, with NUL case being 466mg/L.

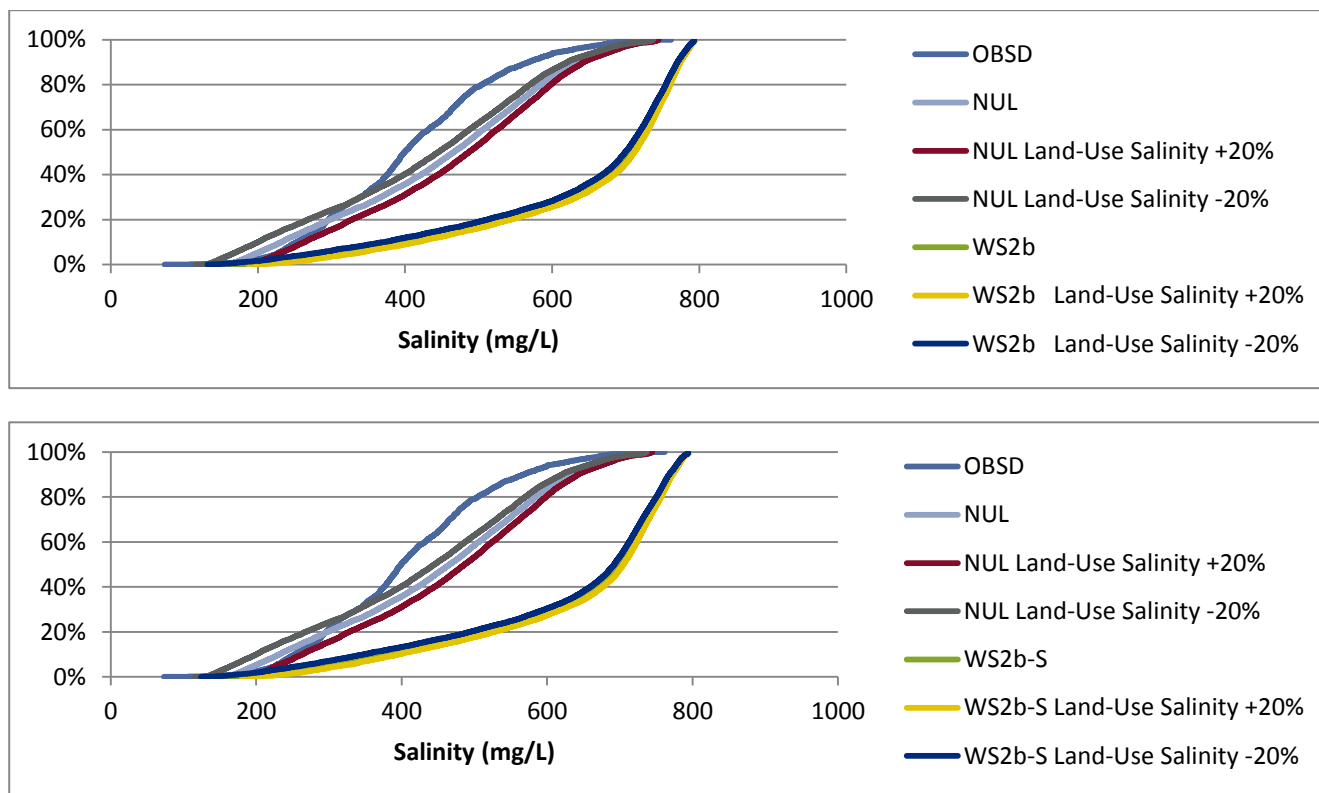


Figure 3.123 : Uncertainty Analysis (Land-Use Salinity) Distribution Plot at #047 (Coxs River above Lake Wallace)

Lake Lyell

Figure 3.124 presents the distribution plot of model output at Lake Lyell (Node #174), for both concurrent and sequential implementation cases.

From Figure 3.124, the 20% increase to Land-Use salinity leads to an increase in median predicted salinity from 398mg/L and 381mg/L, for WS2b and WS2b-S (Table 3.37) , to 427 mg/L and 412mg/L, an increase of 7.2% and 8.1% respectively. The 20% decrease in Land-Use salinity leads to a decrease in median predicted salinity from 398mg/L and 381mg/L to 369mg/L and 351mg/L, a decrease of 7.2% and 7.9% respectively.

Lake Burragorang

Figure 3.125 presents the distribution plot at Node #280 (Lake Burragorang).

From Figure 3.125, the 20% increase in Land-Use salinity leads to an increase in median predicted salinity in Lake Burragorang of 18% for both WS2b and WS2b-S simulations. For the 20% decrease in Land-Use salinity, the respectively decrease in median predicted salinity is 19%.

For reference, the median salinity in the NUL case is 117mg/L for the Land-Use Salinity +20% simulation and is 78mg/L for the Land-Use Salinity -20% simulation. The median salinity of the NUL case in the base predictions is 98mg/L.

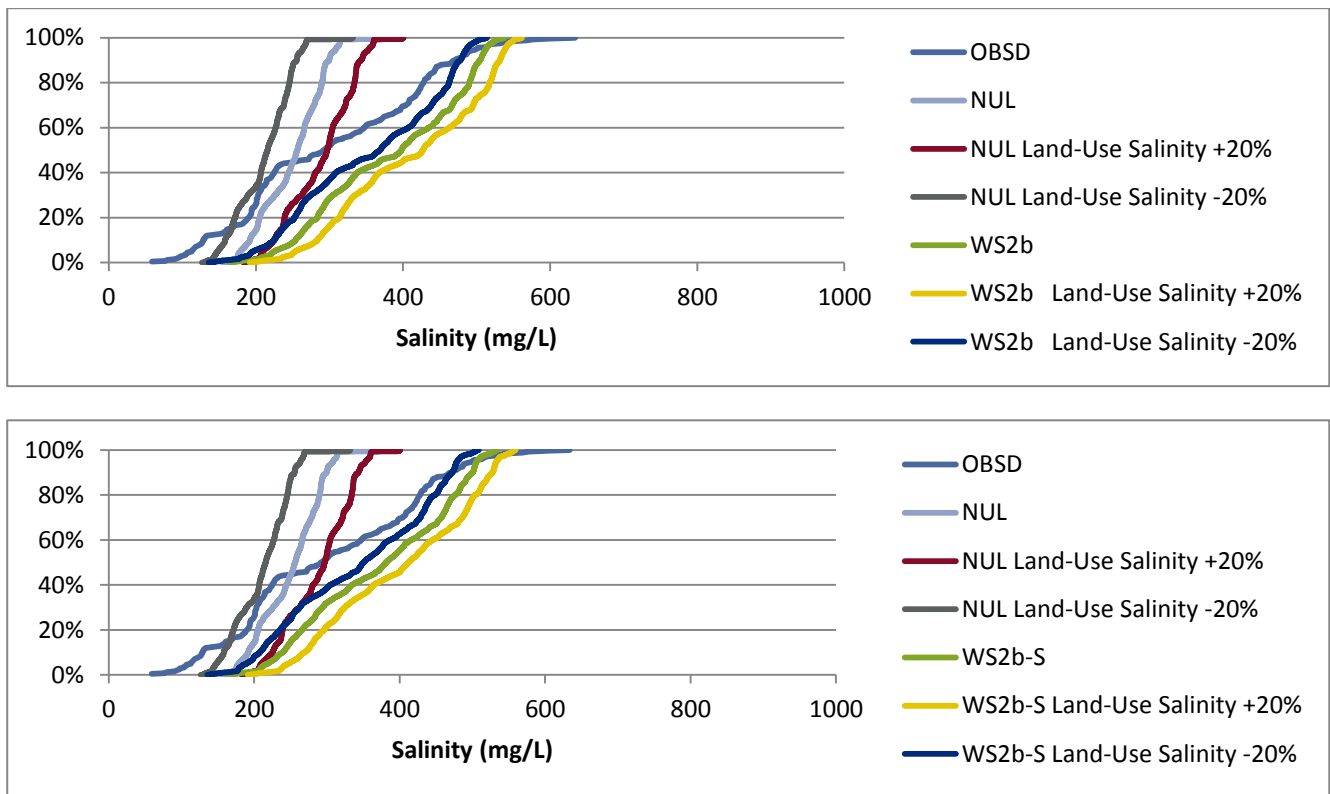


Figure 3.124 : Uncertainty Analysis (Land-Use Salinity) Distribution Plot at #174 (Lake Lyell)

3.8.3 Change to Average Soil Storage Capacity

This uncertainty analysis condition considered a 20% increase and decrease in assumed average soil storage capacity. The average soil storage capacity is a parameter of the AWBM modules. Table 3.20 presents the average soil storage capacity for each land-use class. As noted above, initial conditions were adopted from relevant files from the sensitivity analysis simulations.

The model control files for these simulations were:

- 002a UNC-CAPu_WS2b_01a.gsm
- 002a UNC-CAPu_WS2b-S_01a.gsm
- 002a UNC-CAPu_WS2b_01a_NUL.gsm
- 002a UNC-CAPd_WS2b_01a.gsm
- 002a UNC-CAPd_WS2b-S_01a.gsm
- 002a UNC-CAPd_WS2b_01a_NUL.gsm

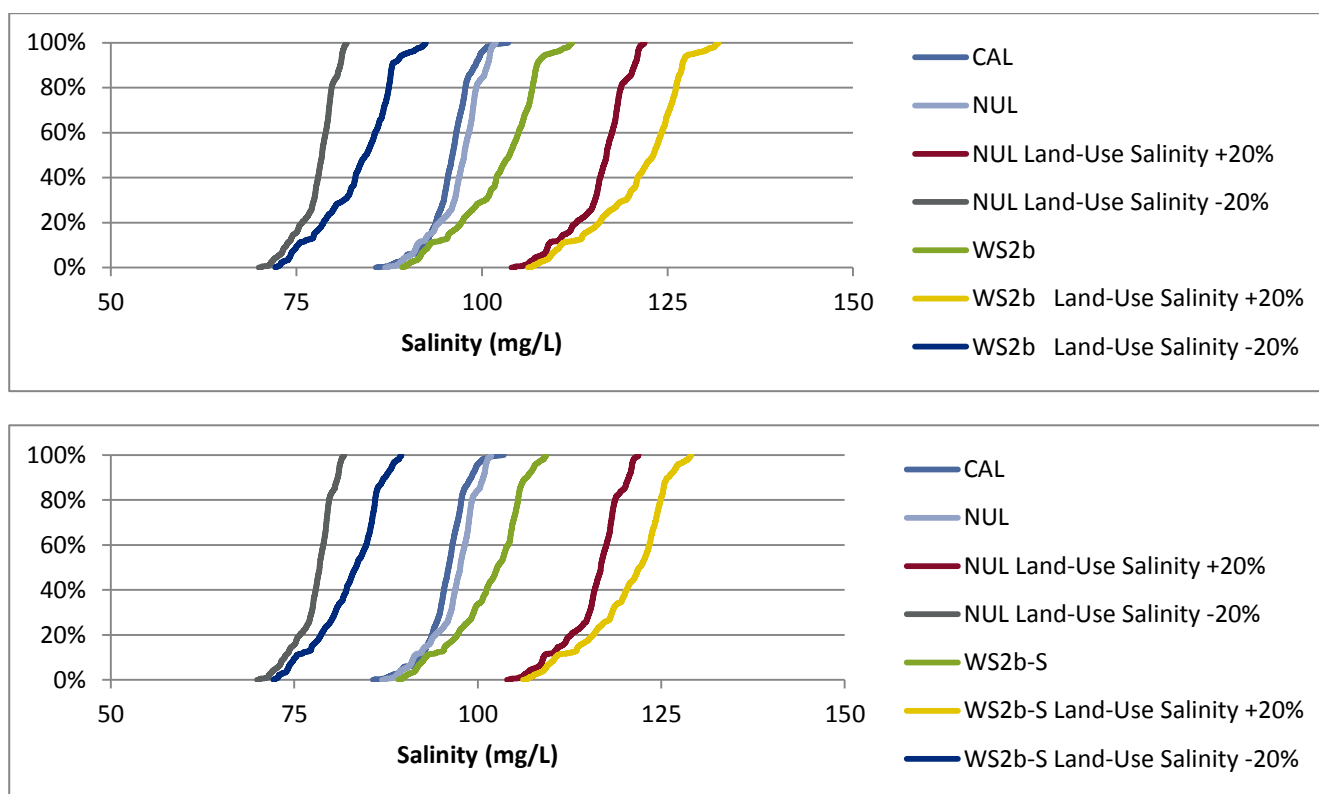


Figure 3.125 : Uncertainty Analysis (Land-Use Salinity) Distribution Plot at #280 (Lake Burragorang)

Lake Wallace

Figure 3.126 presents the distribution of model output at Node #047 (Coxs River above Lake Wallace) for the uncertainty analysis simulation of Average Soil Storage Capacity.

From Figure 3.126, the 20% increase and decrease of Average Soil Storage Capacity does not have a significant effect on flow distribution at this location. The modelled impact to salinity is more significant. From Figure 3.126, the predicted median salinity in the +20% case is 719 and 748mg/L in WS2b and WS2b-S, compared to 706 and 699mg/L (Table 3.33) or an increase of 1.8% and 7.0% respectively. The NUL case in the +20% case is 489mg/L, and is 466mg/L in the base predictions. The increase in salinity is caused by the reduction in runoff, which is more prominent in the WS2b-S case in Figure 3.126 than the WS2b simulation.

From Figure 3.126, there is essentially little difference between the base predictions and the 20% decrease in Average Soil Storage Capacity simulation.

Lake Lyell

Figure 3.127 presents the distribution of model output at Node #174.

From Figure 3.127, there is limited difference between the base predictions and uncertainty analysis conditions at this location. Predicted median salinity in Lake Lyell in the base case is 398mg/L and 381mg/L (Table 3.37) and is 414 and 414 mg/L for 20% increase scenario and is 374 and 358mg/L for the 20% decrease scenario, with respect to WS2b and WS2b-S. Uncertainty analysis indicates that predicted salinity is not particularly sensitive to assumed soil storage capacity.

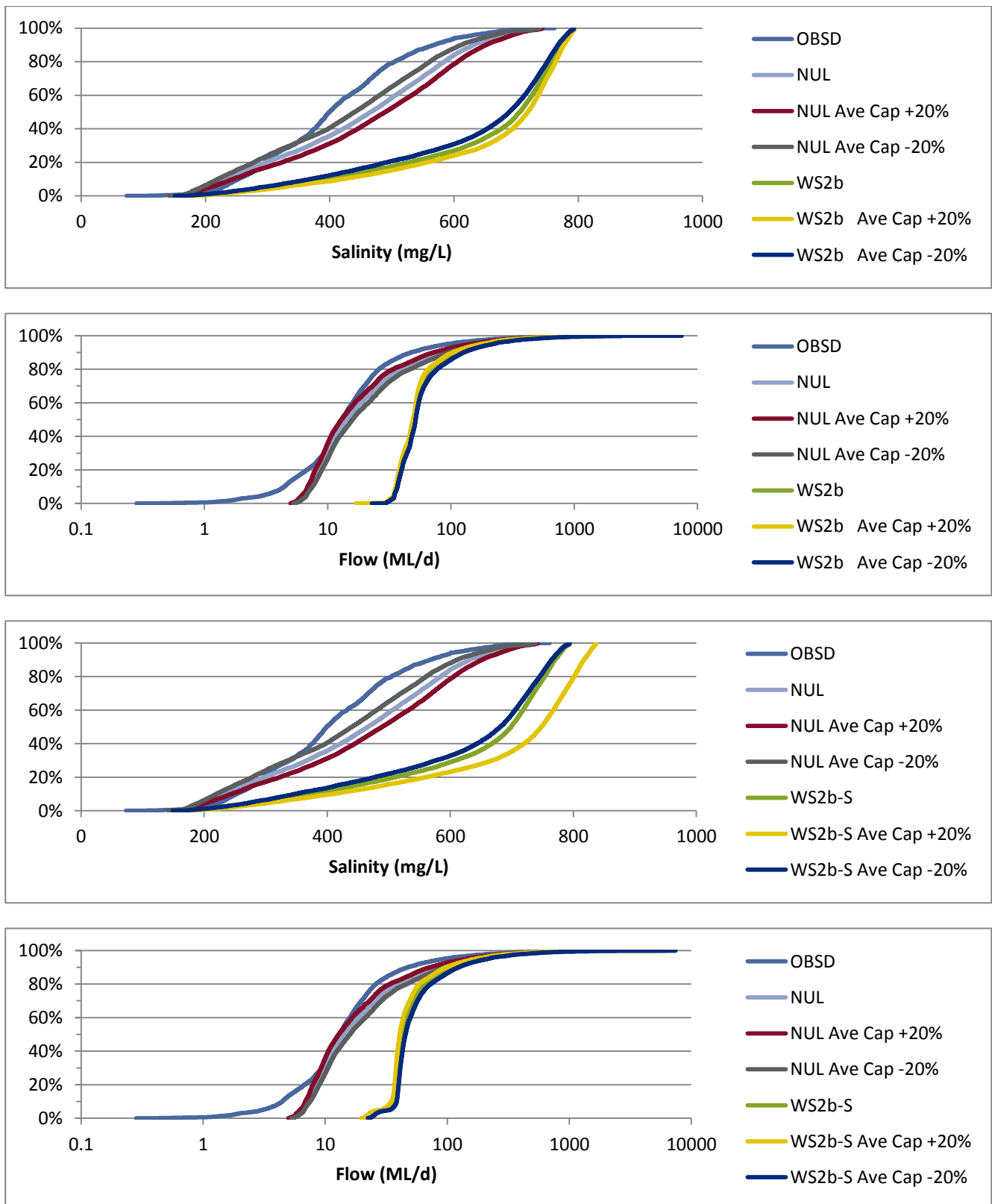


Figure 3.126 : Uncertainty Analysis (Average Capacity) Distribution Plot at #047 (Coxs River above Lake Wallace)

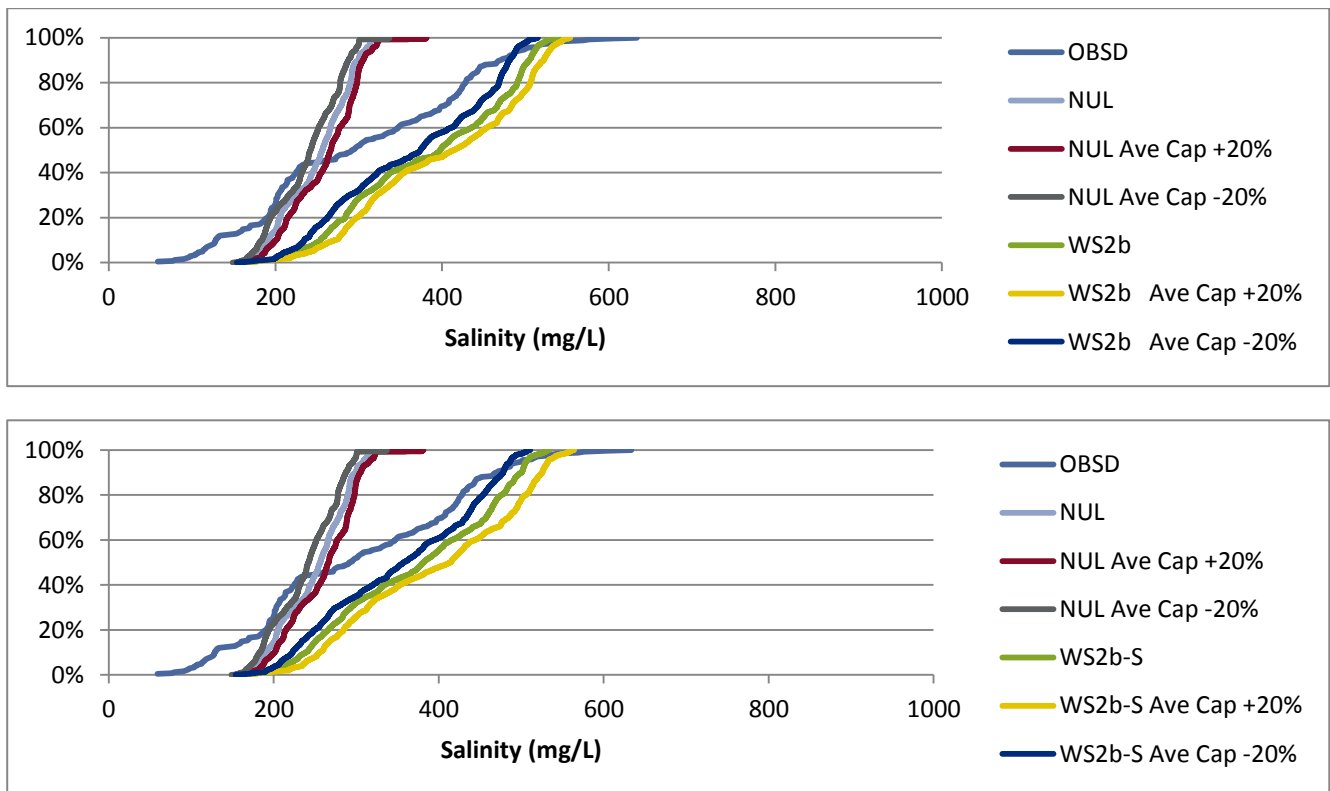


Figure 3.127 : Uncertainty Analysis (Average Capacity) Distribution Plot at #174 (Lake Lyell)

Lake Burragorang

Figure 3.128 presents the distribution plot of model output at Node #280 (Lake Burragorang).

Figure 3.128 indicates that potential uncertainty in Average Soil Storage Capacity has negligible effect on predicted salinity in Lake Burragorang.

3.8.4 Change to Baseflow Index

The final uncertainty analysis simulation considered an increase and decrease by 20% of the partitioning of rainfall excess between the baseflow and surface stores in AWBM. As presented in Section 3.3, the calibration value of the Baseflow Index, BFI, was 25% for each land-use class. Accordingly, the +20% increase to BFI was 0.3 and the -20% decrease to BFI was 0.2.

The model control files for these simulations were:

- 002a_UNC-BFIu-WS2b_01a.gsm
- 002a_UNC-BFIu-WS2b-S_01a.gsm
- 002a_UNC-BFIu-WS2b_01a_NUL.gsm
- 002a_UNC-BFId-WS2b_01a.gsm
- 002a_UNC-BFId-WS2b-S_01a.gsm
- 002a_UNC-BFId-WS2b_01a_NUL.gsm

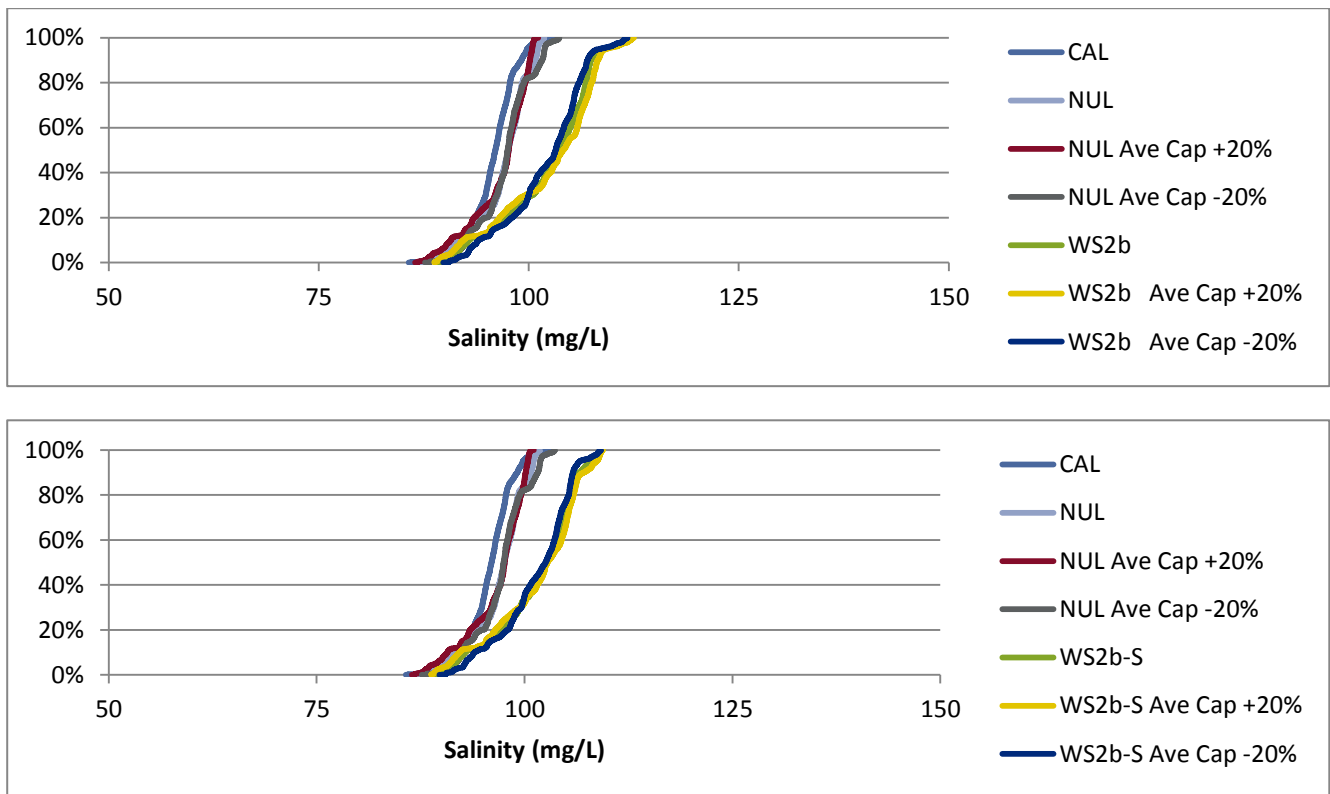


Figure 3.128 : Uncertainty Analysis (Average Capacity) Distribution Plot at #280 (Lake Burragorang)

Lake Wallace

Figure 3.129 presents the distribution plot of model output above Lake Wallace (Node #047) in regard to 20% increase and decrease in Baseflow Index.

From Figure 3.129, predicted flow at Node #047 is insensitive to potential uncertainty in the Baseflow Index.

From Figure 3.129, predicted salinity at Node #047 is also relatively insensitive to the assumed of the Baseflow Index.

Lake Lyell

Figure 3.130 presents the distribution of model output at Lake Lyell (Node #174).

From Figure 3.130, predicted salinity in Lake Lyell is essentially insensitive to the value of Baseflow Index.

Lake Burragorang

Figure 3.131 presents the distribution of model output at Lake Burragorang (Node #280).

From Figure 3.131, predicted salinity in Lake Burragorang is also essentially insensitive to the value of Baseflow Index.

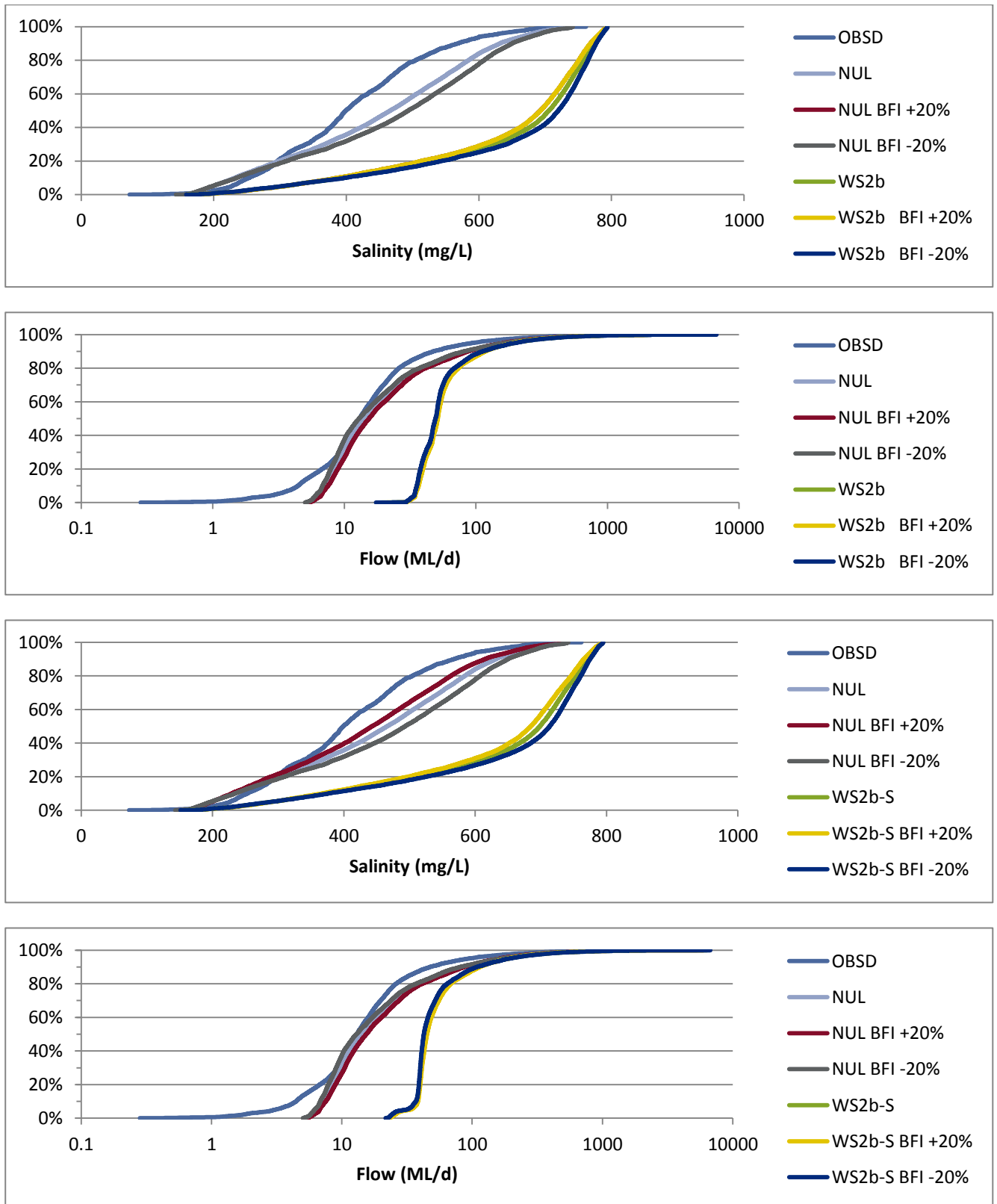


Figure 3.129 : Uncertainty Analysis (Baseflow Index) Distribution Plot at #047 (Coxs River above Lake Wallace)

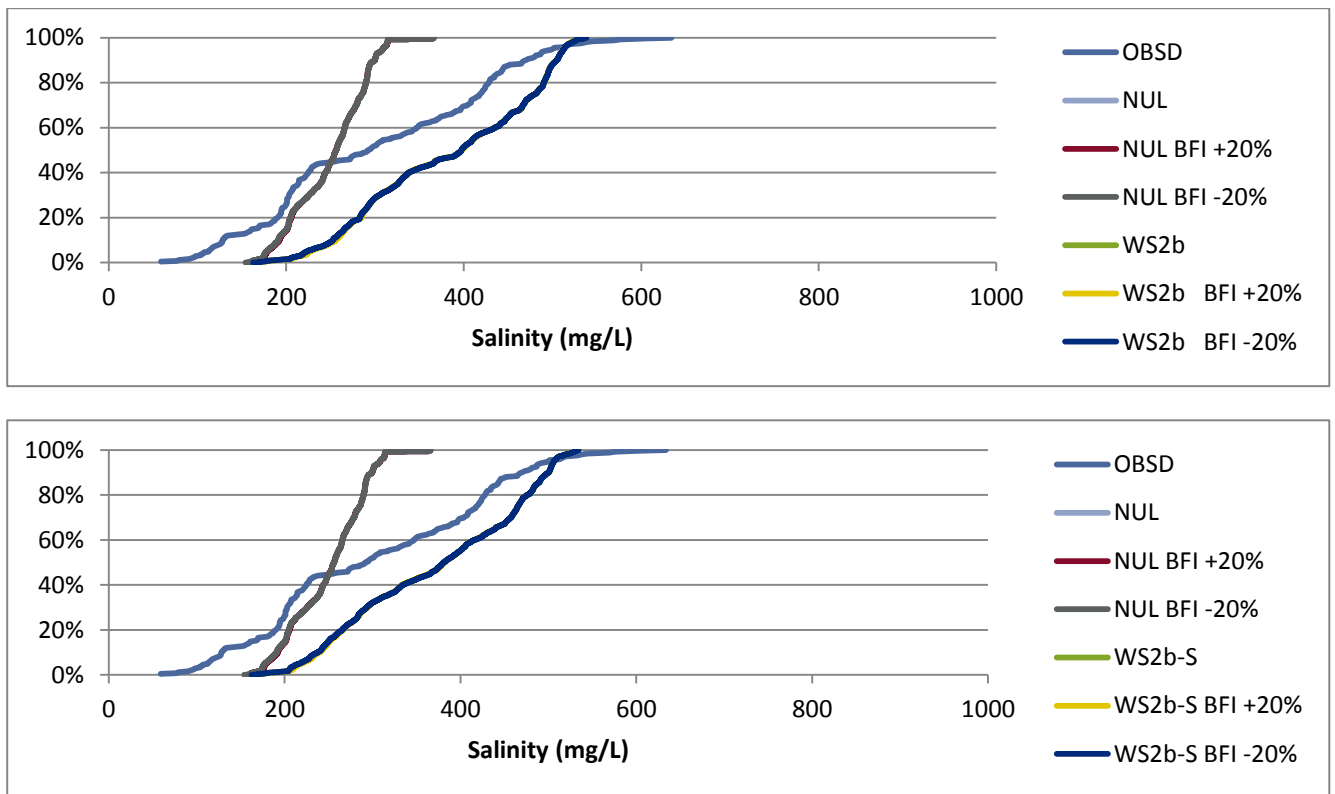


Figure 3.130 : Uncertainty Analysis (Baseflow Index) Distribution Plot at #174 (Lake Lyell)

3.8.5 Summary

Uncertainty analysis was undertaken on four scenarios encompassing the primary model parameters potentially affecting model predictions. Modelling indicates that, for the range of parameters assessed, that model predictions are not overly sensitive to model assumptions. Uncertainty analysis on model predictions also does not contradict the conclusions drawn in Section 3.4 as to the expected changes due to the proposed extensions at Angus Place Colliery and Springvale Mine, implemented either concurrently or sequentially.

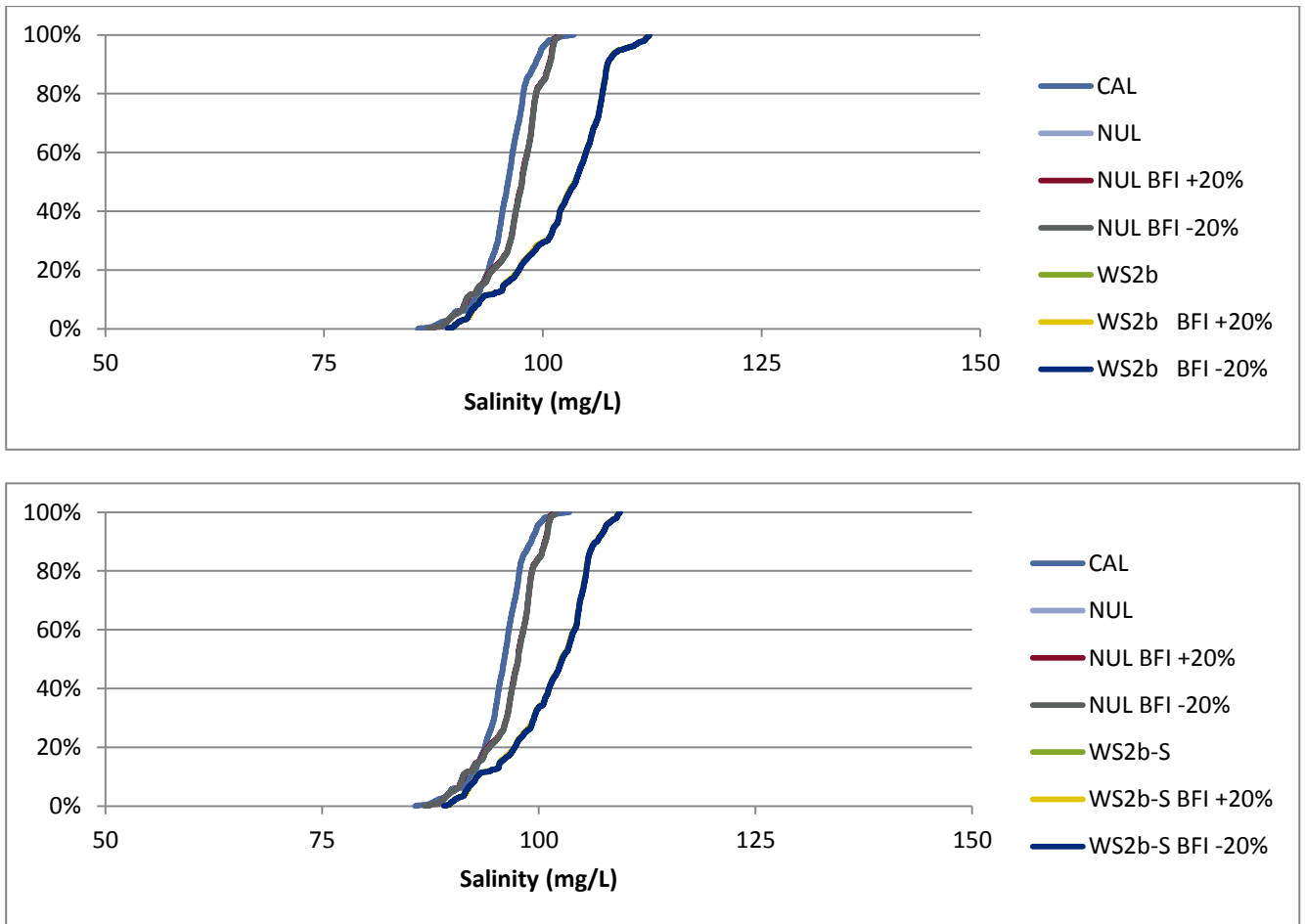


Figure 3.131 : Uncertainty Analysis (Baseflow Index) Distribution Plot at #280 (Lake Burragorang)

4. Impact Assessment

A summary of modelled impacts is presented in Section 4.1 and Section 4.2.

Further detail of impact to flow and salinity is presented in RPS (2014a, b and c).

4.1 Impact to Flow

Table 4.1 and Table 4.2 present a summary of updated model results from the top of the catchment downstream through to Lake Burragorang.

The format of presented model results is median, and then, in subsequent lines, minimum and maximum.

An assessment of a range of End of Pipe Targets is presented in Table 4.3 and Table 4.4.

The outcome of assessment of potential treatment options is presented in Table 4.5 and Table 4.6.

A summary of the End of Pipe Targets including Clarence is presented in Table 4.7 and Table 4.8.

The model results presented in Table 4.1 to Table 4.8 were obtained from results presented in Section 3.

Table 4.1 : Summary of Predicted Daily Flows (ML/d) or Volume (ML) in the Coxs River catchment – Concurrent

Location	Node	OBSD	NUL	WS1	WS2a	WS2b
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>						
Kangaroo Creek downstream of Angus Place LDP001	#011	n/a	0.5 0.0 520	26.4 5.4 535	3.4 2.0 522	2.5 2.0 522
Coxs River above Wangcol Creek/Blue Lagoon	#056	n/a	1.8 0.0 1830	28.0 7.2 1846	7.1 2.0 1832	3.8 2.0 1832
<i>Sawyers Swamp Creek</i>						
Sawyers Swamp Creek downstream of Springvale LDP009	#166	n/a	0.2 0.0 364	14.9 0.0 380	28.5 3.1 393	28.5 3.1 393
<i>Lake Wallace</i>						
Coxs River above Lake Wallace	#047	13.1 0.3 5321	14.2 5.1 6327	50.5 19.2 6358	as per WS1	as per WS1
Lake Wallace (ML)	#074	n/a	4221 4168 4221	4221 4221 4221	as per WS1	as per WS1
<i>Lake Lyell and above Lake Lyell</i>						
Coxs River above Lake Lyell	#154	20.4 4.6 6750	19.0 0.2 11487	53.3 11.5 11518	as per WS1	as per WS1
Lake Lyell (ML)	#174	n/a	33538 24418 34451	34439 29361 34451	as per WS1	as per WS1
<i>Thompsons Creek Reservoir</i>						
Thompsons Creek Reservoir (ML)	#272	n/a	26996 21953 28000	27003 26926 28000	as per WS1	as per WS1
<i>Lake Burragorang and above Lake Burragorang</i>						
Coxs River above Lake Burragorang	#225	n/a	190 5.6 78103	205 20.9 78134	as per WS1	as per WS1
Lake Burragorang (ML)	#280	n/a	2024400 1772200 2031000	2024800 1775400 2031000	as per WS1	as per WS1

Table 4.2 : Summary of Predicted Daily Flows (ML/d) or Volume (ML) in the Coxs River catchment – Sequential

Location	Node	OBSD	NUL	WS1-S	WS2a-S	WS2b-S
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>						
Kangaroo Creek downstream of Angus Place LDP001	#011	n/a	0.5 0.0 520	16.8 14.6 534	2.8 2.0 522	2.5 2.0 522
Coxs River above Wangcol Creek/Blue Lagoon	#056	n/a	1.8 0.0 1830	21.4 14.7 1845	4.1 2.1 1832	3.8 2.0 1832
<i>Sawyers Swamp Creek</i>						
Sawyers Swamp Creek downstream of Springvale LDP009	#166	n/a	0.2 0.0 364	14.9 0.0 380	30.0 12.9 392	30.0 12.9 392
<i>Lake Wallace</i>						
Coxs River above Lake Wallace	#047	13.1 0.3 5321	14.2 5.1 6327	43.8 22.0 6358	as per WS1	as per WS1
Lake Wallace (ML)	#074	n/a	4221 4168 4221	4221 4221 4221	as per WS1	as per WS1
<i>Lake Lyell and above Lake Lyell</i>						
Coxs River above Lake Lyell	#154	20.4 4.6 6750	19.0 0.2 11487	48.2 17.1 11518	as per WS1	as per WS1
Lake Lyell (ML)	#174	n/a	33538 24418 34451	34429 30201 34451	as per WS1	as per WS1
<i>Thompsons Creek Reservoir</i>						
Thompsons Creek Reservoir (ML)	#272	n/a	26996 21953 28000	27003 26927 28000	as per WS1	as per WS1
<i>Lake Burragorang and above Lake Burragorang</i>						
Coxs River above Lake Burragorang	#225	n/a	190 5.6 78103	202 22.0 78133	as per WS1	as per WS1
Lake Burragorang (ML)	#280	n/a	2024400 1772200 2031000	2024700 1775700 2031000	as per WS1	as per WS1

Table 4.3 : Summary of End of Pipe Target Daily Flows (ML/d) or Volume (ML) in the Coxs River catchment - Concurrent

Location	Node	OBSD	NUL	WS2b	WS2b_ T350	WS2b_ T700	WS2b_ T800	WS2b_ T900
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	n/a	0.5 0.0 520	2.5 2.0 522	2.5 2.0 522	2.5 2.0 522	2.5 2.0 522	2.5 2.0 522
Coxs River above Wangcol Creek/Blue Lagoon	#056	n/a	1.8 0.0 1830	3.8 2.0 1832	3.8 2.0 1832	3.8 2.0 1832	3.8 2.0 1832	3.8 2.0 1832
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	n/a	0.2 0.0 364	28.5 3.1 393	28.5 3.1 393	28.5 3.0 393	28.5 3.1 393	28.5 3.0 393
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	13.1 0.3 5321	14.2 5.1 6327	50.5 19.2 6358	50.5 21.5 6358	50.4 21.5 6358	50.5 21.5 6358	50.5 21.5 6358
Lake Wallace (ML)	#074	n/a	4221 4168 4221	4221 4221 4221	4221 4221 4221	4221 4221 4221	4221 4221 4221	4221 4221 4221
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154	20.4 4.6 6750	19.0 0.2 11487	53.3 11.5 11518	53.2 11.5 11518	53.2 11.4 11518	53.3 11.5 11518	53.3 11.4 11518
Lake Lyell (ML)	#174	n/a	33538 24418 34451	34439 29361 34451	34439 29343 34451	34439 29351 34451	34439 29366 34451	34439 29365 34451
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir (ML)	#272	n/a	26996 21953 28000	27003 26926 28000	27003 26928 28000	27003 26926 28000	27003 26927 28000	27003 26927 28000
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	n/a	190 5.6 78103	205 20.9 78134	204 20.9 78134	205 20.9 78134	205 20.9 78134	206 20.9 78134
Lake Burragorang (ML)	#280	n/a	2024400 1772200 2031000	2024800 1775400 2031000	2024800 1775400 2031000	2024800 1775400 2031000	2024800 1775400 2031000	2024800 1775400 2031000

Table 4.4 : Summary of End of Pipe Target Daily Flows (ML/d) or Volume (ML) in the Coxs River catchment - Sequential

Location	Node	OBSD	NUL	WS2b-S	WS2b-S T350	WS2b-S T700	WS2b-S T800	WS2b-S T900
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	n/a	0.5 0.0 520	2.5 2.0 522	2.5 2.0 522	2.5 2.0 522	2.5 2.0 522	2.5 2.0 522
Coxs River above Wangcol Creek/Blue Lagoon	#056	n/a	1.8 0.0 1830	3.8 2.0 1832	3.8 2.0 1832	3.8 2.0 1832	3.8 2.0 1832	3.8 2.0 1832
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	n/a	0.2 0.0 364	30.0 12.9 392	29.9 12.9 393	30.0 12.8 393	30.0 12.9 393	30.0 12.9 393
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	13.1 0.3 5321	14.2 5.1 6327	43.8 22.0 6358	43.8 22.0 6358	43.8 22.0 6358	43.8 21.9 6358	43.8 22.0 6358
Lake Wallace (ML)	#074	n/a	4221 4168 4221	4221 4221 4221	4221 4221 4221	4221 4221 4221	4221 4221 4221	4221 4221 4221
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154	20.4 4.6 6750	19.0 0.2 11487	48.2 17.1 11518	48.2 17.1 11518	48.2 17.1 11518	48.2 17.0 11518	48.2 17.1 11518
Lake Lyell (ML)	#174	n/a	33538 24418 34451	34429 30201 34451	34429 30205 34451	34428 30199 34451	34429 30200 34451	34429 30200 34451
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir (ML)	#272	n/a	26996 21953 28000	27003 26927 28000	27004 26928 28000	27003 26927 28000	27003 26928 28000	27004 26928 28000
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	n/a	190 5.6 78103	202 22.0 78133	202.6 22.0 78133	202.7 22.0 78133	202.7 53 352	202.1 22.0 78133
Lake Burragorang (ML)	#280	n/a	2024400 1772200 2031000	2024700 1775700 2031000	2024700 1775700 2031000	2024700 1775700 2031000	2024700 1775700 2031000	2024700 1775700 2031000

Table 4.5 : Summary of Treatment Option Daily Flows (ML/d) or Volume (ML) in the Coxs River catchment – Concurrent

Location	Node	OBSD	NUL	CLR	WS2b	WS2b with CLR	WS2b with RO6	WS2b with CLR and RO6
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	n/a	0.5 0.0 520	0.5 0.0 520	2.5 2.0 522	2.5 2.0 522	as per WS2b	as per WS2b with CLR
Coxs River above Wangcol Creek/Blue Lagoon	#056	n/a	1.8 0.0 1830	1.8 0.0 1830	3.8 2.0 1832	3.8 2.0 1832	as per WS2b	as per WS2b with CLR
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	n/a	0.2 0.0 364	19.0 13.8 379	28.5 3.1 393	45.9 22.1 408	as per WS2b	as per WS2b with CLR
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	13.1 0.3 5321	14.2 5.1 6327	31.9 20.2 6342	50.5 19.2 6358	67.3 40.5 6373	as per WS2b	as per WS2b with CLR
Lake Wallace (ML)	#074	n/a	4221 4168 4221	4221 4221 4221	4221 4221 4221	4221 4221 4221	as per WS2b	as per WS2b with CLR
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154	20.4 4.6 6750	19.0 0.2 11487	36.7 12.2 11502	53.3 11.5 11518	70.8 30.5 11533	as per WS2b	as per WS2b with CLR
Lake Lyell (ML)	#174	n/a	33538 24418 34451	34334 27610 34451	34439 29361 34451	34451 31791 34451	as per WS2b	as per WS2b with CLR
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir (ML)	#272	n/a	26996 21953 28000	27003 26926 28000	27003 26926 28000	27004 26928 28000	as per WS2b	as per WS2b with CLR
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	n/a	190 5.6 78103	197 17.7 78118	205 20.9 78134	222 25.7 78149	as per WS2b	as per WS2b with CLR
Lake Burragorang (ML)	#280	n/a	2024400 1772200 2031000	2024600 1774800 2031000	2024800 1775400 2031000	2025200 1777100 2031000	as per WS2b	as per WS2b with CLR

Table 4.6 : Summary of Treatment Option Daily Flows (ML/d) or Volume (ML) in the Coxs River catchment – Sequential

Location	Node	OBSD	NUL	CLR	WS2b-S	WS2b-S with CLR	WS2b-S with RO6	WS2b-S with CLR and RO6
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	n/a	0.5 0.0 520	0.5 0.0 520	2.5 2.0 522	2.5 2.0 522	as per WS2b-S	as per WS2b-S with CLR
Coxs River above Wangcol Creek/Blue Lagoon	#056	n/a	1.8 0.0 1830	1.8 0.0 1830	3.8 2.0 1832	3.8 2.0 1832	as per WS2b-S	as per WS2b-S with CLR
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	n/a	0.2 0.0 364	19.0 13.8 379	30.0 12.9 392	47.1 32.1 408	as per WS2b-S	as per WS2b-S with CLR
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	13.1 0.3 5321	14.2 5.1 6327	31.9 20.2 6342	43.8 22.0 6358	61.7 41.1 6373	as per WS2b-S	as per WS2b-S with CLR
Lake Wallace (ML)	#074	n/a	4221 4168 4221	4221 4221 4221	4221 4221 4221	4221 4221 4221	as per WS2b-S	as per WS2b-S with CLR
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154	20.4 4.6 6750	19.0 0.2 11487	36.7 12.2 11502	48.2 17.1 11518	65.7 36.2 11533	as per WS2b-S	as per WS2b-S with CLR
Lake Lyell (ML)	#174	n/a	33538 24418 34451	34334 27610 34451	34429 30201 34451	34451 31791 34451	as per WS2b-S	as per WS2b-S with CLR
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir (ML)	#272	n/a	26996 21953 28000	27003 26926 28000	27003 26927 28000	27004 26927 28000	as per WS2b-S	as per WS2b-S with CLR
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	n/a	190 5.6 78103	197 17.7 78118	202 22.0 78133	216 26.7 78149	as per WS2b-S	as per WS2b-S with CLR
Lake Burragorang (ML)	#280	n/a	2024400 1772200 2031000	2024600 1774800 2031000	2024700 1775700 2031000	2025100 1777800 2031000	as per WS2b-S	as per WS2b-S with CLR

Table 4.7 : Summary of End of Pipe Target with Clarence Daily Flows (ML/d) or Volume (ML) in the Coxs River catchment - Concurrent

Location	Node	OBSD	NUL	WS2b	WS2b T350 with CLR	WS2b T700 with CLR	WS2b T800 with CLR	WS2b T900 with CLR
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	n/a	0.5 0.0 520	2.5 2.0 522	2.5 2.0 522	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR
Coxs River above Wangcol Creek/Blue Lagoon	#056	n/a	1.8 0.0 1830	3.8 2.0 1832	3.8 2.0 1832	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	n/a	0.2 0.0 364	28.5 3.1 393	46.0 22.0 408	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	13.1 0.3 5321	14.2 5.1 6327	50.5 19.2 6358	67.3 38.1 6373	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR
Lake Wallace (ML)	#074	n/a	4221 4168 4221	4221 4221 4221	4221 4221 4221	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154	20.4 4.6 6750	19.0 0.2 11487	53.3 11.5 11518	70.8 30.4 11533	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR
Lake Lyell (ML)	#174	n/a	33538 24418 34451	34439 29361 34451	34451 31791 34451	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir (ML)	#272	n/a	26996 21953 28000	27003 26926 28000	27003 26928 28000	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	n/a	190 5.6 78103	205 20.9 78134	222 25.7 78149	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR
Lake Burragorang (ML)	#280	n/a	2024400 1772200 2031000	2024800 1775400 2031000	2025200 1777100 2031000	as per WS2b T350 CLR	as per WS2b T350 CLR	as per WS2b T350 CLR

Table 4.8 : Summary of End of Pipe Target with Clarence Daily Flows (ML/d) or Volume (ML) in the Coxs River catchment - Sequential

Location	Node	OBSD	NUL	WS2b-S	WS2b-S T350 with CLR	WS2b-S T700 with CLR	WS2b-S T800 with CLR	WS2b-S T900 with CLR
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	n/a	0.5 0.0 520	2.5 2.0 522	2.5 2.0 522	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR
Coxs River above Wangcol Creek/Blue Lagoon	#056	n/a	1.8 0.0 1830	3.8 2.0 1832	3.8 2.0 1832	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	n/a	0.2 0.0 364	30.0 12.9 392	47.1 32.1 408	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	13.1 0.3 5321	14.2 5.1 6327	43.8 22.0 6358	61.7 41.1 6373	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR
Lake Wallace (ML)	#074	n/a	4221 4168 4221	4221 4221 4221	4221 4221 4221	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154	20.4 4.6 6750	19.0 0.2 11487	48.2 17.1 11518	65.7 36.2 11533	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR
Lake Lyell (ML)	#174	n/a	33538 24418 34451	34429 30201 34451	34451 31791 34451	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir (ML)	#272	n/a	26996 21953 28000	27003 26927 28000	27004 26927 28000	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	n/a	190 5.6 78103	2024700 1775700 2031000	2025100 1777800 2031000	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR
Lake Burragorang (ML)	#280	n/a	2024400 1772200 2031000	2024700 1775700 2031000	2025100 1777800 2031000	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR	as per WS2b-S T350 CLR

4.2 Impact to Quality

Table 4.9 and Table 4.10 present a summary of updated model results from the top of the catchment downstream through to Lake Burragorang.

The format of presented model results is median, and then, in subsequent lines, minimum and maximum.

An assessment of a range of End of Pipe Targets is presented in Table 4.11 and Table 4.12.

The outcome of assessment of potential treatment options is presented in Table 4.13 and Table 4.14.

A summary of the End of Pipe Targets including Clarence is presented in Table 4.15 and Table 4.16.

The model results presented in Table 4.9 to Table 4.16 were obtained from results presented in Section 3.

Table 4.9 : Summary of Predicted Daily Salinity (mg/L) in the Coxs River catchment - Concurrent

Location	Node	OBSD	NUL	WS1	WS2a	WS2b
Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon						
Kangaroo Creek downstream of Angus Place LDP001	#011	612	53	788	696	662
		59	50	74	56	56
		784	53	804	803	803
Coxs River above Wangcol Creek/Blue Lagoon	#056	345	62	747	511	455
		36	50	70	57	57
		757	69	804	800	800
Sawyers Swamp Creek						
Sawyers Swamp Creek downstream of Springvale LDP009	#166	175	95	716	798	798
		117	79	79	214	214
		490	809	806	805	805
Lake Wallace						
Coxs River above Lake Wallace	#047	399	466	706	as per WS1	as per WS1
		73	144	160		
		762	741	794		
Lake Wallace	#074	519	280	540	as per WS1	as per WS1
		218	140	121		
		771	427	732		
Lake Lyell and above Lake Lyell						
Coxs River above Lake Lyell	#154 / #035	737	220	490	as per WS1	as per WS1
		168	65	108		
		1240	420	731		
Lake Lyell	#174	259	256	398	as per WS1	as per WS1
		59	155	164		
		634	366	538		
Thompsons Creek Reservoir						
Thompsons Creek Reservoir	#272	285	271	377	as per WS1	as per WS1
		184	238	272		
		436	321	473		
Lake Burragorang and above Lake Burragorang						
Coxs River above Lake Burragorang	#225	107	128	156	as per WS1	as per WS1
		74	52	53		
		302	249	468		
Lake Burragorang	#280	n/a	98	104	as per WS1	as per WS1
			87	89		
			102	112		

Table 4.10 : Summary of Predicted Daily Salinity (mg/L) in the Coxs River catchment - Sequential

Location	Node	OBSD	NUL	WS1-S	WS2a-S	WS2b-S
Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon						
Kangaroo Creek downstream of Angus Place LDP001	#011	612	53	784	667	662
		59	50	74	56	56
		784	53	804	803	803
Coxs River above Wangcol Creek/Blue Lagoon	#056	345	62	736	464	455
		36	50	70	57	57
		757	69	804	801	800
Sawyers Swamp Creek						
Sawyers Swamp Creek downstream of Springvale LDP009	#166	175	95	715	798	798
		117	79	79	155	155
		490	809	806	805	805
Lake Wallace						
Coxs River above Lake Wallace	#047	399	466	699	as per WS1-S	as per WS1-S
		73	144	152		
		762	741	795		
Lake Wallace	#074	519	280	523	as per WS1-S	as per WS1-S
		218	140	122		
		771	427	746		
Lake Lyell and above Lake Lyell						
Coxs River above Lake Lyell	#154 / #035	737	220	473	as per WS1-S	as per WS1-S
		168	65	108		
		1240	420	745		
Lake Lyell	#174	259	256	381	as per WS1-S	as per WS1-S
		59	155	163		
		634	366	534		
Thompsons Creek Reservoir						
Thompsons Creek Reservoir	#272	285	271	359	as per WS1-S	as per WS1-S
		184	238	272		
		436	321	468		
Lake Burragorang and above Lake Burragorang						
Coxs River above Lake Burragorang	#225	107	128	152	as per WS1-S	as per WS1-S
		74	52	53		
		302	249	443		
Lake Burragorang	#280	n/a	98	103	as per WS1-S	as per WS1-S
			87	89		
			102	109		

Table 4.11 : Summary of End of Pipe Target Daily Salinity (mg/L) in the Coxs River catchment - Concurrent

Location	Node	OBSD	NUL	WS2b	WS2b T350	WS2b T700	WS2b T800	WS2b T900
Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon								
Kangaroo Creek downstream of Angus Place LDP001	#011	612	53	662	203	387	448	509
		59	50	56	54	55	55	55
		784	53	803	238	464	539	615
Coxs River above Wangcol Creek/Blue Lagoon	#056	345	62	455	156	275	315	355
		36	50	57	52	54	55	56
		757	69	800	237	462	537	612
Sawyers Swamp Creek								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	175	95	798	233	466	532	599
		117	79	214	116	156	168	179
		490	809	805	584	653	684	714
Lake Wallace								
Coxs River above Lake Wallace	#047	399	466	706	292	469	518	567
		73	144	160	151	155	157	158
		762	741	794	431	562	601	643
Lake Wallace	#074	519	280	540	257	377	411	444
		218	140	121	138	131	129	127
		771	427	732	408	486	535	585
Lake Lyell and above Lake Lyell								
Coxs River above Lake Lyell	#154 / #035	737	220	490	239	346	376	405
		168	65	108	106	112	113	112
		1240	420	731	421	485	535	584
Lake Lyell	#174	259	256	398	255	312	330	347
		59	155	164	155	159	160	161
		634	366	538	366	385	415	446
Thompsons Creek Reservoir								
Thompsons Creek Reservoir	#272	285	271	377	267	311	319	332
		184	238	272	236	258	261	264
		436	321	473	321	365	386	407
Lake Burragorang and above Lake Burragorang								
Coxs River above Lake Burragorang	#225	107	128	156	136	144	147	149
		74	52	53	53	53	53	53
		302	249	468	250	340	366	392
Lake Burragorang	#280	n/a	98	104	100	102	102	102
			87	89	88	88	89	89
			102	112	104	107	108	109

Table 4.12 : Summary of End of Pipe Target Daily Salinity (mg/L) in the Coxs River catchment - Sequential

Location	Node	OBSD	NUL	WS2b-S	WS2b-S T350	WS2b-S T700	WS2b-S T800	WS2b-S T900
Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon								
Kangaroo Creek downstream of Angus Place LDP001	#011	612	53	662	203	387	448	509
		59	50	56	54	55	55	55
		784	53	803	238	464	539	615
Coxs River above Wangcol Creek/Blue Lagoon	#056	345	62	455	156	275	316	355
		36	50	57	42	54	55	56
		757	69	800	237	462	537	612
Sawyers Swamp Creek								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	175	95	798	233	466	532	598
		117	79	155	104	125	131	137
		490	809	805	586	656	685	714
Lake Wallace								
Coxs River above Lake Wallace	#047	399	466	699	296	469	516	564
		73	144	152	151	155	157	158
		762	741	795	431	563	602	642
Lake Wallace	#074	519	280	523	258	370	402	432
		218	140	122	138	131	130	128
		771	427	746	408	488	540	592
Lake Lyell and above Lake Lyell								
Coxs River above Lake Lyell	#154 / #035	737	220	473	239	338	365	392
		168	65	108	106	111	113	112
		1240	420	745	422	487	539	591
Lake Lyell	#174	259	256	381	255	305	321	337
		59	155	163	155	159	160	161
		634	366	534	366	390	419	448
Thompsons Creek Reservoir								
Thompsons Creek Reservoir	#272	285	271	359	267	307	317	321
		184	238	272	235	258	261	264
		436	321	468	321	363	384	405
Lake Burragorang and above Lake Burragorang								
Coxs River above Lake Burragorang	#225	107	128	152	135	142	144	146
		74	52	53	53	53	53	53
		302	249	443	250	329	352	375
Lake Burragorang	#280	n/a	98	103	99	101	101	102
			87	89	88	88	88	89
			102	109	103	106	107	107

Table 4.13 : Summary of Treatment Option Daily Salinity (mg/L) in the Coxs River catchment - Concurrent

Location	Node	OBSD	NUL	CLR	WS2b	WS2b with CLR	WS2b with RO6	WS2b with CLR and RO6
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	612 59 784	53 50 53	53 50 53	662 56 803	662 56 803	662 56 803	662 56 803
Coxs River above Wangcol Creek/Blue Lagoon	#056	345 36 757	62 50 69	62 50 69	455 57 800	455 57 800	455 57 800	455 57 800
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	175 117 490	95 79 809	266 114 644	798 214 805	595 220 702	630 52 733	490 194 645
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	399 73 762	466 144 741	343 146 518	706 160 794	576 160 652	603 156 700	498 158 583
Lake Wallace	#074	519 218 771	280 140 427	276 139 408	540 121 732	483 120 619	470 126 640	427 125 552
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154 / #035	737 168 1240	220 65 420	249 105 395	490 108 731	449 108 617	428 111 637	399 111 550
Lake Lyell	#174	259 59 634	256 155 366	261 155 366	398 164 538	385 164 506	362 161 483	352 162 459
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir	#272	285 184 436	271 238 321	273 242 321	377 272 473	368 273 452	347 266 435	341 266 418
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	107 74 302	128 52 249	133 52 257	156 53 468	165 56 456	151 53 422	159 55 414
Lake Burragorang	#280	n/a 102	98 87 102	99 87 103	104 89 112	105 90 114	103 89 111	104 89 112

Table 4.14 : Summary of Treatment Option Daily Salinity (mg/L) in the Coxs River catchment - Sequential

Location	Node	OBSD	NUL	CLR	WS2b-S	WS2b-S with CLR	WS2b-S with RO6	WS2b-S with CLR and RO6
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	612 59 784	53 50 53	53 50 53	662 56 803	662 56 803	662 56 803	662 56 803
Coxs River above Wangcol Creek/Blue Lagoon	#056	345 36 757	62 50 69	62 50 69	455 57 800	455 57 800	455 57 800	455 57 800
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	175 117 490	95 79 809	266 114 644	798 155 805	597 169 701	638 122 733	502 140 644
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	399 73 762	466 144 741	343 146 518	699 152 795	573 154 647	592 148 681	500 150 578
Lake Wallace	#074	519 218 771	280 140 427	276 139 408	523 122 746	471 121 608	455 126 638	417 125 532
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154 / #035	737 168 1240	220 65 420	249 105 395	473 108 745	436 108 607	412 111 636	387 111 531
Lake Lyell	#174	259 59 634	256 155 366	261 155 366	381 163 534	370 163 489	347 161 471	340 161 437
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir	#272	285 184 436	271 238 321	273 242 321	359 272 468	351 272 444	329 265 419	326 266 402
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	107 74 302	128 52 249	133 52 257	152 53 443	161 55 437	147 53 395	155 54 393
Lake Burragorang	#280	n/a 102	98 87 102	99 87 103	103 89 109	104 90 111	102 89 108	103 89 110

Table 4.15 : Summary of End of Pipe Target with Clarence Daily Salinity (mg/L) in the Coxs River catchment - Concurrent

Location	Node	OBSD	NUL	WS2b	WS2b_ T350 with CLR	WS2b_ T700 with CLR	WS2b_ T800 with CLR	WS2b_ T900 with CLR
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	612 59 784	53 50 53	662 56 803	203 54 238	387 55 464	448 55 539	509 55 615
Coxs River above Wangcol Creek/Blue Lagoon	#056	345 36 757	62 50 69	455 57 800	156 52 237	275 54 462	315 55 537	355 56 612
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	175 117 490	95 79 809	798 214 805	234 129 547	467 191 619	534 209 656	583 220 692
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	399 73 762	466 144 741	706 160 794	276 147 394	469 157 541	524 159 587	566 160 633
Lake Wallace	#074	519 218 771	280 140 427	540 121 732	252 138 408	398 127 490	437 125 547	471 122 585
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154 / #035	737 168 1240	220 65 420	490 108 731	239 108 424	371 112 489	408 110 546	438 108 583
Lake Lyell	#174	259 59 634	256 155 366	398 164 538	254 155 366	335 160 409	358 162 446	378 164 485
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir	#272	285 184 436	271 238 321	377 272 473	266 236 321	322 263 390	342 267 420	360 271 439
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	107 74 302	128 52 249	156 53 468	141 53 253	155 53 371	160 55 399	163 53 433
Lake Burragorang	#280	n/a 102	98 87 102	104 89 112	100 88 105	103 89 110	104 89 112	105 89 113

Table 4.16 : Summary of End of Pipe Target with Clarence Daily Salinity (mg/L) in the Coxs River catchment - Sequential

Location	Node	OBSD	NUL	WS2b-S	WS2b-S_ T350 with CLR	WS2b-S_ T700 with CLR	WS2b-S_ T800 with CLR	WS2b-S_ T900 with CLR
<i>Kangaroo Creek and Coxs River above Wangcol Creek/Blue Lagoon</i>								
Kangaroo Creek downstream of Angus Place LDP001	#011	612 59 784	53 50 53	662 56 803	203 54 238	387 55 464	448 55 539	509 55 615
Coxs River above Wangcol Creek/Blue Lagoon	#056	345 36 757	62 50 69	455 57 800	156 52 237	276 54 462	316 55 537	355 56 612
<i>Sawyers Swamp Creek</i>								
Sawyers Swamp Creek downstream of Springvale LDP009	#166	175 117 490	95 79 809	798 155 805	234 120 548	467 167 620	533 169 656	595 169 693
<i>Lake Wallace</i>								
Coxs River above Lake Wallace	#047	399 73 762	466 144 741	699 152 795	278 146 392	469 153 542	519 153 587	565 154 633
Lake Wallace	#074	519 218 771	280 140 427	523 122 746	253 138 408	393 128 489	429 125 547	463 122 601
<i>Lake Lyell and above Lake Lyell</i>								
Coxs River above Lake Lyell	#154 / #035	737 168 1240	220 65 420	473 108 745	239 108 424	366 112 489	399 111 547	428 108 601
Lake Lyell	#174	259 59 634	256 155 366	381 163 534	254 155 366	329 161 412	351 162 451	367 164 484
<i>Thompsons Creek Reservoir</i>								
Thompsons Creek Reservoir	#272	285 184 436	271 238 321	359 272 468	266 235 321	319 263 389	333 267 418	347 271 440
<i>Lake Burragorang and above Lake Burragorang</i>								
Coxs River above Lake Burragorang	#225	107 74 302	128 52 249	152 53 443	140 53 259	153 53 362	156 54 405	160 53 420
Lake Burragorang	#280	n/a 102	98 87 102	103 89 109	100 88 105	103 89 109	103 89 110	104 89 111

5. References

Jacobs, 2014. *Hydrological Advice to Response to Submissions*. Reference No. IA060400/003c, dated 19 December 2014.

NSW EPA, 2014. *Letter to Department of Planning and Environment*. Reference No. DOC14/257524, dated 4 November 2014.

RPS, 2014a. *Regional Water Quality Impact Assessment – Angus Place and Springvale Mine Extension Projects*. Reference No. S187E/021b, dated 10 September 2014.

RPS, 2014b. *Angus Place Mine Extension Project – Surface Water Impact Assessment*. Reference No. S187D/021c, dated 9 February 2014.

RPS, 2014c. *Springvale Mine Extension Project – Surface Water Impact Assessment*. Reference No. S188E/057c, dated 9 February 2014.

Sydney Catchment Authority, 2014. *Angus Place Mine Project (SSD-5602) and Springvale Mine Extension Project (SSD-5594)*. Reference No. D2014/112207, dated 12 November 2014.

Water NSW Act 2014 No. 74. Current version 2 January 2015, accessed 9 March 2015.