BMT WBM

North-East Business Park and Trask Development Corporation Water Quality Assessment

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Contents

North-East Business Park and Trask Development Corporation Water Quality Assessment

Prepared for:	Moreton Bay Regional Council
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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1 NEBP Numerical WQ Modelling

1.1 Methodology

To enable the potential water quality impacts associated with the operation of the NEBP Marina to be estimated, an assessment was undertaken using a combination of contemporary mathematical water quality modelling techniques. Two modelling suites were developed and coupled to enable the *in-situ* Marina water quality assessment and receiving water quality impact assessment to be undertaken as shown in Figure 1-1.

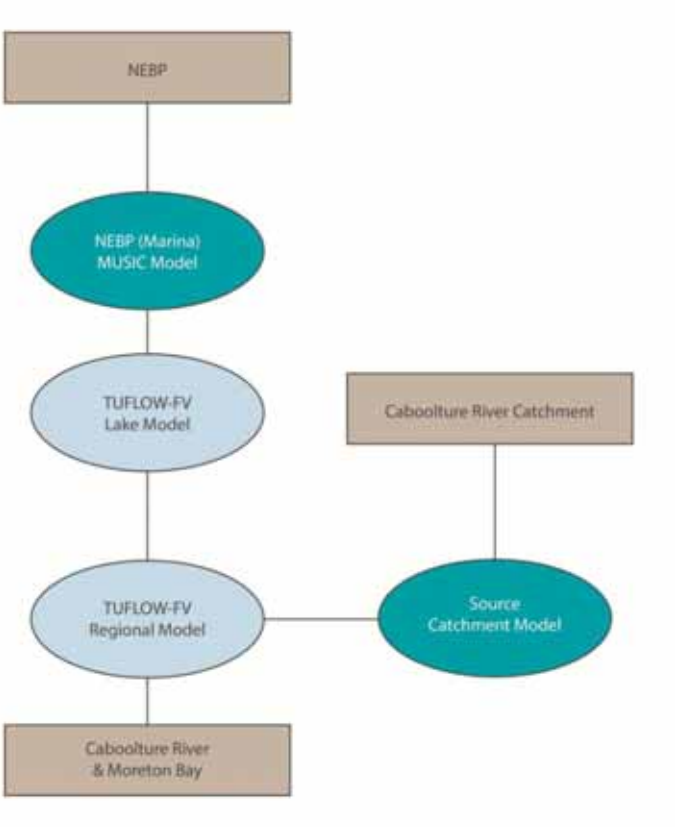


Figure 1-1 Integrated Modelling Conceptual Diagram

The first of these modelling suites are pollutant load based and encompassed a regional Source catchment model of the Caboolture River and a local NEBP (i.e. Marina) MUSIC model. The Source catchment model was previously developed by BMT WBM (refer to BMT WBM, 2014) to define the quantum of pollutant loads that will result from the regional catchment to the Caboolture River. A local MUSIC model was developed for the subsequent *in-situ* Marina water quality assessment and the receiving water quality impact assessment of the development area.

The pollutant load based models (i.e. Source & MUSIC) were subsequently used to inform the second suite of TUFLOW-FV hydrodynamic water quality models for impact assessment purposes. TUFLOW FV is a fully three-dimensional (3D) finite volume hydraulic, advection dispersion and water quality model.

These modelling techniques have been supported and informed by the existing and calibrated Source catchment and the Caboolture Receiving Water Quality Model (RWQM) developed by BMT WBM for Healthy Water Ways as described in BMT WBM (2014).

1.2 MUSIC Model

The eWater software modelling package MUSIC version 5.1 (Build 16) was used to assess local catchment flows and pollutant loads from the proposed Marina development. Meteorological data (both rainfall and potential evapotranspiration) was sourced from the Bureau of Meteorology (BOM) Station Dayboro Post Office (BOM Station No. 40063).

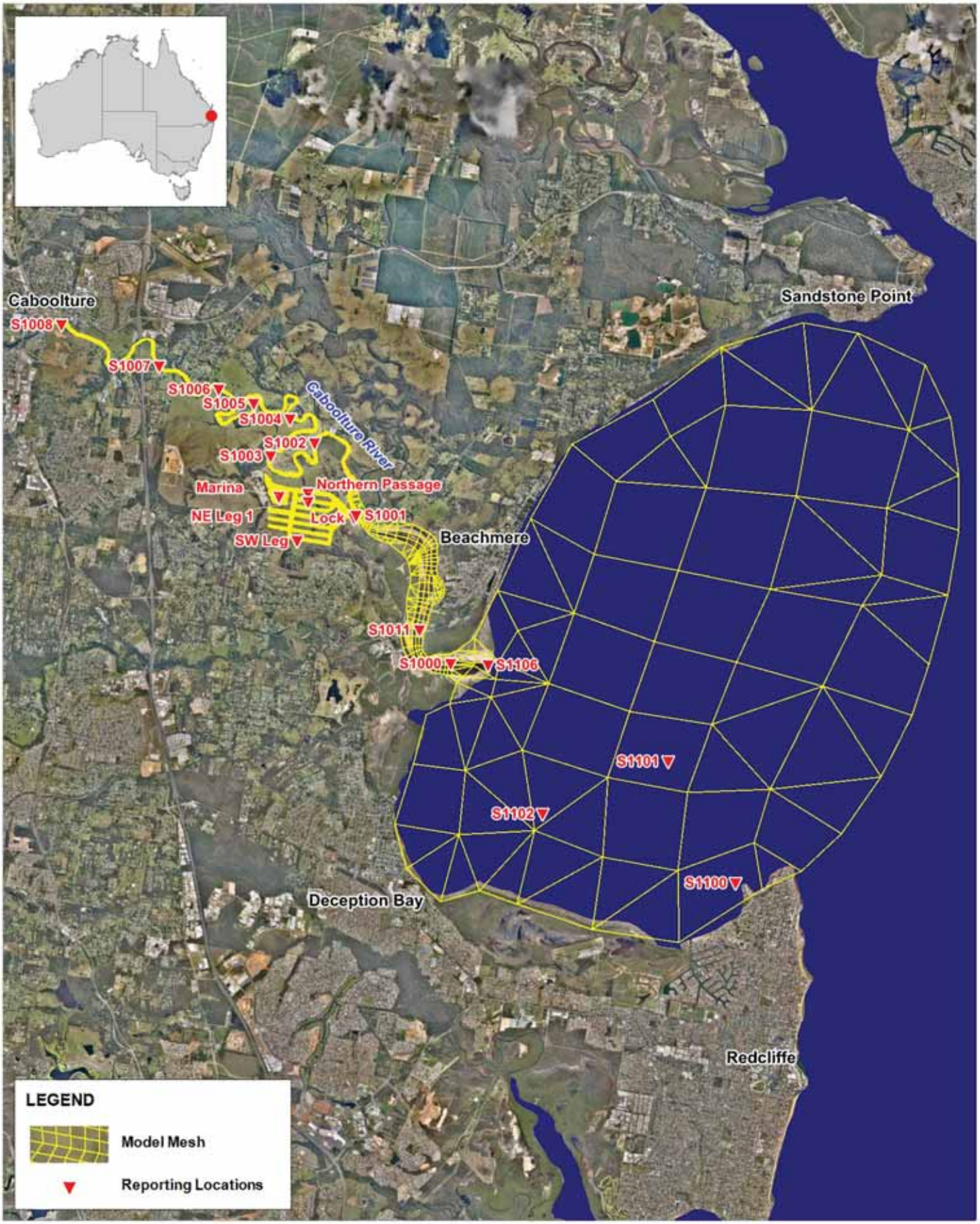
This climate station is located approximately 20km southwest of the site. The model was run using daily data for use as a boundary condition with the TUFLOW-FV water quality model and was also simulated for the same 2 year period from 1 June 2006 to 1 July 2008 to assess the typical loads and reductions.

1.3 TUFLOW-FV Model (Marina & Regional)

1.3.1 General

TUFLOW FV was used to develop the NEBP Marina Model and was integrated with the existing Caboolture River RWQM. The layout of the TUFLOW-FV RWQM is illustrated in Figure 1-2 with the reporting points shown which coincide with the Healthy Waterways Ecosystem Health Monitoring Program (EHMP) locations.

The layout and bathymetry of Marina model was based upon the Digital Elevation Model (DEM) provided by Cardno. The model was used in both AD and full water quality mode to simulate a range of relevant biophysical processes and issues such as stratification, flushing time and the implication of these and other processes such as catchment inflow to be assessed.



Title:

Model Mesh and Reporting Locations

Figure:	Rev:
1-2	A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx.Scale

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1.3.2 Marina Model Application

The Marina water quality model sits as shown in Figure 1-3 as a 'sub' model within the wider 'far field' RWQM (refer to Figure 1-2) encompassing all of Caboolture River and Moreton Bay areas.

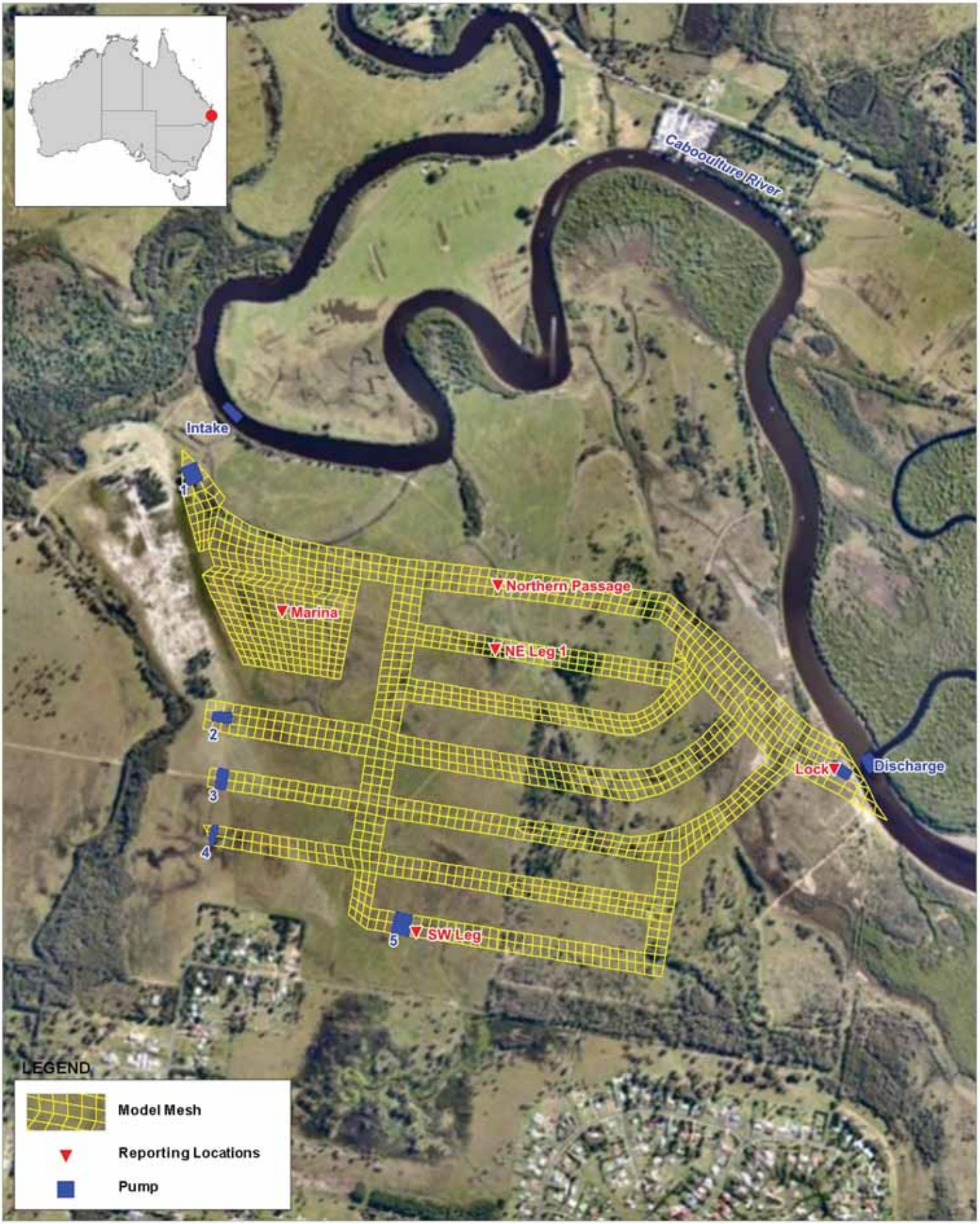
The Marina was forced with the following key datasets, where appropriate:

- local wind speed and direction data, expressed as spatially gridded time series data across the model surfaces;
- relevant meteorological data e.g. temperature; and
- inflow/outflow time series of the proposed Marina pumping/flushing regime;
    - Intake flow rate on the ebb tide of 2.25m^3/s, varying +10% (i.e. 2.48m^3/s) as required to control Marina levels from the impacts of rainfall and evaporation. This rate will provide 24 day turnover.
    - Discharge flow rate also on the ebb tide of 2.25m^3/s varying up to 3.3m^3/s to manage impacts of rainfall events.
- The intake is distributed over 5 locations as shown in Figure 1-3. The intake is split into 5 inlets as follows:
    1. Inlet 1 – 0.75 m^3/s
    2. Inlet 2 – 0.3 m^3/s
    3. Inlet 3 – 0.3 m^3/s
    4. Inlet 4 – 0.55 m^3/s
    5. Inlet 5 – 0.35 m^3/s
- runoff (with best practice stormwater treatment) to the Marina was based on the MUSIC model of the Marina catchment and also rainfall falling directly onto the Marina water surface;
- Simulation period from June 2006 to July 2008 to encompass a typical 'dry' and 'wet ' period as follows:
    - Dry - July 06 to July 07
    - Wet - July 07 to July 08

The following representative water quality constituents have been simulated in the integrated model as these are the most significant parameters of interest:

- Salinity;
- Turbidity;
- Total nitrogen;
- Total phosphorus;
- Chlorophyll *a*; and
- Dissolved Oxygen.

For all relevant parameters, tabulated annual water quality percentiles are presented as well as figures depicting time-series results of the model simulations where appropriate.



Title:

Model Mesh and Reporting Locations - Marina

Figure:	Rev:
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2 Marina Water Quality Characteristics

2.1 Overview

Results for the Marina water quality characteristics are presented in Figure 2-1 at the end of this section and results are discussed herein. The results are presented are depth average (i.e. no notable stratification occurred) for the 5 key reporting points.

2.2 Salinity

Based on the statistical analyses presented it is apparent that the Marina will remain saline throughout its operation (i.e. during wet and dry periods) with salinities varying from 13 PSU up to 31 PSU for the 10th percentile to 90th percentile. Median salinities throughout the Marina are generally expected to be about 25g/L.

For either the relatively 'dry' and 'wet' period assessed, the salinity in the Marina is not predicted to become either hyper-saline or stratified, primarily due to the regular flushing that occurs from the Caboolture River and the associated 24 day Marina turnover cycle. Whilst no salinity stratification is predicted by this modelling the use of submerged mixers could be considered as a mitigation measure to ensure complete mixing will always occur within the Marina.

The Caboolture River is expected to maintain generally high salinities (i.e. 20th percentile of 11 PSU and median of 21 PSU) at this intake point in the river (refer to Section 3.3.1).

2.3 Thermal

Temperature predictions for the Marina will typically vary between 15 ^{o}C to 26 ^{o}C. These temperatures correlate with that from the Caboolture River intake location (refer to Section 3.3.2).

No apparent vertical temperature differentials in the Marina are noted from the assessment. As previously mentioned however, the use of submerged mixers could be considered as a further mitigation measure to ensure complete mixing.

2.4 Turbidity

Turbidity is predicted to vary from 0.5 NTU to 6 NTU within the Marina for the 20th and 80th percentiles and up to 23NTU for the 90th percentile (i.e. not presented). Median turbidity levels are generally between 1.5 NTU to 3 NTU and are within the QWQG (2009) prescribed limits.

In comparison to the Caboolture River, the Marina will potentially be less turbid and typically half of the river level. A reduction in turbidity has primary occurred due to settling characteristics of the Marina.

2.5 Dissolved Oxygen

DO predictions within the Marina are predicted to vary between 77% saturation to 91% saturation for the 20th and 80th percentiles. The median DO level of 86% is within the Queensland Water Quality Guidelines (2009) for tidal canals.

Whilst not presented on the figure, the 10th percentile DO saturation can drop to to 70% which is still well above the 50% saturation required to maintain fish. As a result, the marina will typically remain well oxygenated.

2.6 Nutrients

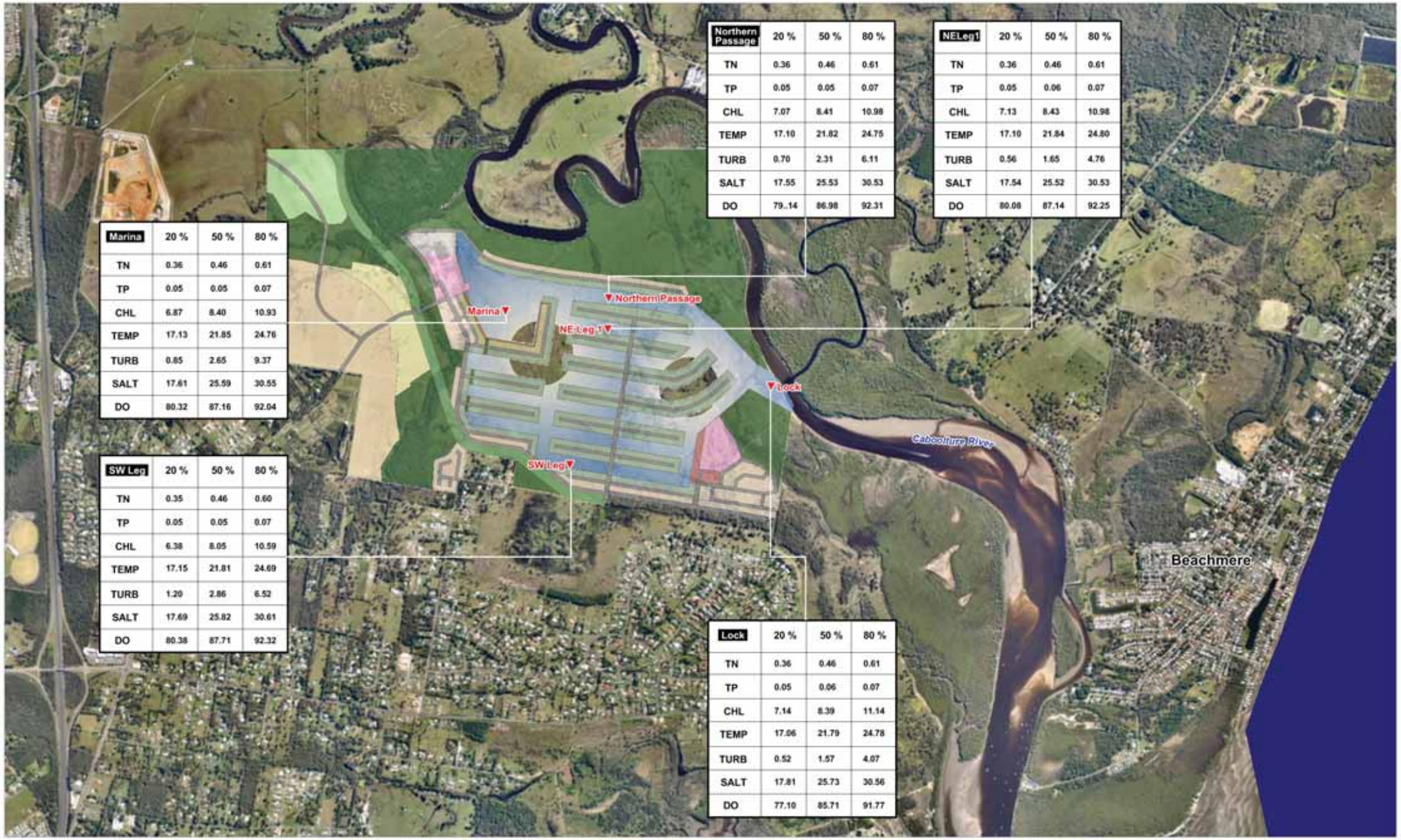
From the total nitrogen (TN) and total phosphorous (TP) results presented and based upon the statistical analysis median concentration are 460µg/L and 60µg/L respectively. The median concentration levels for TN and TP are typically above the QWQG (2009) of 300 µg/L and 25 µg/L and reflect the receiving environment of the Caboolture River.

TN level typically range from 360µg/L to 610µg/L for the 20th and 80th percentile values whilst TP will typically vary with range from 50µg/L to 70µg/L for the 20th and 80th percentile values. Again these concentration ranges are similar the Caboolture River but less than, due to settling in the Marina.

2.7 Chlorophyll a

Chlorophyll *a* predictions based upon the statistical analyses will typically vary between 6µg/L to 11µg/L (20th and 80th percnetiles respectively) with median levels at approximately 8µg/L. These levels are typically above the QWQG (2009) of 4 µg/L and again reflect the elevated levels in the Caboolture River and potential for *in-situ* growth within the Marina.

Further investigation will be undertaken to include the effects of the submerged mixing devices and aerators that have not been included in the modelling to date. These devices are expected to assist in reducing the predicted Chlorophyll a levels, particularly during the warmer months.



Northern Passage	20 %	50 %	80 %
TN	0.36	0.46	0.61
TP	0.05	0.05	0.07
CHL	7.07	8.41	10.98
TEMP	17.10	21.82	24.75
TURB	0.70	2.31	6.11
SALT	17.55	25.53	30.53
DO	79..14	86.98	92.31

NELeg1	20 %	50 %	80 %
TN	0.36	0.46	0.61
TP	0.05	0.06	0.07
CHL	7.13	8.43	10.98
TEMP	17.10	21.84	24.80
TURB	0.56	1.65	4.76
SALT	17.54	25.52	30.53
DO	80.08	87.14	92.25

Marina	20 %	50 %	80 %
TN	0.36	0.46	0.61
TP	0.05	0.05	0.07
CHL	6.87	8.40	10.93
TEMP	17.13	21.85	24.76
TURB	0.85	2.65	9.37
SALT	17.61	25.59	30.55
DO	80.32	87.16	92.04

SW Leg	20 %	50 %	80 %
TN	0.35	0.46	0.60
TP	0.05	0.05	0.07
CHL	6.38	8.05	10.59
TEMP	17.15	21.81	24.69
TURB	1.20	2.86	6.52
SALT	17.69	25.82	30.61
DO	80.38	87.71	92.32

Lock	20 %	50 %	80 %
TN	0.36	0.46	0.61
TP	0.05	0.06	0.07
CHL	7.14	8.39	11.14
TEMP	17.06	21.79	24.78
TURB	0.52	1.57	4.07
SALT	17.81	25.73	30.56
DO	77.10	85.71	91.77

LEGEND

▼ Reporting Locations

Title:

Marina Water Quality Characteristics

Figure: 2-1

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2.8 Flushing Time

A key performance metric for long-term Marina water quality is flushing or residence time. In order to determine how the Marina will flush, the Marina was dosed with a conservative tracer (i.e. 100%) at the beginning of the period and the response of the numerical tracer to pumped inflow and outflows was simulated. The flushing time at the various Marina locations was determined by using the 'e folding' method, that is determining when the concentration of a tracer reduces to a value of 1/e, or 37%, of its initial value.

Results are presented as time-series graph at the 7 key reporting points presented in Figure 2-2 whilst a 7 day time-series plan view snap shot is provided in Figure 2-3. The graphs and plan view shows that flushing times are 3 to 4 weeks. For most water quality parameters in a lacustrine system, a flushing time of this order typically indicates that water quality levels will be comparable with the source water supply of the Caboolture River.

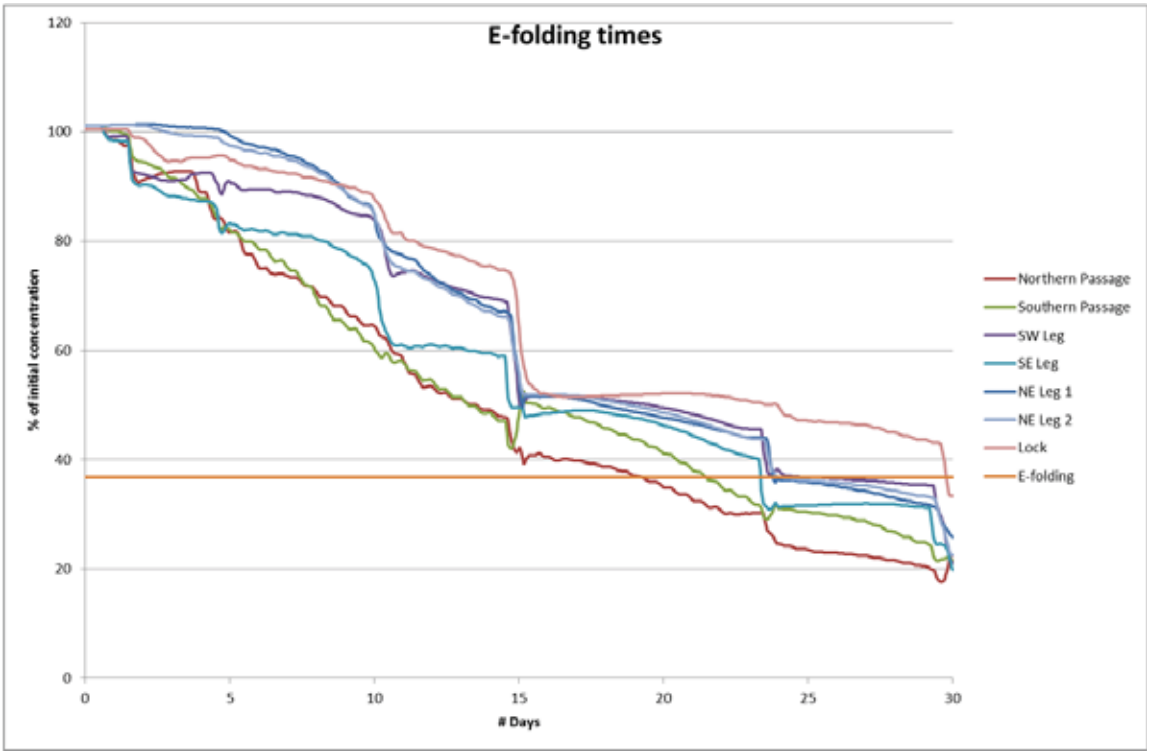


Figure 2-2 Marina Flushing Predictions

The use of bed mounted submersible mixing devices if considered necessary and installed at key locations in the Marina will further promote exchange, mixing and flushing and will reduce residence times further. The precise location and operational regimes of these fans, if considered necessary, will be determined at subsequent modelling and/or design phases.

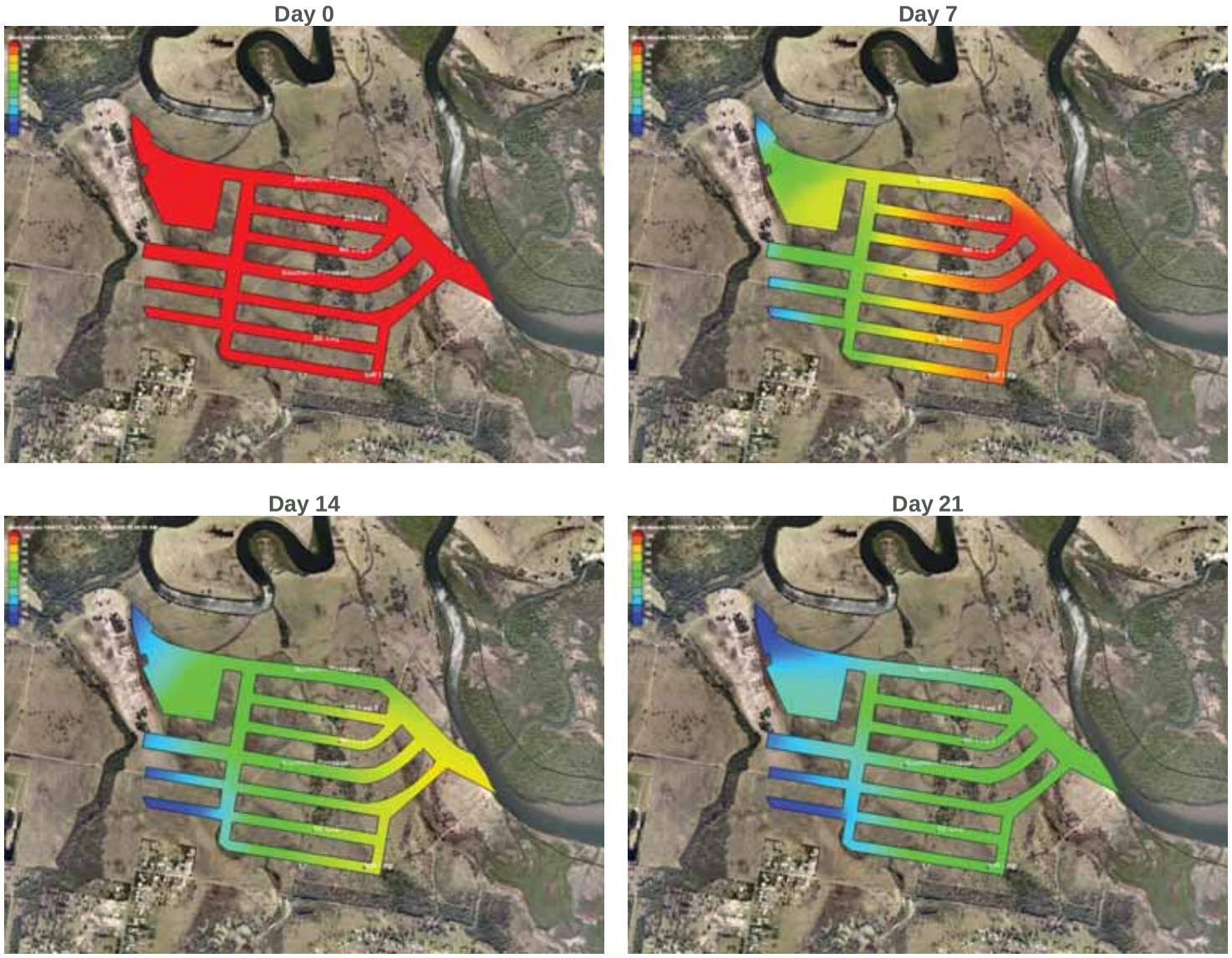


Figure 2-3 Marina Flushing Predictions - 7 Day Interval

3 Receiving Water Quality Impact Assessments

3.1 Overview

The Impact assessment for the Caboolture River (i.e. receiving environment) has been undertaken for the Load Based MUSIC Model and the TUFLOW-FV Marina / RWQM. With regard to the results presented this has consisted of:

- total loads from the catchment based model; and
- statistical analysis from the TUFLOW-FV model.

It should be noted that all results should be viewed in a comparative sense; that is, the results of the impacts assessed are reported as potential changes to ambient loads or concentrations, rather than explicit values, to assist in gauging the likely effects on existing water quality.

3.2 Load Based - MUSIC Model Impact Assessments

Rainfall-runoff and pollutant export characteristics to represent both the current and future developed conditions have been applied using Water by Design's (2010) "MUSIC Modelling Guidelines" and BMT WBM's (2009) "Course Notes: Modelling Rural Catchments using MUSIC".

For this assessment it has been assumed that the land uses on the Marina will be treated to meet the typical operational phase performance objectives. The load based results from the simulation period between June 2006 to July 2008 are presented in Table 3-1 with the assumed performance targets also presented.

Table 3-1 MUSIC Model Load Results

NEBP Catchment	TSS (Tonnes/yr)	TP (kg/yr)	TN (kg)
Development Site			
Existing	76	73	634
Developed Site with No Treatment	195	383	1604
Developed Site with Treatment	39	153	1042
Performance Targets	80	60	45

As noted above, achieving the prescribed operational performance objectives will need to be incorporated through sufficient water sensitive urban design (WSUD) mitigation devices and strategies to ensure pollutant loads are appropriately reduced.

3.3 Caboolture River RWQM Impact Assessment

Results for the receiving water quality impacts assessment of the Caboolture River are presented in Figure 3-1 to Figure 3-7 at the end of this section and the results are discussed herein. The results are presented as depth average and the statistical results are for the EHMP reporting locations.

3.3.1 Salinity

Presented in Figure 3-1 are the changes in modelled salinity predicted along Caboolture River and the Moreton Bay region. From the figure the following conclusions can be drawn:

- There is a general increase in median salinity level of up to 2 PSU at the discharge point with no notable change in salinity upstream from EHMP S1006 and downstream from EHMP S1001.
- At the mouth of the river and Moreton Bay there is no discernible salinity change.

Overall there is an increase in salinity in the Caboolture River but this change is limited to approximately 2 PSU.

3.3.2 Temperature

No discernible changes to temperature are predicted as a result of the proposed development. Al changes in temperature through all statistics assessed indicate changes less than 0.2^{o}C.

3.3.3 Dissolved Oxygen

Presented in Figure 3-2 are the changes in modelled DO predicted along Caboolture River and the Moreton Bay region. From the figure the following conclusions can be drawn:

- There is a no notable change in median DO levels at all reporting points.
- There is a no notable change in 20th to 80th percentile DO levels at all reporting points.

Overall the Marina will have no notable change to the DO level in the Caboolture River. The Caboolture River is typically well oxygen with median levels typically meeting the lower range of the QWQG (2009) limit of 80% saturation. .

3.3.4 Nutrients

Total nitrogen and total phosphorous concentrations are is Figure 3-5 and Figure 3-6 along Caboolture River and the Moreton Bay region. From the figures presented in the following specific conclusions can be drawn:

- A general decrease in median TN and TP of up to 40µg/L and 2µg/L respectively.
- No notable change in nutrient concentration at the mouth of the river or in Moreton Bay.

Overall there is limited change in nutrient concentrations in Caboolture River and Moreton Bay due to the proposed Marina. With WSUD measures integrated within the site, the Marina will typically reduce the release nutrients than the current existing site condition.

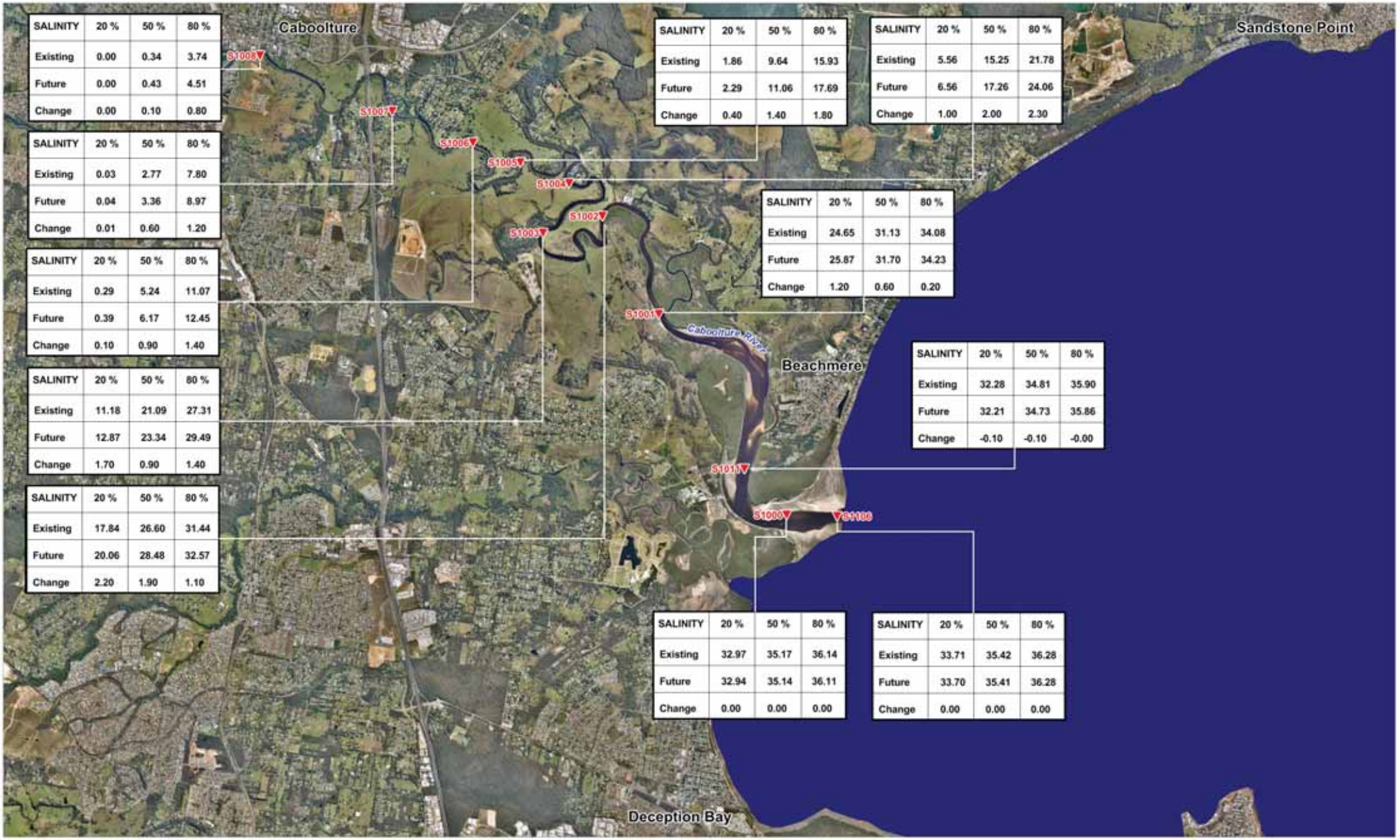
3.3.5 Chlorophyll a

Presented in Figure 3-7 are the changes in modelled DO predicted along Caboolture River and the Moreton Bay region. From the figures the following conclusions can be drawn:

- There is a slight decrease in median chlorophyll *a* level in the Caboolture River upstream of the discharge point of up to 0.3 µg/L
- There a slight increase in median chlorophyll *a* level in the Caboolture River downstream of the discharge point of up to 0.17 µg/L an no notable change at the Mouth and Moreton Bay region.

- An increase in the 20th percentile chlorophyll *a* level of up to 0.64 µg/L may occur in the Caboolture River upstream of the development, but again no notable change at the mouth or Moreton Bay region.
- Conversely, the 80th percentile chlorophyll *a* levels decrease by up to 1 µg/L in the Caboolture River when chlorophyll *a* levels are naturally higher.
- No notable change to chlorophyll *a* is predicted at the mouth or Moreton Bay region for all percentiles analysed. .

Overall there is limited change in chlorophyll *a* concentrations in Caboolture River and the Moreton Bay region due to the proposed resort.



SALINITY	20 %	50 %	80 %
Existing	0.00	0.34	3.74
Future	0.00	0.43	4.51
Change	0.00	0.10	0.80

SALINITY	20 %	50 %	80 %
Existing	0.03	2.77	7.80
Future	0.04	3.36	8.97
Change	0.01	0.60	1.20

SALINITY	20 %	50 %	80 %
Existing	0.29	5.24	11.07
Future	0.39	6.17	12.45
Change	0.10	0.90	1.40

SALINITY	20 %	50 %	80 %
Existing	11.18	21.09	27.31
Future	12.87	23.34	29.49
Change	1.70	0.90	1.40

SALINITY	20 %	50 %	80 %
Existing	17.84	26.60	31.44
Future	20.06	28.48	32.57
Change	2.20	1.90	1.10

SALINITY	20 %	50 %	80 %
Existing	1.86	9.64	15.93
Future	2.29	11.06	17.69
Change	0.40	1.40	1.80

SALINITY	20 %	50 %	80 %
Existing	5.56	15.25	21.78
Future	6.56	17.26	24.06
Change	1.00	2.00	2.30

SALINITY	20 %	50 %	80 %
Existing	24.65	31.13	34.08
Future	25.87	31.70	34.23
Change	1.20	0.60	0.20

SALINITY	20 %	50 %	80 %
Existing	32.28	34.81	35.90
Future	32.21	34.73	35.86
Change	-0.10	-0.10	-0.00

SALINITY	20 %	50 %	80 %
Existing	32.97	35.17	36.14
Future	32.94	35.14	36.11
Change	0.00	0.00	0.00

SALINITY	20 %	50 %	80 %
Existing	33.71	35.42	36.28
Future	33.70	35.41	36.28
Change	0.00	0.00	0.00

LEGEND

▼ Reporting Locations

Title:

Salinity (PSU) - Percentile (20% ,50% & 80 %)

Figure: 3-1

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Approx.Scale

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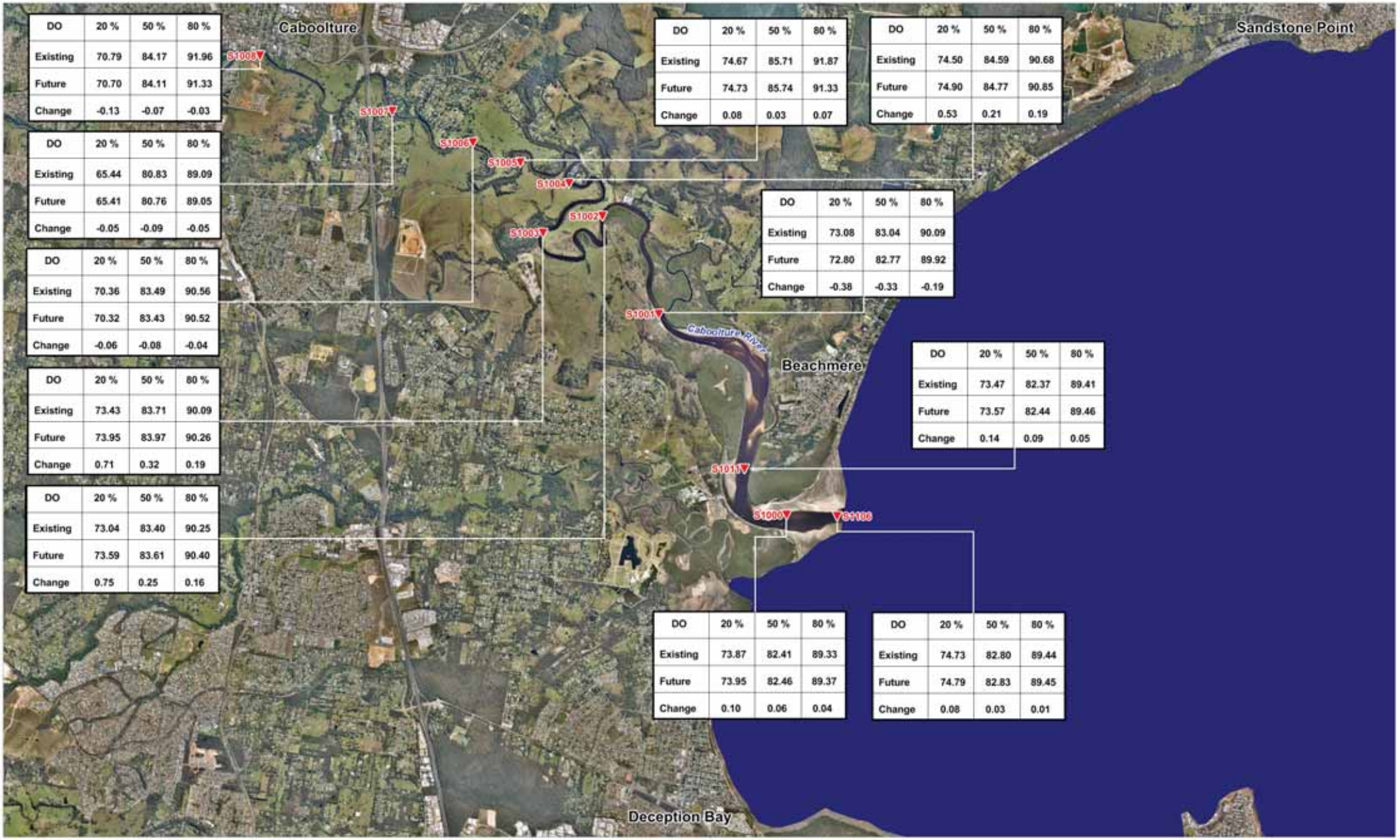

DO	20 %	50 %	80 %
Existing	70.79	84.17	91.96
Future	70.70	84.11	91.33
Change	-0.13	-0.07	-0.03

DO	20 %	50 %	80 %
Existing	74.67	85.71	91.87
Future	74.73	85.74	91.33
Change	0.08	0.03	0.07

DO	20 %	50 %	80 %
Existing	74.50	84.59	90.68
Future	74.90	84.77	90.85
Change	0.53	0.21	0.19

DO	20 %	50 %	80 %
Existing	65.44	80.83	89.09
Future	65.41	80.76	89.05
Change	-0.05	-0.09	-0.05

DO	20 %	50 %	80 %
Existing	73.08	83.04	90.09
Future	72.80	82.77	89.92
Change	-0.38	-0.33	-0.19

DO	20 %	50 %	80 %
Existing	70.36	83.49	90.56
Future	70.32	83.43	90.52
Change	-0.06	-0.08	-0.04

DO	20 %	50 %	80 %
Existing	73.47	82.37	89.41
Future	73.57	82.44	89.46
Change	0.14	0.09	0.05

DO	20 %	50 %	80 %
Existing	73.43	83.71	90.09
Future	73.95	83.97	90.26
Change	0.71	0.32	0.19

DO	20 %	50 %	80 %
Existing	73.04	83.40	90.25
Future	73.59	83.61	90.40
Change	0.75	0.25	0.16

DO	20 %	50 %	80 %
Existing	73.87	82.41	89.33
Future	73.95	82.46	89.37
Change	0.10	0.06	0.04

DO	20 %	50 %	80 %
Existing	74.73	82.80	89.44
Future	74.79	82.83	89.45
Change	0.08	0.03	0.01

LEGEND

▼ Reporting Locations

Title:

Dissolved Oxygen (%)

Figure: 3-2

Rev: A

N

0 1 2km

Approx.Scale

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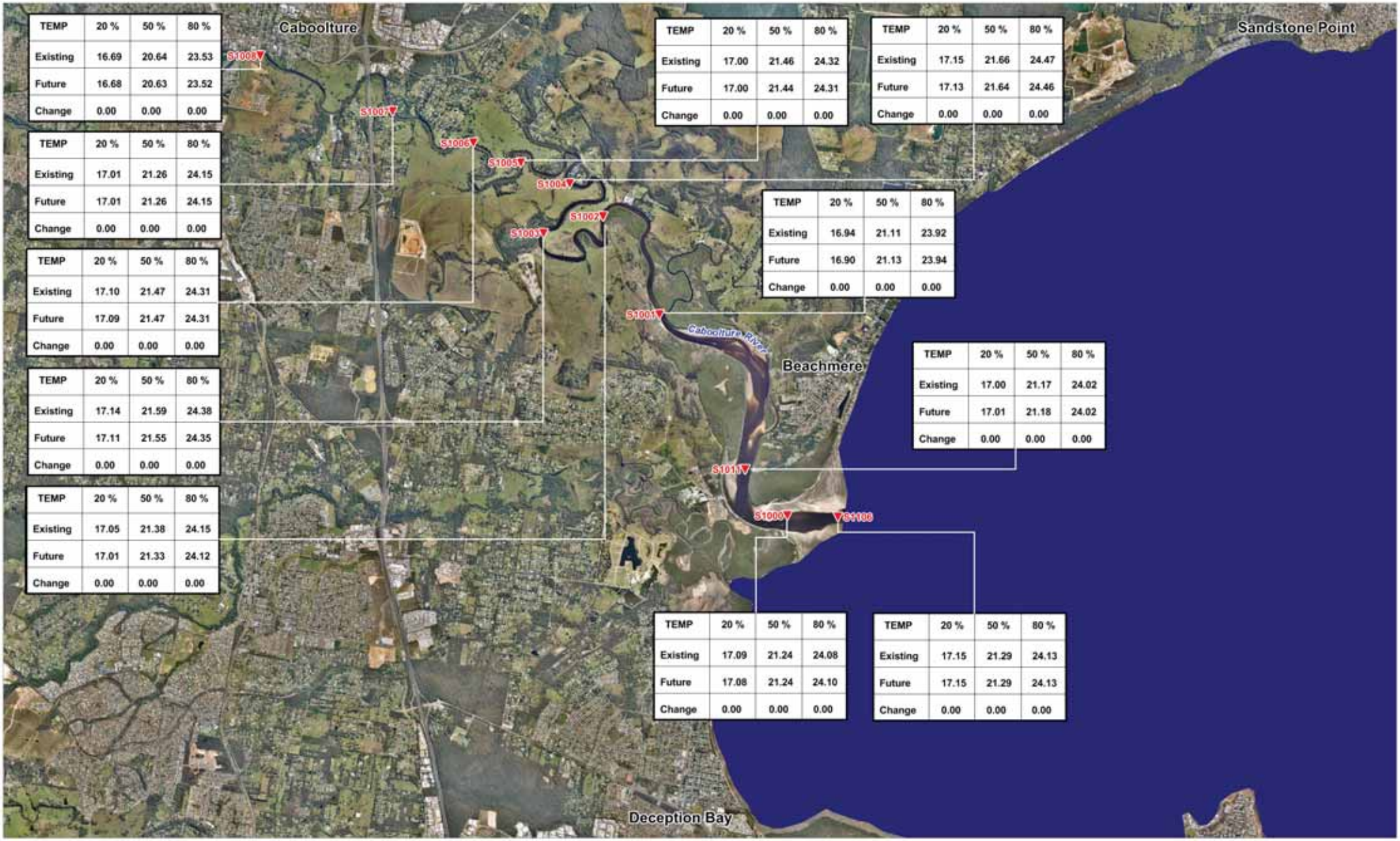


TEMP	20 %	50 %	80 %
Existing	16.69	20.64	23.53
Future	16.68	20.63	23.52
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	17.01	21.26	24.15
Future	17.01	21.26	24.15
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	17.10	21.47	24.31
Future	17.09	21.47	24.31
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	17.14	21.59	24.38
Future	17.11	21.55	24.35
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	17.05	21.38	24.15
Future	17.01	21.33	24.12
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	17.00	21.46	24.32
Future	17.00	21.44	24.31
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	17.15	21.66	24.47
Future	17.13	21.64	24.46
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	16.94	21.11	23.92
Future	16.90	21.13	23.94
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	17.00	21.17	24.02
Future	17.01	21.18	24.02
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	17.09	21.24	24.08
Future	17.08	21.24	24.10
Change	0.00	0.00	0.00

TEMP	20 %	50 %	80 %
Existing	17.15	21.29	24.13
Future	17.15	21.29	24.13
Change	0.00	0.00	0.00

LEGEND

▼ Reporting Locations

Title:
Temperature (°C)

Figure: 3-3

Rev: A

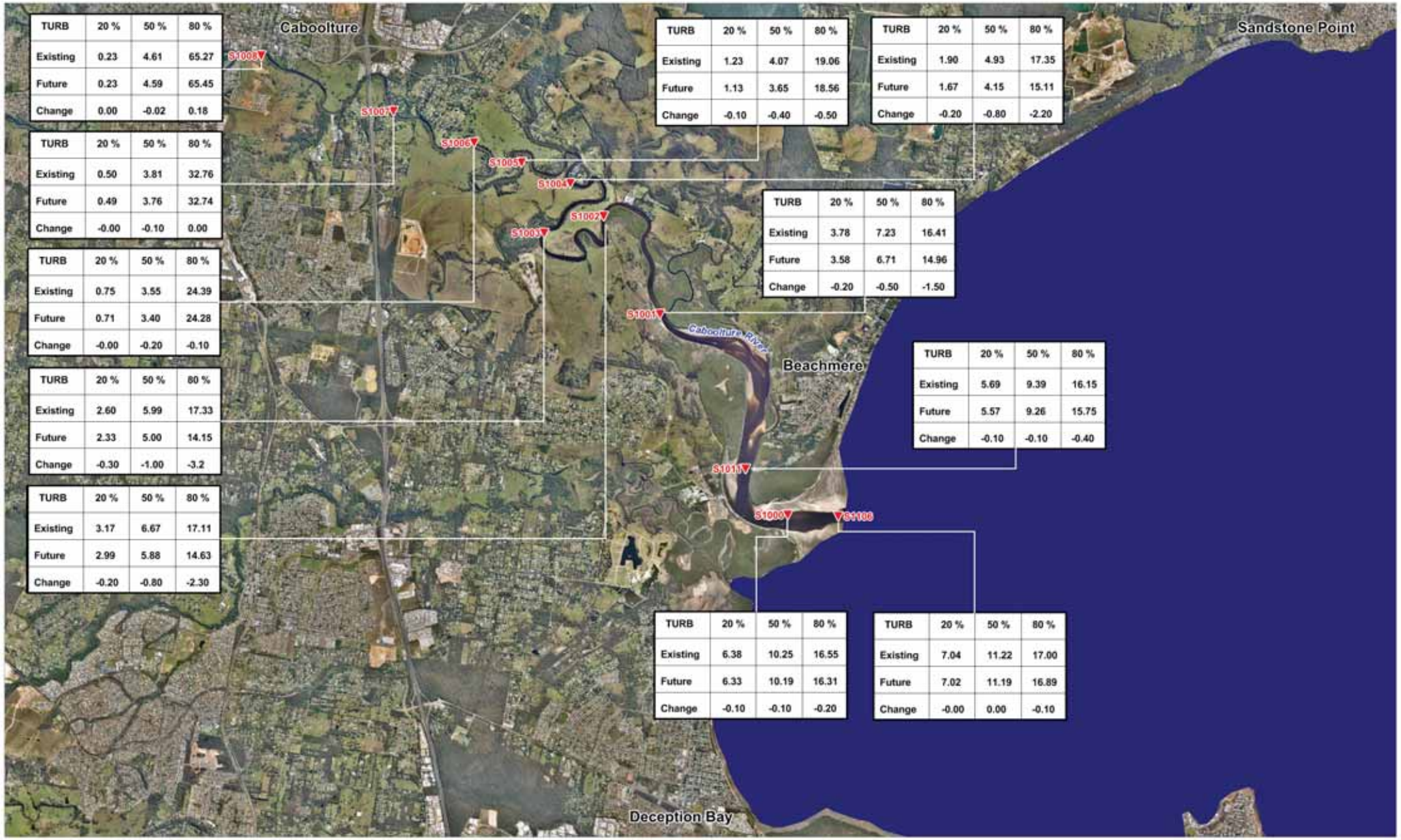
N

0 1 2km

Approx.Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B20670_I_nc_NEBP\ORG\GIS_010_TEMP_Reporting Locations.wor



TURB	20 %	50 %	80 %
Existing	0.23	4.61	65.27
Future	0.23	4.59	65.45
Change	0.00	-0.02	0.18

TURB	20 %	50 %	80 %
Existing	0.50	3.81	32.76
Future	0.49	3.76	32.74
Change	-0.00	-0.10	0.00

TURB	20 %	50 %	80 %
Existing	0.75	3.55	24.39
Future	0.71	3.40	24.28
Change	-0.00	-0.20	-0.10

TURB	20 %	50 %	80 %
Existing	2.60	5.99	17.33
Future	2.33	5.00	14.15
Change	-0.30	-1.00	-3.2

TURB	20 %	50 %	80 %
Existing	3.17	6.67	17.11
Future	2.99	5.88	14.63
Change	-0.20	-0.80	-2.30

TURB	20 %	50 %	80 %
Existing	1.23	4.07	19.06
Future	1.13	3.65	18.56
Change	-0.10	-0.40	-0.50

TURB	20 %	50 %	80 %
Existing	1.90	4.93	17.35
Future	1.67	4.15	15.11
Change	-0.20	-0.80	-2.20

TURB	20 %	50 %	80 %
Existing	3.78	7.23	16.41
Future	3.58	6.71	14.96
Change	-0.20	-0.50	-1.50

TURB	20 %	50 %	80 %
Existing	5.69	9.39	16.15
Future	5.57	9.26	15.75
Change	-0.10	-0.10	-0.40

TURB	20 %	50 %	80 %
Existing	6.38	10.25	16.55
Future	6.33	10.19	16.31
Change	-0.10	-0.10	-0.20

TURB	20 %	50 %	80 %
Existing	7.04	11.22	17.00
Future	7.02	11.19	16.89
Change	-0.00	0.00	-0.10

LEGEND

▼ Reporting Locations

Title:
Turbidity (ntu)

Figure: 3-4

Rev: A

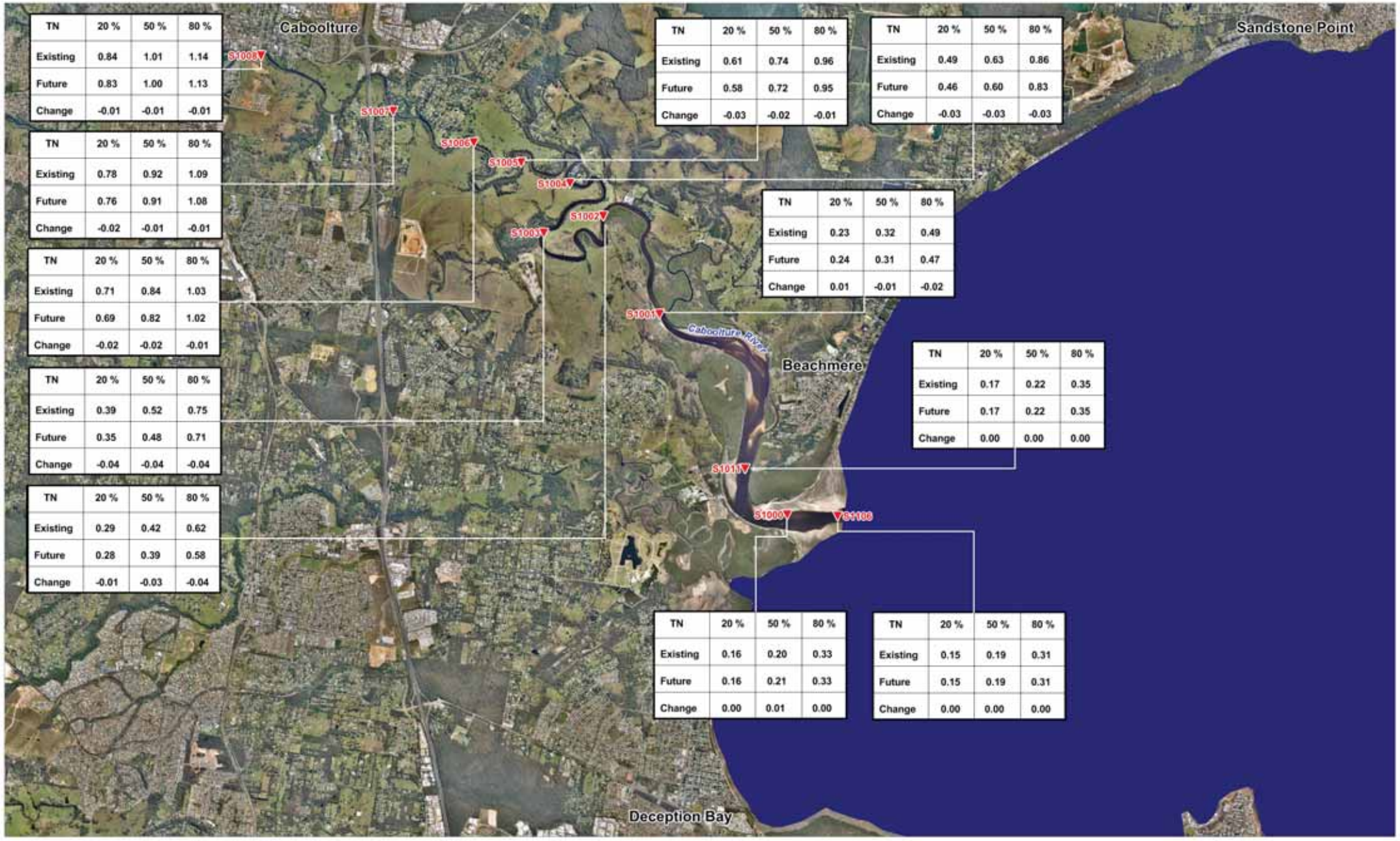
N

0 1 2km

Approx.Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B20670_I_nc_NEBP\ORG\GIS_011_TURB_Reporting Locations.wor



TN	20 %	50 %	80 %
Existing	0.84	1.01	1.14
Future	0.83	1.00	1.13
Change	-0.01	-0.01	-0.01

TN	20 %	50 %	80 %
Existing	0.78	0.92	1.09
Future	0.76	0.91	1.08
Change	-0.02	-0.01	-0.01

TN	20 %	50 %	80 %
Existing	0.71	0.84	1.03
Future	0.69	0.82	1.02
Change	-0.02	-0.02	-0.01

TN	20 %	50 %	80 %
Existing	0.39	0.52	0.75
Future	0.35	0.48	0.71
Change	-0.04	-0.04	-0.04

TN	20 %	50 %	80 %
Existing	0.29	0.42	0.62
Future	0.28	0.39	0.58
Change	-0.01	-0.03	-0.04

TN	20 %	50 %	80 %
Existing	0.61	0.74	0.96
Future	0.58	0.72	0.95
Change	-0.03	-0.02	-0.01

TN	20 %	50 %	80 %
Existing	0.49	0.63	0.86
Future	0.46	0.60	0.83
Change	-0.03	-0.03	-0.03

TN	20 %	50 %	80 %
Existing	0.23	0.32	0.49
Future	0.24	0.31	0.47
Change	0.01	-0.01	-0.02

TN	20 %	50 %	80 %
Existing	0.17	0.22	0.35
Future	0.17	0.22	0.35
Change	0.00	0.00	0.00

TN	20 %	50 %	80 %
Existing	0.16	0.20	0.33
Future	0.16	0.21	0.33
Change	0.00	0.01	0.00

TN	20 %	50 %	80 %
Existing	0.15	0.19	0.31
Future	0.15	0.19	0.31
Change	0.00	0.00	0.00

LEGEND

▼ Reporting Locations

Title:
Total Nitrogen (mg/L)

Figure: 3-5

Rev: A

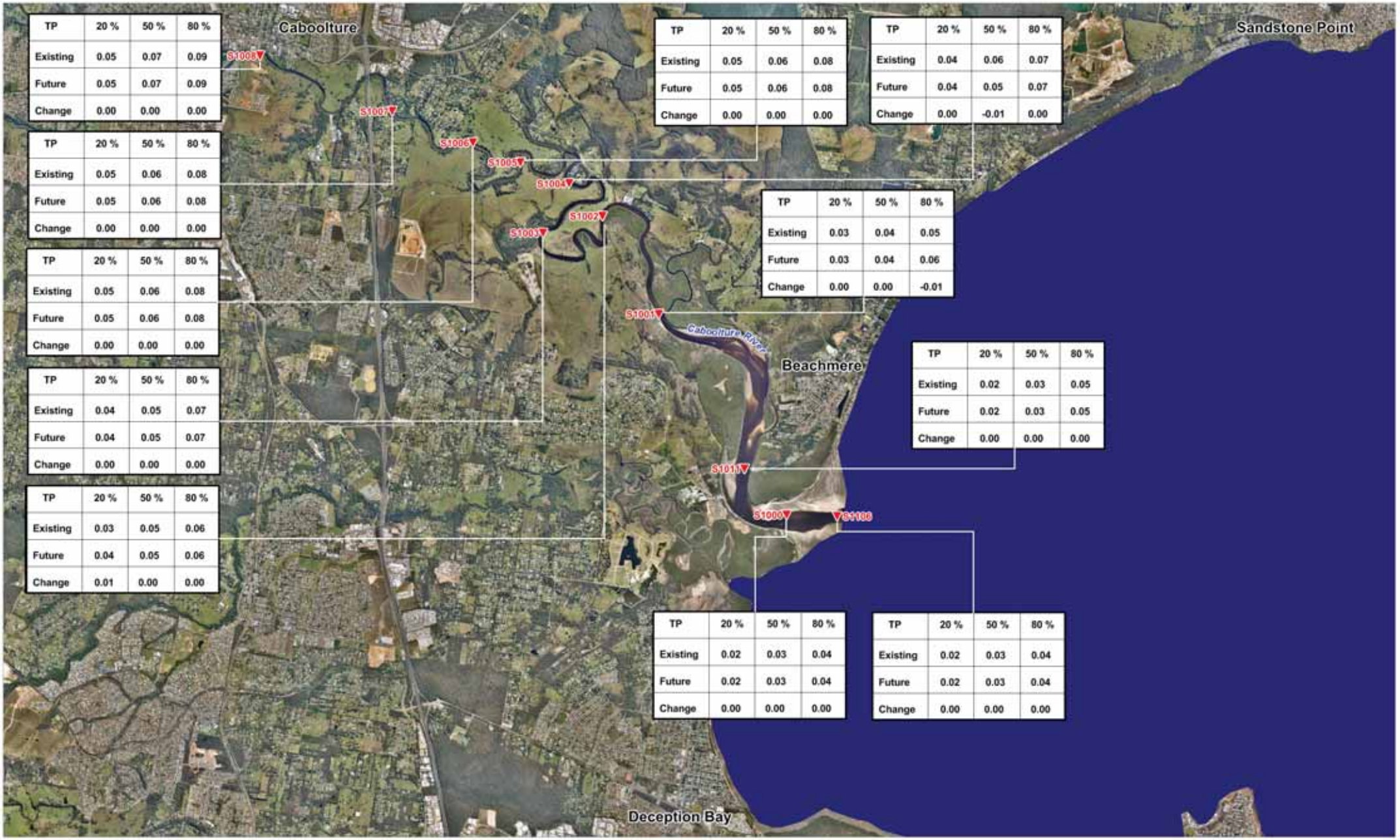
N

0 1 2km

Approx.Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B20670_I_nc_NEBP\ORG\GIS_007_TN_Reporting Locations.wor



TP	20 %	50 %	80 %
Existing	0.05	0.07	0.09
Future	0.05	0.07	0.09
Change	0.00	0.00	0.00

TP	20 %	50 %	80 %
Existing	0.05	0.06	0.08
Future	0.05	0.06	0.08
Change	0.00	0.00	0.00

TP	20 %	50 %	80 %
Existing	0.05	0.06	0.08
Future	0.05	0.06	0.08
Change	0.00	0.00	0.00

TP	20 %	50 %	80 %
Existing	0.04	0.05	0.07
Future	0.04	0.05	0.07
Change	0.00	0.00	0.00

TP	20 %	50 %	80 %
Existing	0.03	0.05	0.06
Future	0.04	0.05	0.06
Change	0.01	0.00	0.00

TP	20 %	50 %	80 %
Existing	0.05	0.06	0.08
Future	0.05	0.06	0.08
Change	0.00	0.00	0.00

TP	20 %	50 %	80 %
Existing	0.04	0.06	0.07
Future	0.04	0.05	0.07
Change	0.00	-0.01	0.00

TP	20 %	50 %	80 %
Existing	0.03	0.04	0.05
Future	0.03	0.04	0.06
Change	0.00	0.00	-0.01

TP	20 %	50 %	80 %
Existing	0.02	0.03	0.05
Future	0.02	0.03	0.05
Change	0.00	0.00	0.00

TP	20 %	50 %	80 %
Existing	0.02	0.03	0.04
Future	0.02	0.03	0.04
Change	0.00	0.00	0.00

TP	20 %	50 %	80 %
Existing	0.02	0.03	0.04
Future	0.02	0.03	0.04
Change	0.00	0.00	0.00

LEGEND

▼ Reporting Locations

Title:

Total Phosphorous (mg/L)

Figure: 3-6

Rev: A

N

0 1 2km

Approx.Scale

BMT WBM
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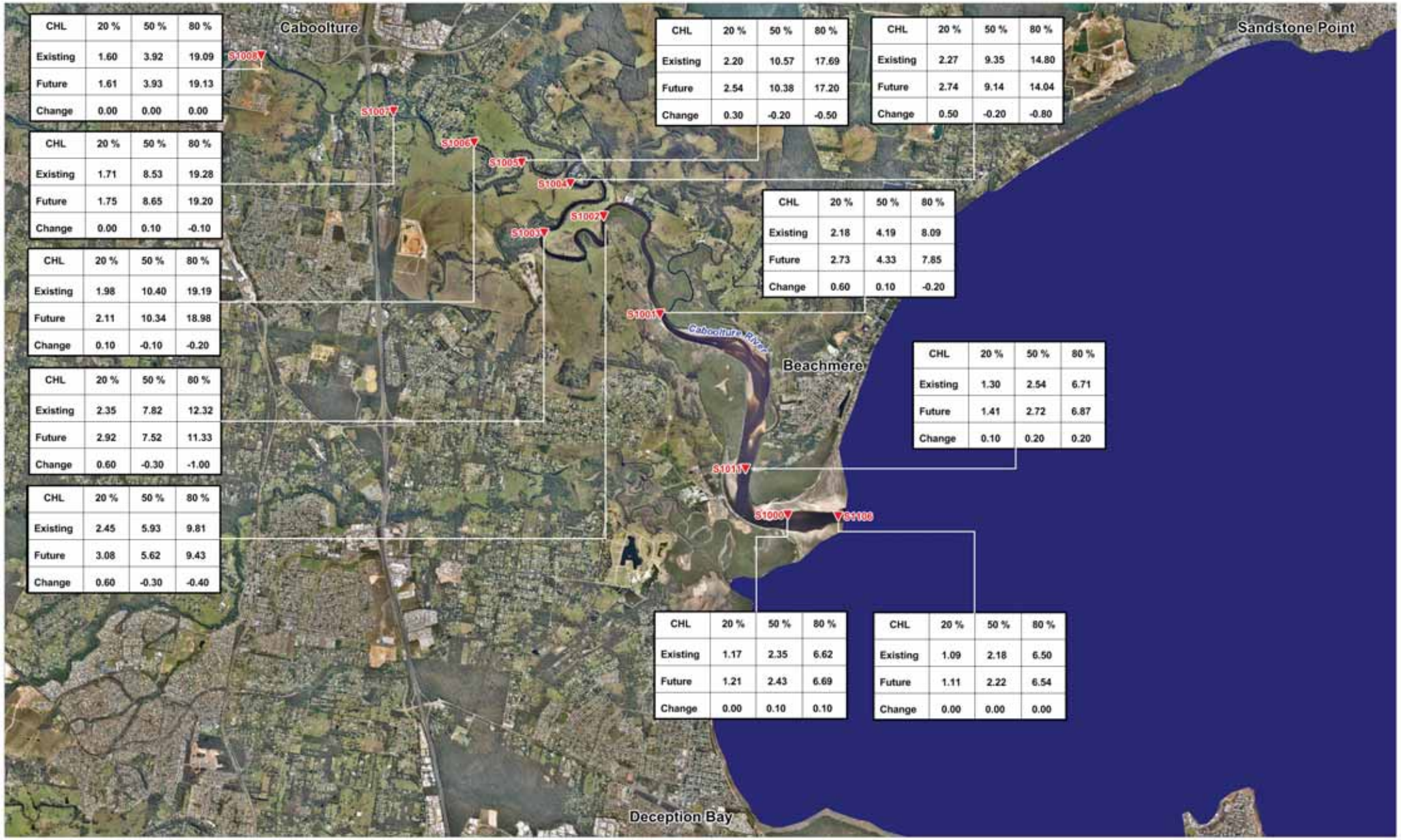
Filepath : I:\B20670_I_nc_NEBP\ORG\GIS_008_TP_Reporting Locations.wor



CHL	20 %	50 %	80 %
Existing	1.60	3.92	19.09
Future	1.61	3.93	19.13
Change	0.00	0.00	0.00

CHL	20 %	50 %	80 %
Existing	2.20	10.57	17.69
Future	2.54	10.38	17.20
Change	0.30	-0.20	-0.50

CHL	20 %	50 %	80 %
Existing	2.27	9.35	14.80
Future	2.74	9.14	14.04
Change	0.50	-0.20	-0.80

CHL	20 %	50 %	80 %
Existing	1.71	8.53	19.28
Future	1.75	8.65	19.20
Change	0.00	0.10	-0.10

CHL	20 %	50 %	80 %
Existing	2.18	4.19	8.09
Future	2.73	4.33	7.85
Change	0.60	0.10	-0.20

CHL	20 %	50 %	80 %
Existing	1.98	10.40	19.19
Future	2.11	10.34	18.98
Change	0.10	-0.10	-0.20

CHL	20 %	50 %	80 %
Existing	1.30	2.54	6.71
Future	1.41	2.72	6.87
Change	0.10	0.20	0.20

CHL	20 %	50 %	80 %
Existing	2.35	7.82	12.32
Future	2.92	7.52	11.33
Change	0.60	-0.30	-1.00

CHL	20 %	50 %	80 %
Existing	2.45	5.93	9.81
Future	3.08	5.62	9.43
Change	0.60	-0.30	-0.40

CHL	20 %	50 %	80 %
Existing	1.17	2.35	6.62
Future	1.21	2.43	6.69
Change	0.00	0.10	0.10

CHL	20 %	50 %	80 %
Existing	1.09	2.18	6.50
Future	1.11	2.22	6.54
Change	0.00	0.00	0.00

LEGEND

▼ Reporting Locations

Title:

Chlorophyll-a - ug/L

Figure: 3-7

Rev: A

N

0 1 2km

Approx.Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B20670_I_nc_NEBP\ORG\GIS_009_CHL_Reporting Locations.wor

3.3.6 Dilution Rates

The full water quality assessment has typically predicted no significant impacts from the discharge proposed from the Marina system provided that water quality remains acceptable as predicted. To ensure the impact assessment is rigorous, an assessment of how the proposed Marina discharge could affect the receiving water quality levels in Caboolture River and Moreton Bay was undertaken as if adverse conditions in the Marina resulted. In order to inform such, the TUFLOW FV model was interrogated to determine what levels of dilution of Marina waters will be present in the receiving waters using a conservative tracer assessment.

The results of the assessments are presented in Table 3-2 below. Values of 100 and 0 correspond to pure Marina water and pure estuarine water, respectively. Intermediate values represent various dilutions with, for example, a value of 60 representing 60 parts Marina water and 40 parts estuarine water.

Table 3-2 Long-Term Dilution Rates

Location	Percentiles				
	10th	20th	Median	80th	90th
S1008	0	0	0	3	3
S1007	0	0	2	5	6
S1006	0	0	4	7	9
S1005	0	2	7	11	13
S1004	1	5	11	15	17
S1003	4	9	15	19	21
S1002	8	13	18	21	22
S1001	10	12	17	21	22
S1011	1	1	4	9	11
S1000	0	1	2	5	7
S1106	0	0	1	2	3

From the tabulated, data, dilutions are generally high (i.e. low tracer concentrations), including in the immediate vicinity of the Marina water discharge point. The following conclusions can be drawn from the results presented:

- There is negligible change in water quality concentrations at the Mouth with 90th percentile changes indicating over 97% dilution.
- Median tracer concentrations in the Caboolture River at the location of the Marina are in the order of 15% to 18% indicating relatively high dilution rates from the discharge. It is also noted that the 90th percentile dilution is of the order of 22%.
- Dilution rates in the upper Caboolture River (i.e. upstream of S1004) are also generally high with median tracer concentration in the order of 2% to 11%.

4 Summary

In general, and within the limitations of the modelling undertaken to date, the following observations can be made for the numerical water quality modelling assessment of the Marina and the receiving environment of the Caboolture River:

- The Marina system is well flushed and oxygenated and does not show a propensity to develop either saline or thermal stratification. Additional mitigation measures such as submerged mixer devices and aerators (i.e. not currently assessed) within the Marina will further minimise any potential for stratification.
- Nutrient levels in the Marina are largely consistent with background levels (i.e. those of the intake) and as a result of settling within the Marina will typically reduce concentrations in the Caboolture River when discharged.
- Median tracer concentrations within the Caboolture River are in the order of 15% to 18%, whilst at the mouth of the river the dilutions increase to 97% (i.e. 3% concentration).
- Chlorophyll *a* levels in the Marina show a propensity for elevated levels of primary productivity due to the elevated level in the Caboolture River intake and the warmer *in-situ* Marina temperatures levels expected during the warmer months of the year. To reduce the chlorophyll *a* levels that are internally derived management of the following will be required:
  - nutrients from the Marina to reduce the potential for phytoplankton growth; and
  - circulation of water (horizontally and vertically) within the Marina via mechanical mixers and aerators (the influence of which have not been included in the modelling to date) will assist in reduce surface temperatures and to increase benthic DO levels which will jointly limit the potential for algal growth.

Overall the proposed Marina water quality is expected to be adequately controlled through the use of a pumped system from the Caboolture River intake and will provide a system that is well buffered which as a result has no major short or long term water quality issues. Increased water circulation (i.e. vertically & horizontally) measures within the Marina via mechanical mixers and aerators may further reduce the impact of the Marina and will limit the propensity of elevated chlorophyll *a* growth.

The influence of the proposed Marina discharge is expected to have only a small influence on the receiving environment of Caboolture River. Furthermore, and as demonstrated herein, if Marina water quality is maintained in a similar or better condition to the Caboolture River, then no discernible reduction in water quality is expected in the river. The Marina model indicates water quality is likely to be better than that of Caboolture River in most instances, however an increase in Chlorophyll *a* is predicted.

5 Limitations

This integrated numerical water quality modelling has been constructed to demonstrate the potential water quality characteristics within the Marina and the potential impact to the Caboolture River to assess if there is a low risk of environmental harm or environmental nuisance in relation to water quality.

Whilst full water quality and advection-dispersion modelling has been carried out to inform these assessments, more detailed work and assessments will be required to allow refinement of the development proposal and to ensure impacts are limited to acceptable levels. This will include optimising the development and including additional mitigation measures not included in this assessment to further reduce the residual risk to water quality impacts to both the Marina and the receiving environment.

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