

CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

APPENDIX AJ: Marine Water Quality Impact Assessment Report (2017)





Marine Water Quality Impact Assessment - Technical Report

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Contents**Contents**

1	Introduction	1
2	Assessment of Potential Impacts	2
2.1	Overview	2
2.2	Methodology	4
2.2.1	Baseline water quality data	6
2.2.2	Impact Assessment Threshold Values	9
2.2.3	Benchmarking to Biological Thresholds	11
2.2.4	Development of Impact Zones	14
2.2.5	Testing of Impact Zones	14
2.2.6	Sediment Deposition	17
2.2.6.1	Tolerance Limits	17
2.2.6.2	Adopted Thresholds	18
2.3	Modelling Outputs	20
2.4	Construction Phase Impacts	20
2.4.1	Turbid Plumes from Capital Dredging	20
2.4.1.1	Screening Assessment against Water Quality Guidelines and Baseline Data	21
2.4.1.2	Percentile Plots	22
2.4.1.3	Time Series Plots	27
2.4.1.4	Zones of Impact	30
2.4.1.5	Prop Wash	33
2.4.1.6	Summary of Key Findings – Capital Dredging Turbid Plumes	33
2.4.2	Sediment Deposition from Capital Dredging	34
2.4.3	Tailwater Impacts – Northern Sands DMPA	39
2.4.3.1	Turbidity	41
2.4.3.2	Salinity	44
2.4.3.3	Summary of Key Findings – Northern Sands DMPA Tailwater	54
2.4.4	Tailwater Impacts – Tingira Street DMPA	55
2.4.5	Dredge Mooring Point Impacts	55
2.4.6	Pipeline Crossing – Richters Creek	55
2.4.7	Mobilisation of Contaminants from Capital Dredging	57
2.4.7.1	Pore water results	57
2.4.7.2	Elutriate results	59
2.4.8	Potential Acid Sulfate Soil Impacts from Capital Dredging	60
2.4.9	Dredging and Construction Plant and Equipment	61

Contents

2.5	Operational Phase Impacts	61
2.5.1	Increased Shipping	61
2.5.2	Future Maintenance Dredging	63
2.6	Cumulative Dredging Assessment	71
3	Recommended Mitigation Measures	73
3.1	Mitigation Measures – Construction Phase	73
3.1.1	Capital Dredging	73
3.1.2	Tailwater Discharges from Northern Sands DMPA	74
3.1.3	Pipeline Crossing at Richters Creek	74
3.1.4	Potential Acid Sulfate Soil (PASS) Impacts from Dredging	74
3.1.5	Dredging and Construction Plant and Equipment	74
3.2	Mitigation Measures – Operational Phase	75
3.2.1	Future Maintenance Dredging	75
3.2.2	Increased Shipping	75
3.3	Monitoring	75
4	Residual Impacts and Assessment Summary	76
5	References	81
Appendix A	Baseline Data Percentile Curves	A-1
Appendix B	Time Series Salinity Graphs	B-1

List of Figures

Figure 2-1	Concept design of impact zones (WA EPA 2016)	6
Figure 2-2	Baseline Water Quality Sites	8
Figure 2-3	Example summary analysis of baseline data for Site 4 at Trinity Inlet	10
Figure 2-4	Total daily PAR (mol/m ² /day as 2 week rolling average) at intertidal seagrass monitoring sites (A, B and C) showing baseline (actual monitoring data) and addition of impact zone thresholds	16
Figure 2-5	Preliminary estimates of loads and durations of sediment likely to cause impacts to corals in north-west Australia (Source: Gilmour et al 2006)	18
Figure 2-6	Modelled ambient turbidity (without dredging) – 50 th percentile (top) and 95 th percentile (bottom)	24
Figure 2-7	Impact of dredging on 50 th percentile turbidity – likely best case (top) and likely worst case (bottom) (scale: 2 to 40 NTU)	25
Figure 2-8	Impact of dredging on 95 th percentile turbidity – likely best case (top) and likely worst case (bottom) (scale: 10 to 200 NTU)	26
Figure 2-9	Natural re-suspension (ambient sediments) vs. dredge sediments – Palm Cove (top), Yorkey's Knob (middle) and Trinity Bay (bottom)	28

Contents

Figure 2-10	Natural re-suspension (ambient sediments) vs. dredge sediments – Cape Grafton (top), False Cape (middle) and Trinity Inlet (bottom)	29
Figure 2-11	Zones of impact – turbidity - capital dredging	31
Figure 2-12	Zones of impact – turbidity - capital dredging – Trinity Inlet and Cairns Harbour	32
Figure 2-13	Impact of dredging on 50 th percentile sediment deposition – likely best case (top) and likely worst case (bottom) (scale: 0.5 to 10 mg/cm ² /day)	36
Figure 2-14	Impact of dredging on 95 th percentile sediment deposition – likely best case (top) and likely worst case (bottom) (scale: 5 to 100 mg/cm ² /day)	37
Figure 2-15	Zones of impact (corals) – sediment deposition	38
Figure 2-16	Northern Sands dredge material placement configuration	40
Figure 2-17	Tailwater impacts to 50 th percentile turbidity – Discharge Point A (left) and Discharge Point B (right)	42
Figure 2-18	Zones of impact – turbidity – tailwater discharge	43
Figure 2-19	Tailwater impacts to 50 th percentile salinity – Discharge Point A (left) and Discharge Point B (right)	45
Figure 2-20	Tailwater impacts to 99 th percentile salinity – Discharge Point A (left) and Discharge Point B (right)	46
Figure 2-21	Time series model extraction points	49
Figure 2-22	Salinity at Site 2 (Upper Barron River) – Discharge Point A (top) and Discharge Point B (bottom)	50
Figure 2-23	Salinity at Site 5 (near Discharge Point A) – Discharge Point A (top) and Discharge Point B (bottom)	51
Figure 2-24	Salinity at Site 7 (near Discharge Point B) – Discharge Point A (top) and Discharge Point B (bottom)	52
Figure 2-25	Salinity at Site 8 (Lower Barron River) – Discharge Point A (top) and Discharge Point B (bottom)	53
Figure 2-26	Salinity at Site 10 (Thomatis / Richters Creek) – Discharge Point A (top) and Discharge Point B (bottom)	54
Figure 2-27	Sketch of prospective Richters Creek pipeline crossing	56
Figure 2-28	Zones of Impact – Maintenance Dredging – Existing DMPA	66
Figure 2-29	Zones of Impact – 12 Month Resuspension – Existing DMPA	67
Figure 2-30	Turbidity data and maintenance dredging period at Palm Cove (top) and Yorkey's Knob (bottom)	68
Figure 2-31	Turbidity data and maintenance dredging period at False Cape (top) and Cape Grafton (bottom)	69
Figure 2-32	Turbidity data and maintenance dredging period at Trinity Bay (top) and Trinity Inlet (bottom)	70
Figure 2-33	Zones of impact – turbidity – cumulative dredging	72

Contents

List of Tables

Table 2-1	Categories used to define consequence of impact (water quality)	2
Table 2-2	Classifications of the duration of identified impacts	3
Table 2-3	Categories used to define likelihood of impact (water quality)	3
Table 2-4	Risk matrix for water quality	4
Table 2-5	Risk rating legend	4
Table 2-6	Description of impact assessment threshold values	12
Table 2-7	Turbidity threshold values (above background) for impact assessment purposes	13
Table 2-8	Impact thresholds for sediment deposition for corals (above background)	19
Table 2-9	Predicted impacts to median turbidity	22
Table 2-10	Nutrients in Pore Water	58
Table 2-11	Dissolved Metals/Metalloids in Pore Water	58
Table 2-12	Elutriate Nutrient Concentrations (1:144 dilution) ¹	60
Table 2-13	Elutriate Metal / Metalloid Concentrations (1:144 dilution) ¹	60
Table 4-1	Risk assessment summary – marine water quality	77

1 Introduction

The Cairns Shipping Development (CSD) Project (the project) is a capital dredging project in Trinity Inlet and Trinity Bay to increase the capacity of the Port of Cairns for tourism and shipping.

Up to 1 M m³ of material is proposed to be dredged and placed onshore, with the majority of material placed at the Northern Sands Dredge Material Placement Area (DMPA), and stiff clays placed at Ports North land at Tingira Street (hereafter referred to as the Tingira Street DMPA). As only stiff clays will be placed at the Tingira Street DMPA, discharge of tailwater will not be required.

The project has the potential to influence water quality within Trinity Inlet and Trinity Bay during both the construction phase and operational phases. Impacts on water quality could result from capital dredging of the existing shipping channel into Cairns port, the channel bend, swing basins and inner port. Additionally, land placement of dredge material at the Northern Sands DMPA could also have water quality impacts in the Barron River due to the proposed hydraulic placement of the material and associated tailwater releases from this DMPA. These influences are potentially both short term (i.e. construction) and long term (i.e. maintenance dredging and operation). Potential impacts from placement at the Tingira Street DMPA will be managed onsite in accordance with existing practices, and marine water quality impacts are not expected.

Terms of Reference (TOR) for the project have been set by the Queensland Government (2012) with provisions to address marine water quality, potential impacts, mitigation and monitoring in Section 5.3.2 of the TOR. Additionally, the Environmental Impact Statement (EIS) guidelines for the project have been set by the Australian Government (2012) with provisions to address the existing environment, potential impacts, mitigation and monitoring in Section 5.9 through 5.14 of the EIS guidelines.

This report presents the findings of the assessment of potential impacts to marine water quality associated with the construction and operation of the revised CSD EIS, with particular focus on the following:

- Construction related – primarily capital dredging and placement activities, and also construction of wharf infrastructure.
- Operation of the port facilities, focusing on accommodating an increased number of larger cruise vessels at Trinity Inlet wharves, maintenance dredging of the entrance channel, and placement of maintenance dredge material at the approved marine Dredge Material Placement Area (DMPA).
- Options for managing and mitigating identified impacts.

Baseline marine water quality relevant to the project is reported separately in the Marine Water Quality chapter of the EIS.

2 Assessment of Potential Impacts

2.1 Overview

This section outlines the potential impacts the project may have on the marine water quality. This section describes:

- Potential impacts on the ambient water quality from the construction and operation of the port facilities
- Options for managing and mitigating identified impacts during both construction and operation.

In this section, potential impacts are discussed in terms of the construction and operational stages, as follows:

- Construction stage – primarily focusing on capital dredging and placement activities
- Operational stage - operation of the port facilities, maintenance dredging of the inner port and entrance channel, and placement of maintenance dredge material.

A risk-based approach has been used to assess water quality impacts, and is based on the consideration of the following:

- Consequence of Impact – made up of assessment of the intensity, scale (geographic extent), duration of water quality impacts and sensitivity of environmental receptors to the impact (as prescribed in the EPP Water). Table 2-1 is a summary of the categories used to define impact significance
- Duration of impact - the duration of identified impacts is classified as per Table 2-2
- Likelihood of Impact – which assesses the probability of the impact occurring. Table 2-3 is a summary of the categories used to define impact likelihood

Risk rating – which assesses the level of risk for key impacting processes. The risk table (

- Table 2-4) adopted is generated from the Consequence and Likelihood scores, based on the overall matrix presented in Part A.

Table 2-1 Categories used to define consequence of impact (water quality)

Impact Consequence	Description for Water Quality (includes magnitude, duration, and sensitivity of receiving values)
Very High	Permanent change in the Ecosystem for Trinity Inlet and Trinity Bay and surrounds resulting from changes to water quality due to direct impacts of the construction or operational phases of the Cairns Shipping Development project and associated activities. Generally corresponds to the 'Zone of High Impact' in terms of dredge-related turbidity as per Section 2.2 below.
High	Water quality in Trinity Inlet and Trinity Bay and surrounds is permanently altered due to direct impacts of the construction or operational phases of the Cairns Shipping Development project and associated activities such that the scheduled Environmental Values and Water Quality Objectives are no longer achievable if currently being

Assessment of Potential Impacts

Impact Consequence	Description for Water Quality (includes magnitude, duration, and sensitivity of receiving values)
	achieved, or are prevented from being achieved in the future if currently not being achieved. Generally corresponds to the 'Zone of High Impact' in terms of dredge-related turbidity as per Section 2.2 below.
Moderate	Water quality in Trinity Inlet and Trinity Bay and surrounds is temporarily altered due to direct and indirect impacts of the construction phase of the Cairns Shipping Development project and associated activities such that the scheduled Environmental Values and Water Quality Guidelines are no longer achievable if currently being achieved, or are prevented from being achieved in the future if currently not being achieved. Generally corresponds to the 'Zone of Low to Moderate Impact' in terms of dredge-related turbidity as per Section 2.2 below.
Minor	Water quality in Trinity Inlet and Trinity Bay and surrounds is temporarily impacted such that mitigation measures prevent changes to water quality over an annual period, though short term exceedances may occur during construction activities. Generally corresponds to the 'Zone of Low to Moderate' Impact in terms of dredge-related turbidity as per Section 2.2 below.
Negligible	No detectable impacts on the water quality in Trinity Inlet and Trinity Bay and surrounds through the use of effective mitigation measures during the construction and operational phases and no perceptible change to long term water quality through altered flow regimes or other hydrologic changes resulting from the Project. Generally corresponds to the 'Zone of Influence' in terms of dredge-related turbidity as per Section 2.2 below.
Beneficial	Existing water quality is improved in Trinity Inlet and Trinity Bay and surrounds.

Table 2-2 Classifications of the duration of identified impacts

Relative duration of impacts	
Temporary	Days to months
Short Term	Up to one year
Medium Term	From one to five years
Long Term	From five to 50 years
Permanent / Irreversible	In excess of 50 years

Table 2-3 Categories used to define likelihood of impact (water quality)

Likelihood	Categories
Highly Unlikely/Rare	Highly unlikely to occur but theoretically possible
Unlikely	May occur during construction/life of the project but probability well below 50%; unlikely but not negligible
Possible	Less likely than not but still appreciable; probability of about 50%

Assessment of Potential Impacts

Likelihood	Categories
Likely	Likely to occur during construction or during a 12 month timeframe; probability greater than 50%
Almost Certain	Very likely to occur as a result of the proposed project construction and/or operations; could occur multiple times during relevant impacting period

Table 2-4 Risk matrix for water quality

Likelihood	Impact Consequence				
	Negligible	Minor	Moderate	High	Very High
Highly Unlikely/ Rare	Negligible	Negligible	Low	Medium	High
Unlikely	Negligible	Low	Low	Medium	High
Possible	Negligible	Low	Medium	Medium	High
Likely	Negligible	Medium	Medium	High	Extreme
Almost Certain	Low	Medium	High	Extreme	Extreme

Table 2-5 Risk rating legend

Extreme Risk	An issue requiring change in project scope; almost certain to result in a 'significant' impact to marine water quality
High Risk	An issue requiring further detailed investigation and planning to manage and reduce risk; likely to result in a 'significant' impact to marine water quality
Medium Risk	An issue requiring project specific controls and procedures to manage
Low Risk	Manageable by standard mitigation and similar operating procedures
Negligible Risk	No additional management required

2.2 Methodology

The typical approach to assessing the predicted impacts from construction and operations works is to assess compliance against water quality guideline values (such as the EPP Water). This method allows a direct comparison of the likely compliance with established guidelines to ensure protection and/or enhancement of environmental values for the waters of concern.

As the actual capital dredging works are anticipated to occur only over a span of approximately 12 weeks (depending on the dredge plant used and not including mobilisation and demobilisation), impacts over this short duration are problematic to compare for compliance against annual median water quality guidelines. Specifically, calculation of an annual median from only 12 weeks of impact would result in underestimation of potential impacts.

Given this, three levels of assessment were undertaken to support assessment of the potential impacts from the proposed dredging and placement works.

Assessment of Potential Impacts

Firstly, median concentrations for the dredging campaign were assessed against water quality guideline values. Although it is acknowledged (as above) that this approach is not strictly precise, it does provide a high level 'screening' type assessment tool to allow rapid identification of potential impacts, worthy of subsequent rigorous assessment. This approach is also a minimum requirement of the State Terms of Reference (ToR).

Secondly, percentile exceedance plots of dredging related turbidity are presented. These percentile plots are direct outputs from the modelling, and provide an indication of excess turbidity from dredging activities (these plots are discussed further in Section 2.3). Additionally, time series plots of modelled turbidity at particular locations are presented. These plots are separated out into ambient turbidity natural re-suspension and dredge-related turbidity for the modelling period. This was undertaken to aid in the assessment of impacts at particular locations by identifying the proportion of turbidity originating naturally and from dredging and placement works.

Thirdly, project-specific threshold values were developed to assess potential impacts to marine water quality and ecologically sensitive areas. These impact predictions are presented as 'zones of impact' as recommended by the Commonwealth EIS Guidelines and GBRMPA Modelling Guidelines, and are derived using the percentile exceedance plots described above. The zones of impact approach is now recognised as 'best practice' in dredging environmental assessments, building on the methodologies set out in the dredging environmental assessment guidelines produced by the WA EPA (2016).

The zones adopted for the current assessment, include the following:

- Zone of High Impact = water quality impacts resulting in predicted mortality of ecological receptors with recovery time greater than 24 months.
- Zone of Low to Moderate Impact = water quality impacts resulting in predicted sub-lethal impacts to ecological receptors and/or mortality with recovery between 6 months (lower end of range) to 24 months (upper end of range).
- Zone of Influence = extent of detectable¹ plume, but no predicted ecological impacts.

It is important to note that the recovery times outlined for the various zones should be considered as indicative only, noting that such timeframes are dependent on a range of factors that are extremely complex and difficult to accurately predict. The zones and their 'recovery timeframes' represent a means for comparing the likelihood that significant, detectable impact to sensitive receptors could occur, and are based on the assumption that recovery timeframes are dependent on the magnitude of impact.

A concept design of the zones of impact (sourced from WA EPA 2016) is shown in Figure 2-1.

¹ 'Detectable' plume in terms of detectable above background conditions by instrumentation deployed in the water column

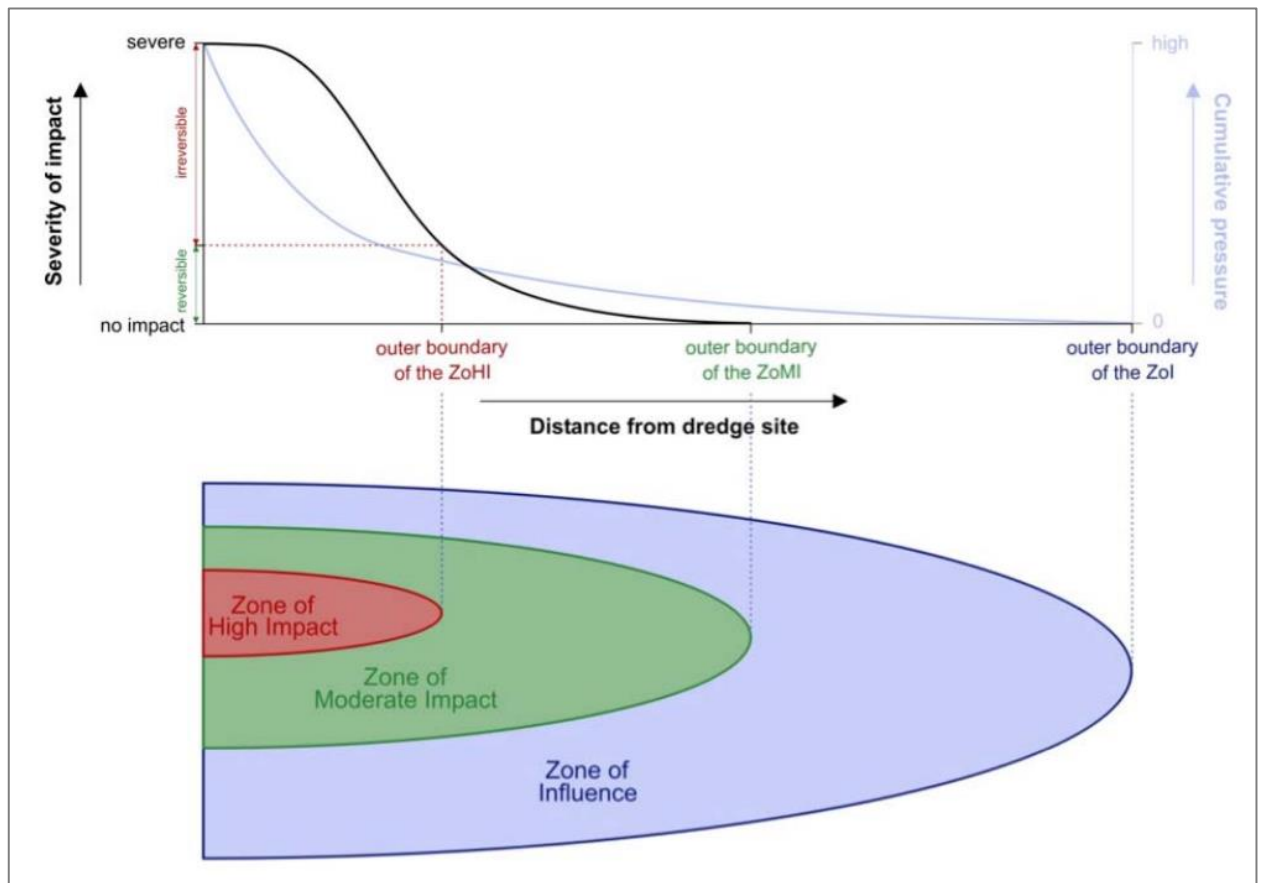


Figure 2-1 Concept design of impact zones (WA EPA 2016)

To determine the threshold values to delineate the zones of impact, a combination of water quality (turbidity) and biological tolerances methods was used. This entailed using baseline water quality monitoring data to set initial threshold values. These values were then compared to biological tolerances from literature values as a 'reality check' to confirm that the threshold values are biologically meaningful.

2.2.1 Baseline water quality data

Continuous turbidity data (and other parameters) were collected over a 12 month period (July 2013 to July 2014) for the CSD EIS at six sites generally representing sensitive ecological receptor locations. The locations of these sites include:

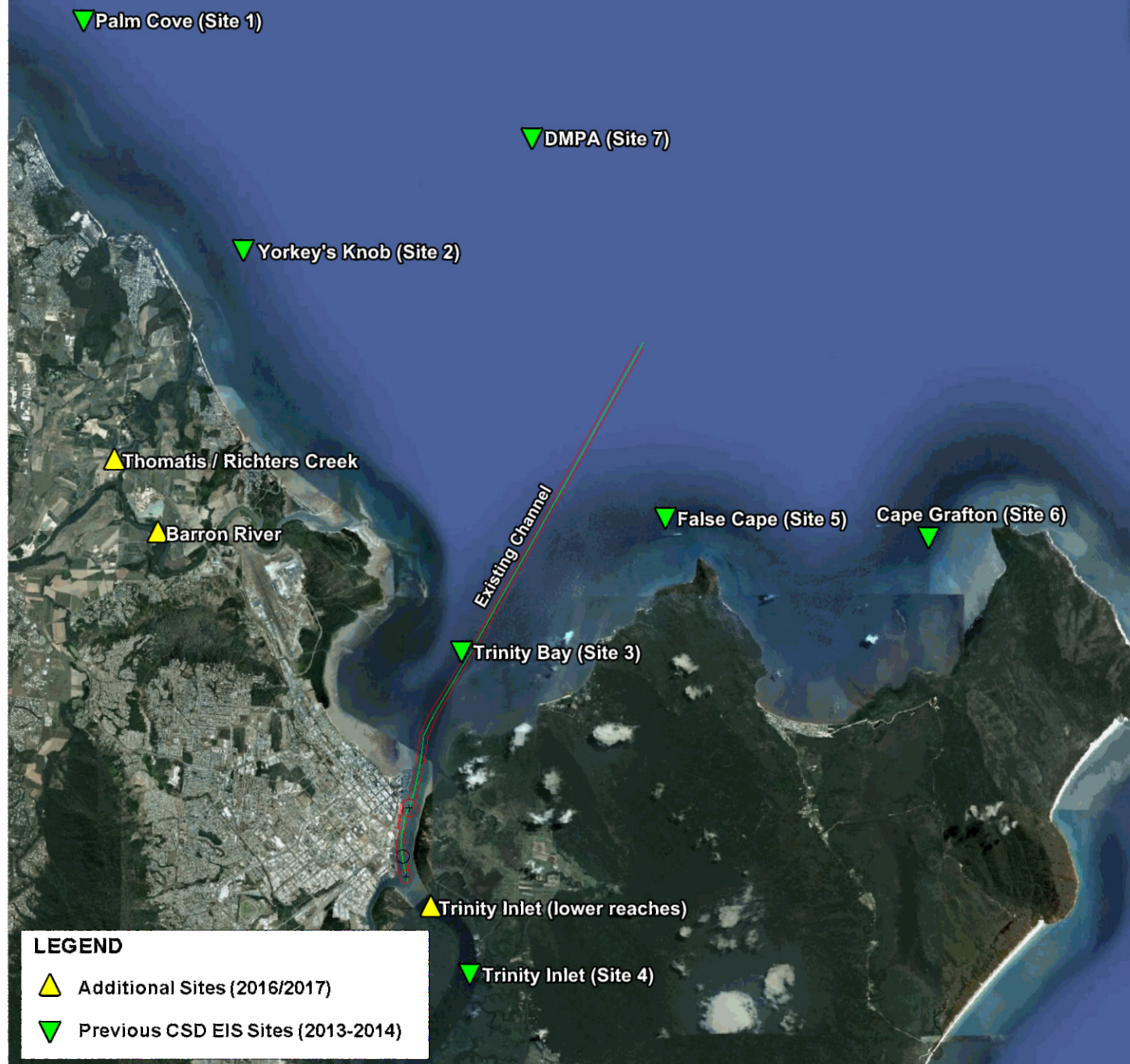
- Palm Cove Beach – generally representing corals at Double Island.
- Yorkey's Knob – generally representing Northern Beaches.
- Trinity Bay – generally representing historical subtidal seagrass areas.
- Trinity Inlet (upper reaches) – generally representing remnant seagrass in Trinity Inlet.
- False Cape – generally representing historic seagrass areas near False Cape.
- Cape Grafton – generally representing corals in Mission Bay.

- DMPA – generally representing clearer offshore waters near the existing marine DMPA.

Additional data was collected in 2016/2017 at the following locations:

- Trinity Inlet (lower reaches) – generally representing areas near the Port of Cairns.
- Barron River - generally representing the tailwater receiving environment of the Barron River.
- Thomatis / Richters Creek - generally representing the tailwater receiving environment of the Barron River during flooding tides.

The location of these sites is shown in Figure 2-2.



Title:
Baseline Water Quality Sites

Figure:
2-2

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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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The 12-month monitoring data set underwent a quality control process whereby periods of data were quarantined to ensure the data represented baseline conditions. Periods of data were quarantined if the following occurred during the monitoring period:

- Obvious signs of sensor bio-fouling.
- Equipment failure.
- Any unusually large rainfall events (i.e. larger than 1 in 5-year recurrence interval).

Overall, the data set quality was very adequate, with only approximately 10% of the data quarantined due to bio-fouling and periods of equipment failure. After the quality control process was complete, the 12-month monitoring data set included approximately 50,000 water quality data points at each monitoring site across the wet and dry season.

Further information in regard to the baseline water quality monitoring program is provided in BMT WBM (2014).

2.2.2 Impact Assessment Threshold Values

As the long-term data shows variability in turbidity among sites, site-specific impact assessment thresholds were deemed more appropriate than a 'one size fits all' approach. To determine impact assessment threshold values, the 12-month baseline water quality monitoring data set was analysed and percentile curves were produced. These percentile curves provide an indication of magnitude of turbidity and combined duration/frequency metrics for a range of conditions.

The 12-month baseline data was analysed over a moving 30-day window period to give a range of percentile values over different periods. The 30-day window period is somewhat arbitrary but in a physical hydrodynamic context represents the approximate duration of two consecutive spring-neap tidal cycles. The 30-day moving window analysis was undertaken by moving the 30-day window by 10 day increments over the entire dataset. This method provides an indication of natural variability around each percentile value and provides context for excess turbidity from dredging.

As an example, Figure 2-3 shows the percentile curves for data collected at Trinity Inlet. This shows the natural variability measured around the median (50thile) and other percentile values. The x-axis in Figure 2-3 represents the different percentile values extracted from the moving 30-day window analysis moving from frequently exceeded on the left to rarely exceeded on the right. The different curves are statistics representing the variability of the percentile analysis results across the different 30 day periods (making up the entire baseline monitoring period). The lower curve represents the least turbid conditions experienced across the baseline period while the upper limit is conversely the most turbid conditions. The solid green line is the mean of the different 30-day window conditions.

Percentile curves for all monitoring sites are included in Appendix A.

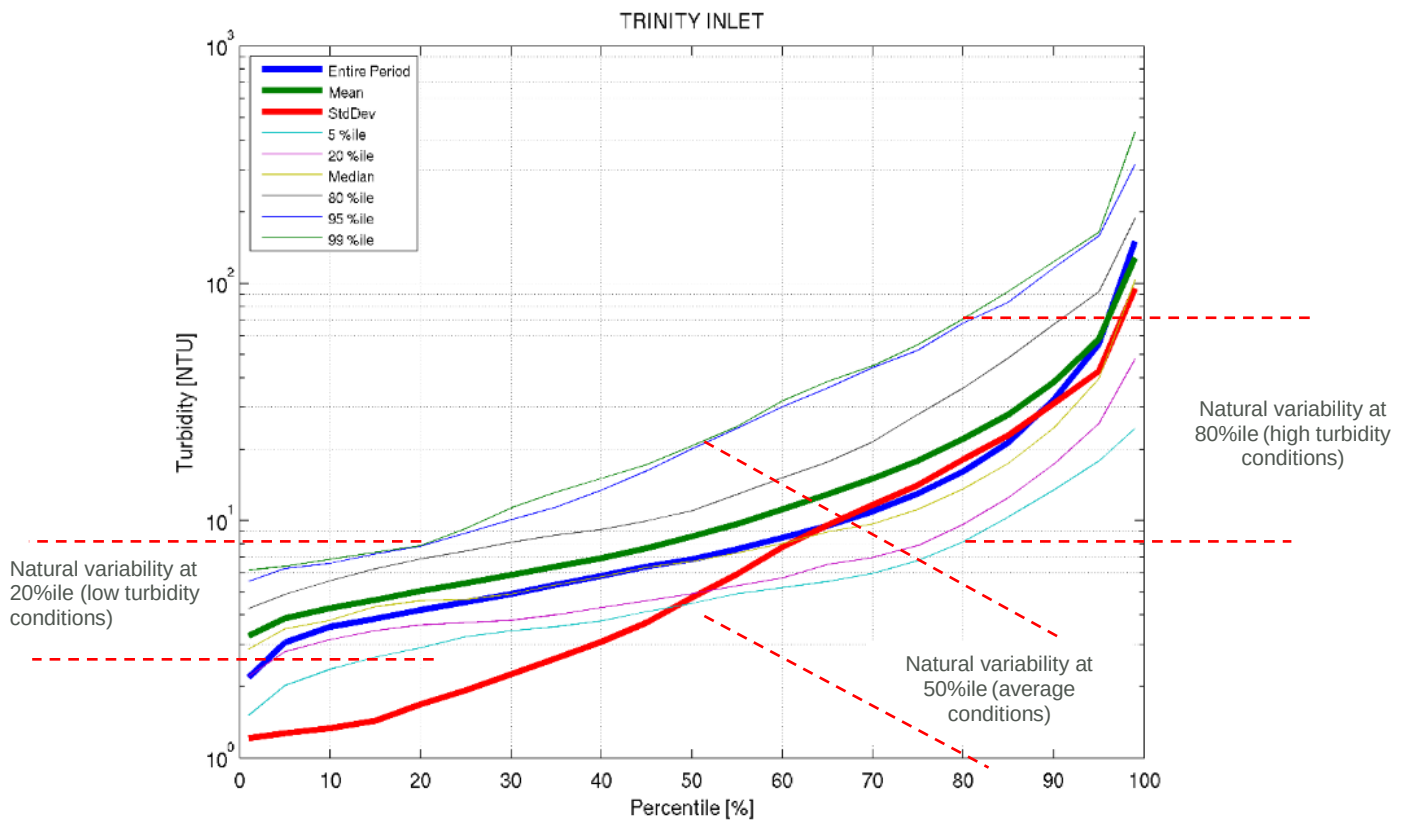


Figure 2-3 Example summary analysis of baseline data for Site 4 at Trinity Inlet

Threshold values were derived from these percentile curves based on the natural variability around the 50th percentile (average conditions), 20th percentile (good conditions – low wind and waves) and the 80th percentile (poor conditions – moderate to high wind and waves). Therefore, this method considers both acute and chronic impacts.

A description of the threshold values for the three zones of impact and how they relate to the natural variability is provided in Table 2-6. The approach used to determine the threshold level for the ‘zone of low to moderate impact’ (i.e. when water quality extends beyond natural variation and impacts to ecological receptors may begin to occur) involve using one standard deviation from the natural background mean at each percentile (i.e. 20th, 50th and 80th percentiles). This is a similar approach developed by Orpin *et al.* (2004) to assess impacts from construction-related turbidity increases in Townsville. Orpin *et al.* (2004) suggested using one standard deviation from ambient conditions as a possible conservative upper limit of an acceptable increase in turbidity. Orpin *et al.* (2004) noted that the standard deviation of natural turbidity levels was considered to be a reasonable and convenient envelope within which an allowable construction-related increase could occur. If construction-related turbidity (such as from dredging) remained within one standard deviation, Orpin *et al.* (2004) suggested it would not be detectable over and above the natural variability.

Extending this method out, threshold levels for the 'zone of high impact' were determined using three standard deviations from the mean. The validity of this approach was tested using biological thresholds, as discussed in Section 2.2.5.

The 'zone of influence' was defined as the extent of detectable plumes due to the proposed dredging. Turbid plumes were assumed to become detectable once they were approximately 10-20% above background conditions (background conditions were conservatively assumed to be clearer waters in Trinity Inlet and offshore areas, as opposed to more turbid nearshore waters). To determine the extent of this zone, the following criteria were used:

- Greater than 0.5 NTU above 50th percentile conditions
- Greater than 2 NTU above 80th percentile conditions
- Greater than 5 NTU above 95th percentile conditions
- Greater than 10 NTU above 99th percentile conditions.

2.2.3 Benchmarking to Biological Thresholds

Descriptions of the zones of impact and how they relate to water quality (turbidity) thresholds are included in Table 2-6. Also included in this table are biological tolerance values for seagrass for each zone of impact, which were provided by TropWATER at James Cook University (JCU). TropWATER also reviewed and provided input into the zones of impact methodology, including testing whether the zones of impact thresholds are biologically meaningful (refer to Section 2.2.5).

Only biological tolerances for seagrass are included as corals are too variable among species and sites to define at this stage, and corals present a very low portion of inshore habitat relevant to this project. The purpose of these biological tolerances is to test the impact zone predictions (Section 2.2.5) developed using water quality (turbidity) thresholds, and are not intended to be used for light based thresholds. Locally relevant and tested light thresholds for seagrass would need to be developed following further monitoring prior to commencement of the dredging campaign.

Table 2-6 Description of impact assessment threshold values

Zone of Impact	Water Quality (Turbidity)	Biological Tolerances (Seagrass)
Zone of High Impact	Excess turbidity causes total turbidity to go beyond natural variation Threshold value = excess turbidity greater than three standard deviations from the natural background mean	LR [#] for <i>Zostera</i> (4.5-12 mol/m ² /day rolling 2 week average) is not met for <u>more than</u> 6 weeks LR for <i>Halophila ovalis</i> (2.8-4.4 mol/m ² /day) ^{##} not met during the growing season (July-Dec) for <u>more than</u> 3 weeks Resulting in total loss of seagrass and no recovery within 1 year (reliant on new recruitment)
Zone of Low to Moderate Impact	Excess turbidity <i>may</i> push total turbidity beyond natural variation Threshold value = excess turbidity greater than one standard deviation from the natural background mean	LR for <i>Zostera</i> (4.5-12 mol/m ² /day rolling 2 week average) is not met for 1 week (low impact) to 6 weeks (moderate impact) LR for <i>Halophila ovalis</i> (2.8-4.4 mol/m ² /day) not met for 1 week (low impact) to 3 weeks (moderate impact) during the growing season (July-Dec). Resulting in declines in seagrass but some recovery within one month likely (moderate impacts); management action can occur avoiding declines in seagrass cover (low impacts).
Zone of Influence	Extent of detectable plumes Dredging related turbidity exceeds 0.5 NTU above 50 th percentile conditions, 2 NTU above 80 th percentile conditions, 5 NTU above 95 th percentile conditions, and 10 NTU above 99 th percentile conditions	Light does not fall below the LR for <i>Halophila ovalis</i> (2.8-4.4 mol/m ² /day) for at least 7 consecutive days. Light does not fall below the LR for <i>Zostera</i> (4.5-12 mol/m ² /day) for at least 7 consecutive days.

Notes:

LR = Light Requirement

Collier et al 2009 lab experiments found significant loss of *H. ovalis* after 14 days below LR and based on lab experiments determined a light requirement of 4.4 mol/m²/day. JCU work in Gladstone also noted declines of *Halophila ovalis* in shaded treatments within 2 weeks

The output from the analysis of data was turbidity impact assessment threshold values for each impact zone at each monitoring site. These values represent turbidity above background levels, and are included in Table 2-7. It should be noted that with the use of these impact threshold values, an assumption has to be made in regard to what constitutes 'background turbidity'. For the purposes of this impact assessment, background turbidity is assumed to be the mean turbidity of background data at each percentile (i.e. 20thile mean, 50thile mean and 80thile mean – refer to Figure 2-3 for example).

It is important to note that the threshold values presented in Table 2-7 are suitable for impact assessment purposes but are not proposed at this stage as the actual trigger values during dredging.

The current threshold values will be supplemented through further monitoring immediately prior to commencement of the dredging campaign.

Assessment of Potential Impacts

Table 2-7 Turbidity threshold values (above background) for impact assessment purposes

Impact Zone	Description	Method	Percentile	Descriptor	Palm Cove	Yorkey's Knob	Trinity Bay	Trinity Inlet - upper	Trinity Inlet - lower	Barron River	Thomatis / Richters Creek	False Cape	Cape Grafton	DMPA
					Turbidity Threshold Values (NTU) - above background									
Zone of High Impact	Excess turbidity <i>definitely</i> pushes total turbidity beyond natural variation	3 x standard deviations from 20%ile mean	20%ile	Exceeded 80% of the time	18	24	30	6	8	24	12	36	30	3
		3 x standard deviations from 50%ile mean	50%ile	Exceeded 50% of the time	48	39	66	15	15	45	33	75	123	6
		3 x standard deviations from 80%ile mean	80%ile	Exceeded 20% of the time	87	75	183	54	66	165	135	399	327	15
Zone of Low to Moderate Impact	Excess turbidity <i>may</i> push total turbidity beyond natural variation	One standard deviation from 20%ile mean	20%ile	Exceeded 80% of the time	6	8	10	2	3	8	4	12	10	1
		One standard deviation from 50%ile mean	50%ile	Exceeded 50% of the time	16	13	22	5	5	15	11	25	41	2
		One standard deviation from 80%ile mean	80%ile	Exceeded 20% of the time	29	25	61	18	22	55	45	133	109	5
Zone of Influence	Full extent of detectable plumes (including resuspension)	Dredging related turbidity exceeds 0.5 NTU	50%ile	Exceeded 50% of the time	0.5									
		Dredging related turbidity exceeds 2 NTU	80%ile	Exceeded 20% of the time	2									
		Dredging related turbidity exceeds 5 NTU	95%ile	Exceeded 5% of the time	5									
		Dredging related turbidity exceeds 10 NTU	99%ile	Exceeded 1% of the time	10									

2.2.4 Development of Impact Zones

To delineate the zones of impact, the site-specific impact threshold values were interpolated spatially across the study area using GIS mapping software to produce 3-dimensional threshold grids. These threshold grids were then analysed against the 3-dimensional model output grids. This produced impact zone maps which indicate areas where modelled turbidity is higher than the relevant impact threshold value.

2.2.5 Testing of Impact Zones

To test whether the zones of impact developed using turbidity thresholds in Table 2-7 are biologically meaningful, the turbidity thresholds were added to actual PAR monitoring data (Apr-Dec 2013) for three intertidal sites known to previously contain seagrass and monitored by JCU. These JCU monitoring sites include the following:

- Site A – Ellie Point.
- Site B – Esplanade.
- Site C – Bessie Point.

The aim of undertaking this analysis was to assess the amount of PAR available to these seagrass areas if additional turbidity as per the turbidity impact thresholds was added to the measured PAR data. The aim was to simulate a hypothetical scenario whereby a dredge would be operating with turbid plumes being created at these threshold values (note that in reality, a dredge would not be operating for this entire period). An outcome of this analysis, for example, should be that PAR available to seagrass after adding the low to moderate turbidity threshold (22 NTU) should only result in predicted low to moderate impacts and not high impacts (i.e. seagrass mortality).

To undertake this analysis, it was necessary to use the turbidity/PAR relationship described in the Marine Water Quality chapter of the CSD EIS to convert between PAR and turbidity.

The threshold values applicable to the intertidal seagrass areas include those for Trinity Bay (Table 2-7). The 50th percentile values were used as this allowed a relatively simple addition of excess turbidity to the time series PAR data.

Two week rolling averages of the derived PAR data for each of the three monitoring sites are presented in Figure 2-4, which also shows baseline monitoring data (actual recorded data).

As *Zostera* is the seagrass species found in the intertidal areas, the results were compared to the biological tolerances for *Zostera* in Table 2-6. The results indicate that:

- Using the high impact zone threshold (66 NTU), there would be periods at Sites A and C when PAR would be below the *Zostera* light requirement for longer than 6 weeks – this would potentially result in total loss of seagrass (as expected of this zone).
- Using the low to moderate zone threshold (22 NTU), there would be short periods (1-6 weeks) when PAR would be below the *Zostera* light requirement, but PAR would remain mostly within the light requirement range.

Assessment of Potential Impacts

- The zone of influence (no predicted impacts) is very similar to the baseline PAR values, with the addition of 0.5 NTU having minimal impact on benthic light levels. As indicated in Figure 2-4, PAR in this range would remain above the lower limit light requirement for most of the simulated period (especially during the growing season of July-Dec).
- At Site B, PAR would remain above the lower limit light requirement even using the high impact zone thresholds. This indicates that the turbidity thresholds are on the conservative side.

Therefore, based on this analysis, the zones of impact derived using the turbidity threshold values in Table 2-7 are considered to be suitable for impact assessment purposes.

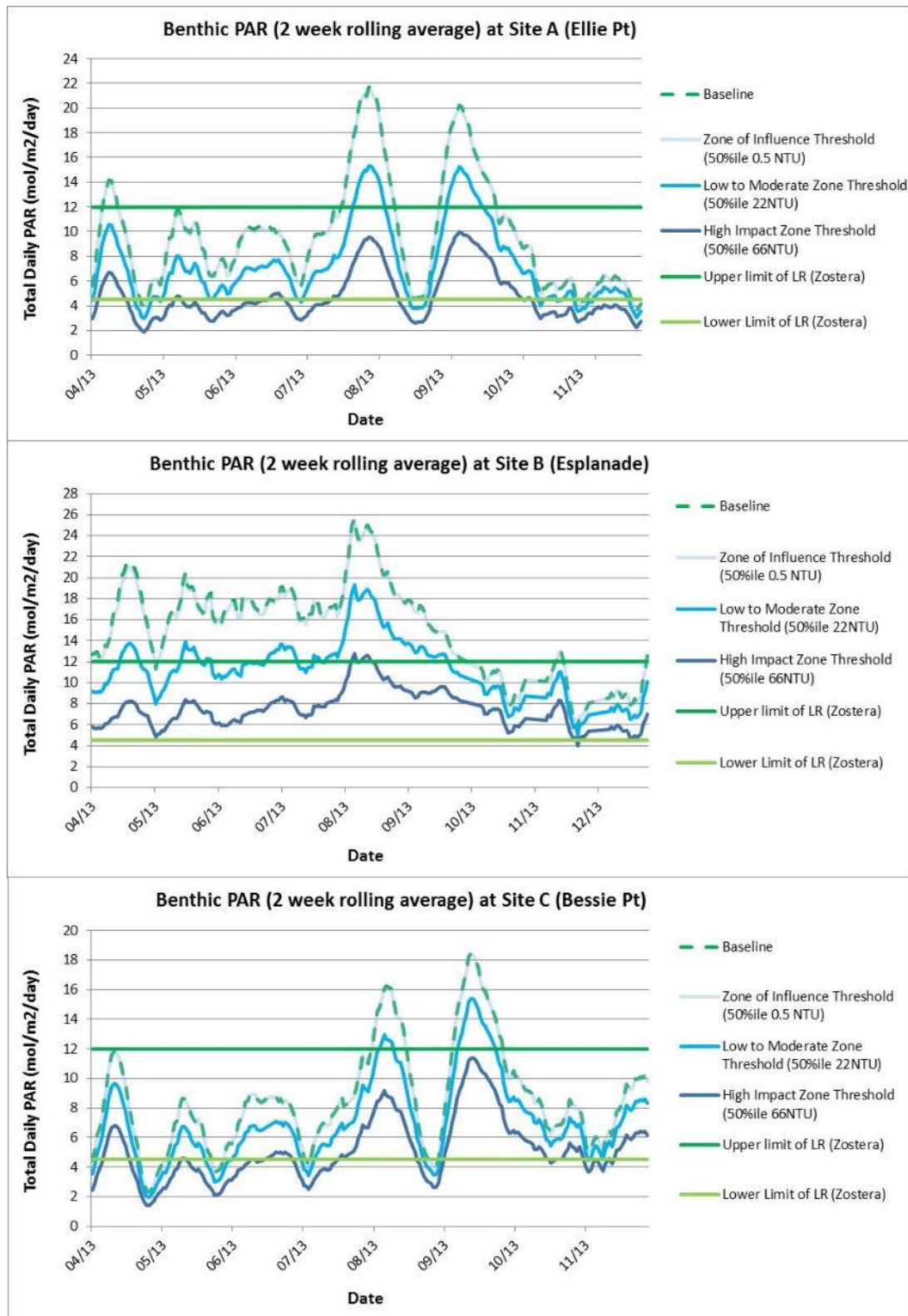


Figure 2-4 Total daily PAR (mol/m²/day as 2 week rolling average) at intertidal seagrass monitoring sites (A, B and C) showing baseline (actual monitoring data) and addition of impact zone thresholds

2.2.6 Sediment Deposition

Sediment deposition impact thresholds should ideally:

- Take into account ambient background conditions at the site
- Be based on the tolerance limits of resident biota, and incorporate different levels of ecosystem stress
- Use consistent methods, and have similar underlying assumptions as modelling with regard to deposition and erosion processes.

2.2.6.1 Tolerance Limits

Tolerance limits vary greatly among species, as outlined in reviews by Erftemeijer *et al.* (2012) for corals, and Erftemeijer *et al.* (2006) for seagrass. In general terms, many corals tend to be more sensitive to sediment deposition than seagrasses (Erftemeijer *et al.* 2006; 2012). On this basis, adopting thresholds that protect corals should protect most seagrass species. However, there is a risk that using coral thresholds for seagrass can overstate sedimentation impacts, particularly those found in turbid depositional environments as occur in Trinity Bay and surrounds, where data on seagrass tolerances to sedimentation is limited.

GBRMPA (2010) recommends sedimentation trigger values of 3 mg/cm²/day (mean annual) and 15 mg/cm²/day (daily maximum) for corals. GBRMPA (2010) indicates that the trigger value has low confidence, but has been developed to mitigate “excessive coral recruit mortality and includes an uncertainty factor for higher organic content or small grain sizes”.

GBRMPA (2010) suggests that this trigger value may not necessarily apply to all environments, and that “experimental evidence suggests that 10 mg/cm²/day sedimentation is valid in areas with coarse calcareous sediments, but trigger levels need to be lower where sediments are largely of terrigenous origin, of small grain size or of high organic content” (De’ath and Fabricius 2008).

Gilmour *et al.* (2006) calculated preliminary estimates of different loads and durations likely to cause increasing levels of impacts to corals. Gilmour *et al.* (2006) cautions that the estimates are based on very limited data from their investigation area (the Pilbara) and other regions, and that levels will need to be refined and corrected through further research. The curves shown in Figure 2-5 apply to relatively tolerant coral taxa in nearshore reef systems in the Pilbara, which can have high background sedimentation rates as occurs in Trinity Bay. These curves were assessed in the benchmarking exercise of the indicative thresholds developed for the purposes of this impact assessment.

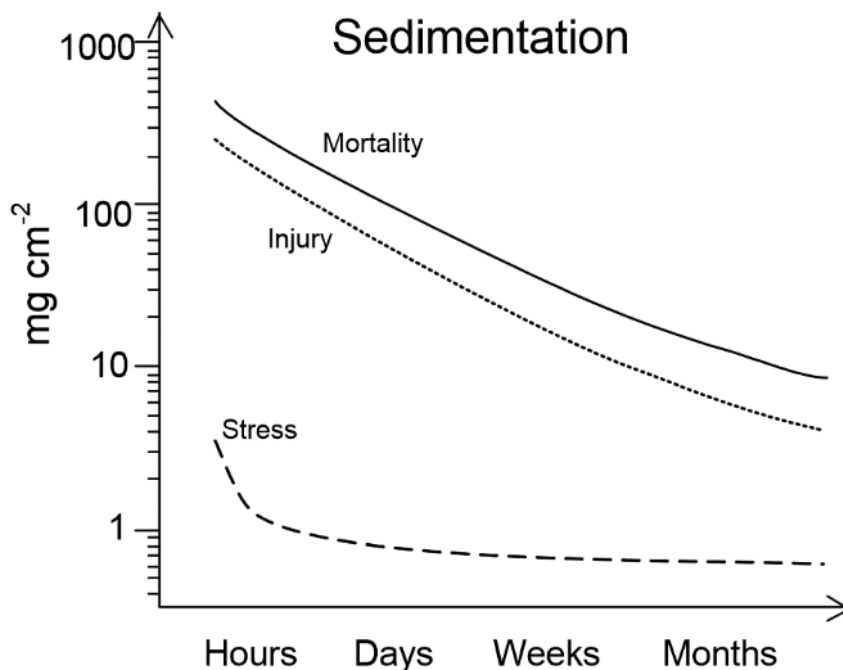


Figure 2-5 Preliminary estimates of loads and durations of sediment likely to cause impacts to corals in north-west Australia (Source: Gilmour et al 2006)

2.2.6.2 Adopted Thresholds

Coral Thresholds

Indicative impact thresholds were developed to assess potential risks of sediment deposition impacts to corals. Similar to the water quality thresholds discussed previously, sediment deposition thresholds were scaled to take into account impact duration and intensity (i.e. 95th percentile equivalent to 1.5 days per month, 50th percentile equivalent to 15 days per month), and benchmarked to:

- GBRMPA (2010) guidelines.
- Gilmour *et al.* (2006) sedimentation loads, as shown in Figure 2-5.
- Sedimentation impact thresholds adopted by DHI (in Chevron 2010) for a dredging project in north west Australia.

It is important to note that GBRMPA (2010) guidelines and Gilmour *et al.* (2006) are based on total sediment deposition levels, whereas impact thresholds adopted by DHI (in Chevron 2010) are for 'excess' sediment resulting from dredging (i.e. above background sedimentation levels) and reportedly take into account the tolerance limits of corals and seagrass found in their investigation area (North West Australia). As the modelling in the present study also reports 'excess' sediment resulting from dredging, a level of conservatism was adopted for the indicative impact thresholds.

The indicative impact thresholds were developed for impact assessment reporting purposes, i.e. prediction of potential impacts of a two-month dredging campaign. These threshold values for corals

are presented in Table 2-8. It is recommended that any future monitoring program should establish trigger values based on locally specific field measurements data, and should supplement the indicative impact thresholds adopted in the present study.

Table 2-8 Impact thresholds for sediment deposition for corals (above background)

Impact zone	50%ile i.e. 15 days per month (mg/cm ² /day)	95%ile i.e. 1.5 days per month (mg/cm ² /day)	Notes
Zone of High Impact	>20.0	>200	- Similar to DHI's most conservative Zone of Mortality threshold of >20 mg/cm²/day averaged over 14 days - More conservative (50th percentile) or similar to (95th percentile) 'mortality' thresholds in Gilmour <i>et al.</i> (2006): - days (>200 mg/cm²) - weeks (>70-80 mg/cm²)
Zone of Low to Moderate Impact	1.5-20	15-200	50%ile (medium term impact) similar to range of GBRMPA (2010) mean annual and daily max values (3-15 mg/cm²/day) - Similar to DHIs most conservative Zone of Partial Mortality thresholds for corals = 5-20 mg/cm²/day averaged over 14 days - Upper bounds approximate 'injury' thresholds in Gilmour <i>et al.</i> (2006): - days (~>100 mg/cm²) - weeks (~>20 mg/cm²)
Zone of Influence	0.5-1.5	5.0-15	- Upper bound of 95%ile value (short term acute impact) = daily max value of GBRMPA (2010), i.e. 15 mg/cm²/day 50%ile (medium term impact) below GBRMPA (2010) mean annual and daily max values (3-15 mg/cm²/day) - Similar to DHI's most conservative ZOI thresholds for corals = 1-5 mg/cm²/day averaged over 14 days

Seagrass Thresholds

As mentioned previously, seagrass tends to be less sensitive to sediment deposition than corals, and using coral thresholds for seagrass can overstate sedimentation impacts. However, there is currently limited data available on sediment deposition thresholds for seagrasses found in turbid depositional environments along the east coast of Australia. There are literature values developed by DHI (in Chevron 2010) which were applied to a dredging project in north west Australia. While the applicability of the DHI thresholds to seagrass in the Cairns region is unknown, the thresholds include the following:

- Zone of high impact: greater than 70 mg/cm²/day
- Zone of low to moderate impact: 20 – 70 mg/cm²/day
- Zone of influence: 3 – 20 mg/cm²/day

2.3 Modelling Outputs

To assist with the impact assessment, dredge plume modelling results from BMT WBM (2017) were used. These modelling results consist of time series results and percentile contour plots.

Similar to the analysis of baseline monitoring data, the percentile contour plots were developed using a 30-day moving window. The percentile impacts correspond to the maximum increase due to dredging of the 30-day moving window derived percentile statistics during the entire simulation. Different locations within the model will have experienced their worst period at different times during the simulation and the different percentile statistics may also have occurred during different 30-day windows. Key features of the 30-day moving window percentile analysis include:

- Consideration of a range of impact durations from acute to chronic.
- Can be applied to a long-term program and capture periods of high intensity versus low intensity impacts.
- A similar analysis applied to the baseline data can quantify the ambient conditions including natural variability across different periods. This can be used to derive meaningful thresholds for the impacts.

When interpreting percentile contour plots presented throughout this report, it is important to note that these are not snap-shots in time and therefore do not represent the spatial extent of the dredge plume at any given time. Instead, these plots indicate the areas where turbidity was elevated at some point during the dredge campaign. The type of percentile plot (e.g. 50th percentile or 95th percentile) indicates the amount of time that the turbidity was exceeded at a particular location.

Percentile contour plots included in this report represent depth averaged turbidity (i.e. turbidity averaged vertically in the water column from surface to sea bed). Percentile plots also showing near-bed turbidity are presented in BMT WBM (2017).

Further details on modelling outputs and assumptions are provided in the BMT WBM (2017).

2.4 Construction Phase Impacts

2.4.1 Turbid Plumes from Capital Dredging

A key concern regarding water quality for the project is from the release of sediment particles to the water body during the capital dredging program. Turbid plumes may occur to some extent as a result of dredging activities.

The proposed capital dredging using a mechanical backhoe dredge (BHD) and a trailer suction hopper dredge (TSHD) will generate turbid plumes. The turbid plumes have the potential to migrate and impact upon nearby sensitive ecological receptors. The extent of the plume will depend on a range of factors including season, wind strength and direction, currents, tide status, type of sediment, location and type of dredge, as well as working methods and productivity.

The total duration of the capital dredging campaign is expected to be approximately 12 weeks for the TSHD, with the BHD dredging component expected to take approximately 5-6 weeks within this dredging period. Modelling was undertaken using the following two dredging scenarios, representing the lower and upper bounds of likely dredging works:

- **Scenario 1** - lower end of the expected total dredge material volume (710,000 m³ of soft material from the channel and 100,000 m³ of stiff clay material from the inner channel and harbour) and limited overflow from the TSHD (maximum 10 minutes of overflow).
- **Scenario 2** - upper end of the expected total dredge material volume (900,000 m³ of soft material from the channel and 100,000 m³ of stiff clay material from the inner channel and harbour) and less-restricted overflow from the TSHD (30 minutes of overflow per cycle).

Modelling of both dredging scenarios was undertaken over three different weather periods (representing a range of wind and wave conditions), with the best and worst of the modelling outputs representing the 'likely best case' and 'likely worst case' scenarios presented in this report. These scenarios provide lower and upper bounds to expected water quality impacts.

It should be noted that extreme climatic events are not included as part of the worst-case scenarios as dredging would be unlikely to be occurring during these periods as dredging is proposed to be undertaken during the dry season. Furthermore, the dredge would not likely operate during extreme conditions for safety reasons.

2.4.1.1 Screening Assessment against Water Quality Guidelines and Baseline Data

An initial high level screening assessment of the potential impacts to median water quality concentrations based on the modelling data was undertaken for the sensitive ecological receptor sites where baseline monitoring was undertaken (refer to Figure 2-2 for locations).

Results for this approach are presented in Table 2-9, which shows potential increases to median concentrations at the water quality monitoring locations.

Table 2-9 Predicted impacts to median turbidity

Location	Water Quality Conditions	Median Turbidity (NTU)	
		Likely Best Case	Likely Worst Case
Palm Cove Beach	Increase above ambient	0.1	0.5
	Ambient condition	22	22
	% Increase	0.5%	2.3%
Yorkeys Knob	Increase above ambient	0.5	1.3
	Ambient condition	19	19
	% Increase	2.6%	6.8%
Trinity Bay	Increase above ambient	2.4	7.2
	Ambient condition	16	16
	% Increase	15.0%	45.0%
Trinity Inlet - Upper	Increase above ambient	0.5	2.1
	Ambient condition	12	12
	% Increase	4.2%	17.5%
Trinity Inlet - Lower	Increase above ambient	2.0	3.8
	Ambient condition	16	16
	% Increase	12.5%	23.8%
False Cape	Increase above ambient	0.4	1.2
	Ambient condition	28	28
	% Increase	1.4%	4.3%
Cape Grafton	Increase above ambient	0.03	0.1
	Ambient condition	31	31
	% Increase	0.1%	0.3%
Existing DMPA	Increase above ambient	0.00	0.01
	Ambient condition	6	6
	% Increase	0.0%	0.2%
QWQG (annual)		10	

Note: Shaded cells indicate exceedance of the QWQG guideline value

The results in Table 2-9 indicate that capital dredging will only minimally increase median turbidity values (less than 7 percent increase) at most locations compared to ambient conditions. Areas where ambient median turbidity is expected to increase more substantially include Trinity Bay (up to 45% during worst case – however this is located next to the channel dredging), and Trinity Inlet, where increases of up to 18% (Trinity Upper) and 24% (Trinity Lower) are expected during the worst case. Notwithstanding that ambient turbidity in these areas is already elevated above the water quality guideline value (10 NTU), further assessment was undertaken and discussed in the following sections.

2.4.1.2 Percentile Plots

The following percentile contour plots (Figure 2-7 and Figure 2-8) show depth averaged dredging-related turbidity above background levels. Note that these plots include capital dredging by the TSHD and the BHD. Also note that the scales used on the plots differ between the 50th and 95th percentiles

to reflect ambient turbidity during these varying conditions. Plots shown are based on the following percentile values:

- 50th percentile plot (Figure 2-7) - typical (median) turbidity levels, which occur 50 percent of the time.
- 95th percentile plot (Figure 2-8) - infrequent periods (occurring five percent of the time) of high turbidity.

For context, percentile contour plots showing modelled ambient turbidity (without dredging) during 50th and 95th percentile conditions are provided in Figure 2-6.

Figure 2-7 indicates that as a result of capital dredging, median (50th percentile) turbidity is predicted to increase slightly (up to 2 NTU for the best case and up to 6 NTU for the worst case) along the northern coastline up to Double Island. Turbid plumes are also predicted to mobilise up Trinity Inlet due to dredging in the inner port, with median turbidity predicted to increase by approximately 2-4 NTU in Trinity Inlet. The greatest increase to median turbidity is predicted to be in and adjacent to the outer channel dredging area, which is predicted to increase by approximately 10-20 NTU.

Figure 2-8 indicates that under 95th percentile conditions, turbidity is predicted to increase by approximately 10-30 NTU above background conditions (approximately 100-150 NTU) in close proximity to the outer channel dredging area, and up to 10 NTU above background conditions (approximately 75 NTU) in Trinity Inlet.

Due to the predominant south-easterly wind and wave direction in the area, turbid dredge plumes are less likely to mobilise in an easterly direction towards False Cape and Cape Grafton.

The impact significance of these results is interpreted using time series plots and zones of impact in the following section.

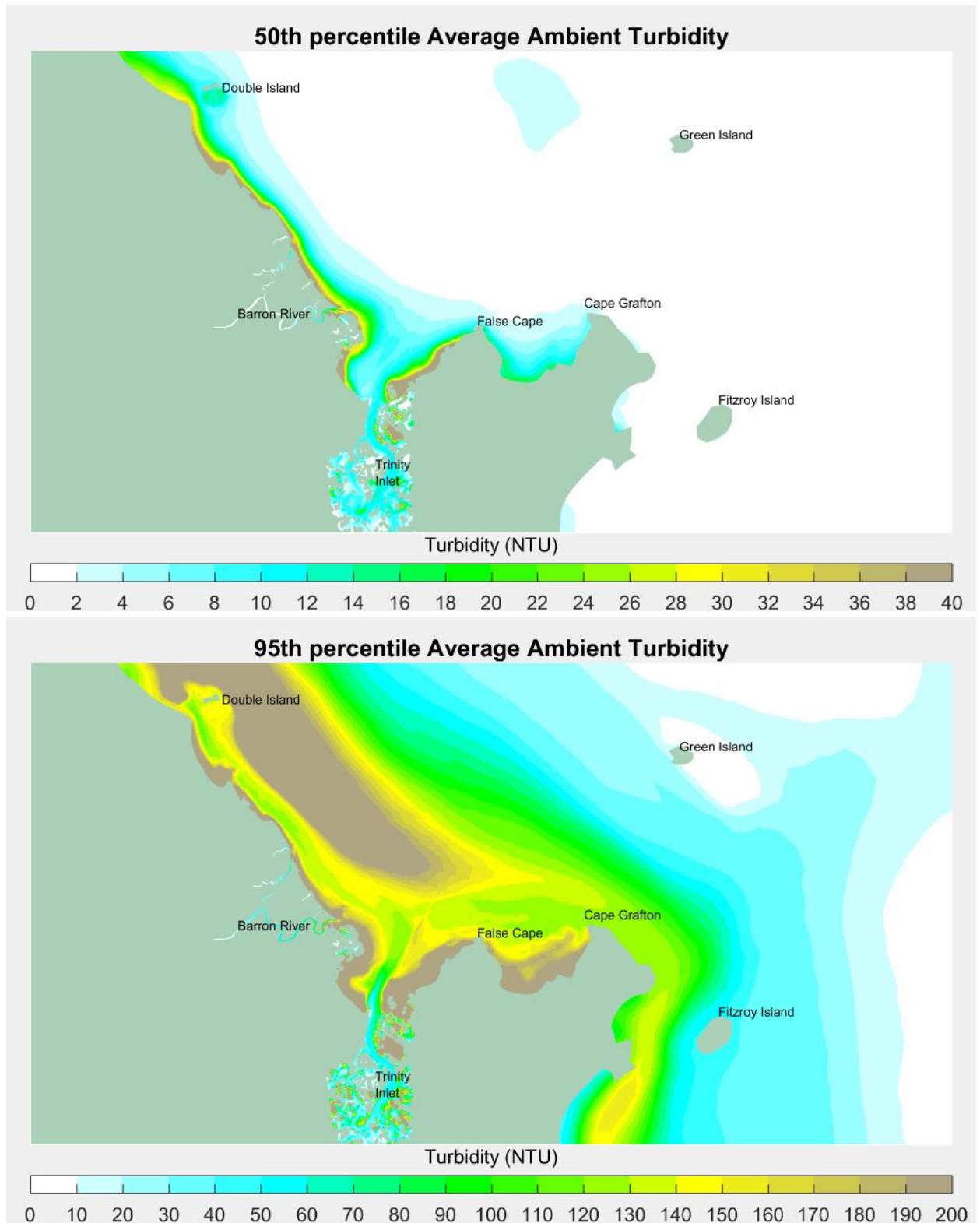


Figure 2-6 Modelled ambient turbidity (without dredging) – 50th percentile (top) and 95th percentile (bottom)

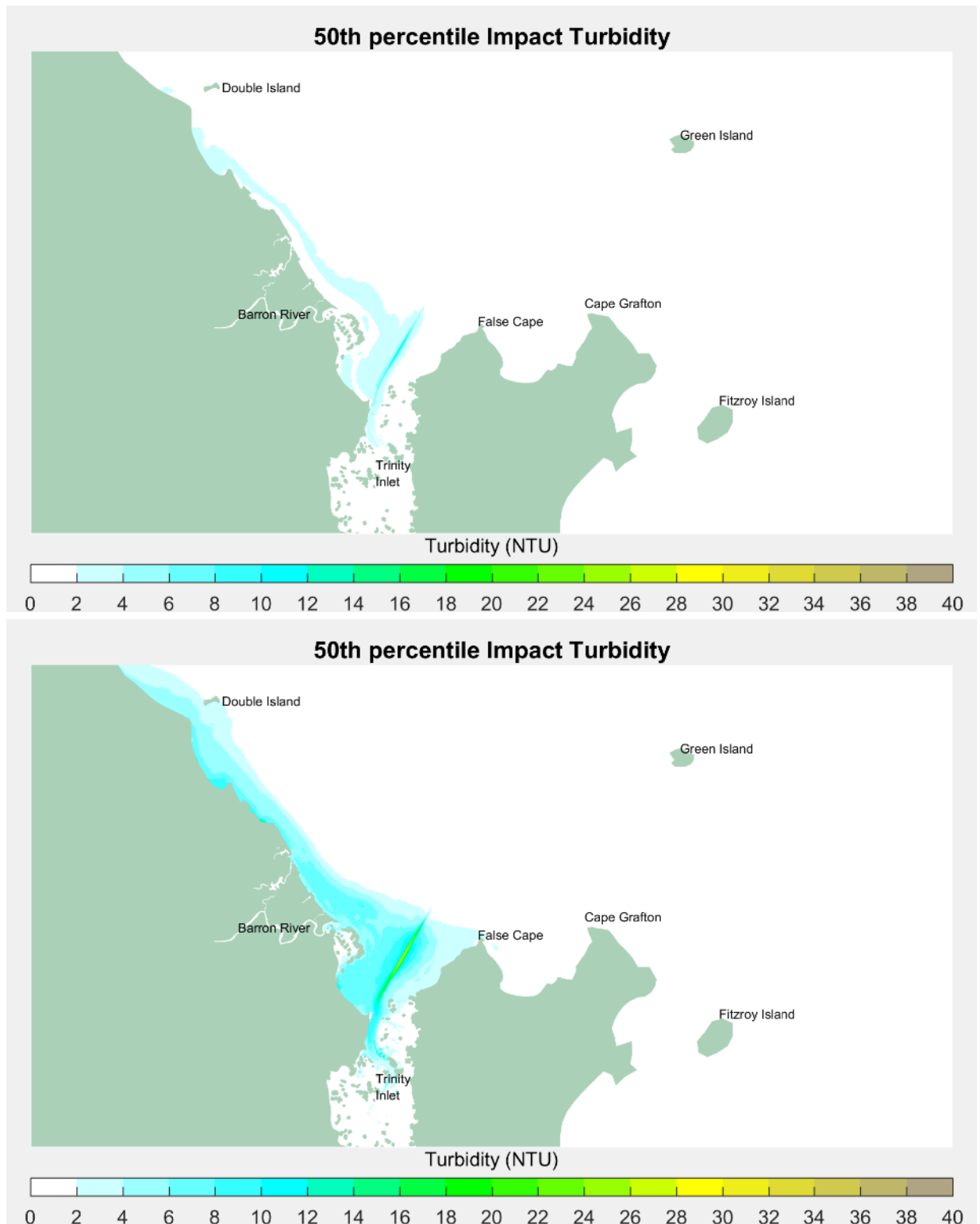


Figure 2-7 Impact of dredging on 50th percentile turbidity – likely best case (top) and likely worst case (bottom) (scale: 2 to 40 NTU)

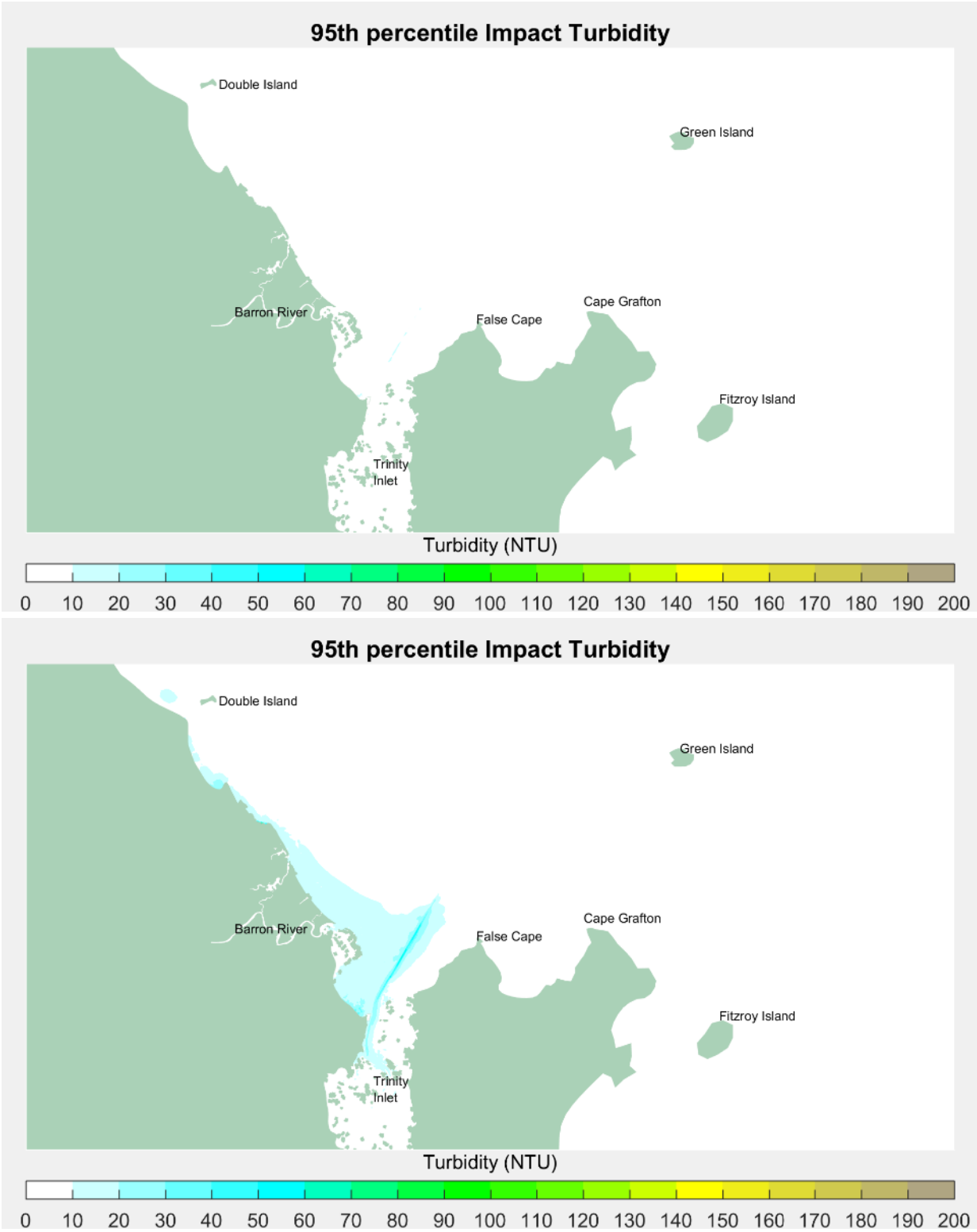


Figure 2-8 Impact of dredging on 95th percentile turbidity – likely best case (top) and likely worst case (bottom) (scale: 10 to 200 NTU)

2.4.1.3 Time Series Plots

The above sections presented the turbid plumes predicted by modelling of the capital dredging campaign. These predicted turbid plumes would consist of suspended sediment from the dredge plume and subsequent re-suspension of dredge material during wind and wave events over the modelling period. However, in addition to the suspended sediment from dredge material, there would also be a proportion of naturally occurring suspended sediment in the water column from natural re-suspension during windy conditions.

Therefore, to put the magnitude of modelled turbid plumes into some context at locations of sensitive receptors, ambient turbidity from natural re-suspension was modelled for the duration of the dredging campaign. This enables a comparison of ambient turbidity to dredge-related turbidity at sensitive receptors.

The time series data was extracted from the model at six of the baseline water quality monitoring locations, representing sensitive receptors (Section 2.4.1.1).

Figure 2-9 and Figure 2-10 present time series plots of ambient turbidity versus dredge-related turbidity, with ambient turbidity shown as green lines and dredge-related turbidity shown as blue lines (note the different turbidity scales on the y axis for each location). These plots indicate that sediment from natural re-suspension is the dominant source of turbidity at all sites. The only plots where dredge-related turbidity is noticeable is at Trinity Bay which is close to the outer channel dredging area, and at Trinity Inlet which is relatively close to the inner harbour dredging area. Ambient turbidity is much lower in Trinity Inlet than other sites and therefore dredge-related turbidity is more noticeable. Nevertheless, spikes in dredge-related turbidity at these two sites also correspond to spikes in ambient turbidity when climatic conditions lead to wave and wind conditions that re-suspend sediment and/or during spring tides in Trinity Inlet.

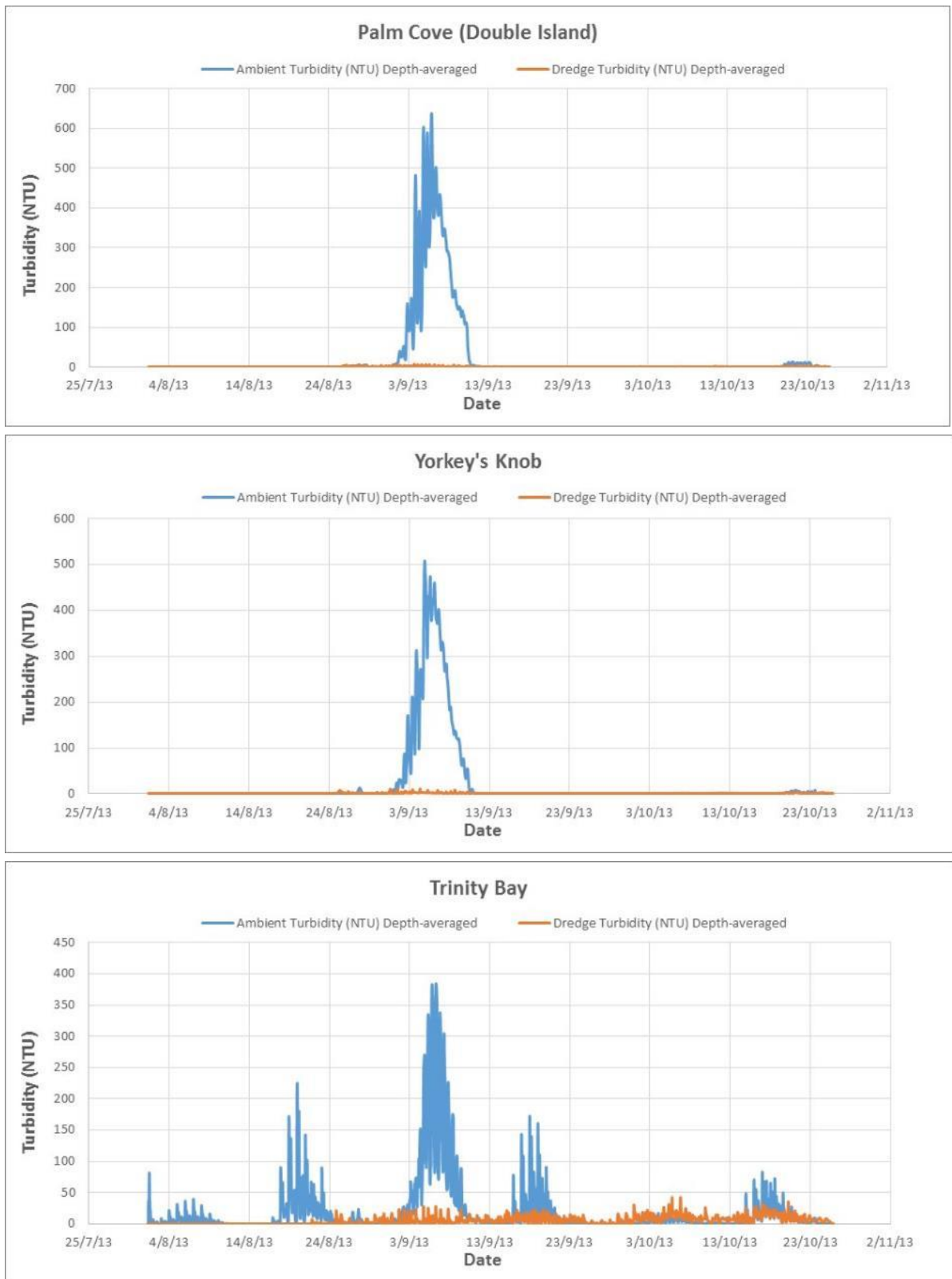


Figure 2-9 Natural re-suspension (ambient sediments) vs. dredge sediments – Palm Cove (top), Yorkey's Knob (middle) and Trinity Bay (bottom)

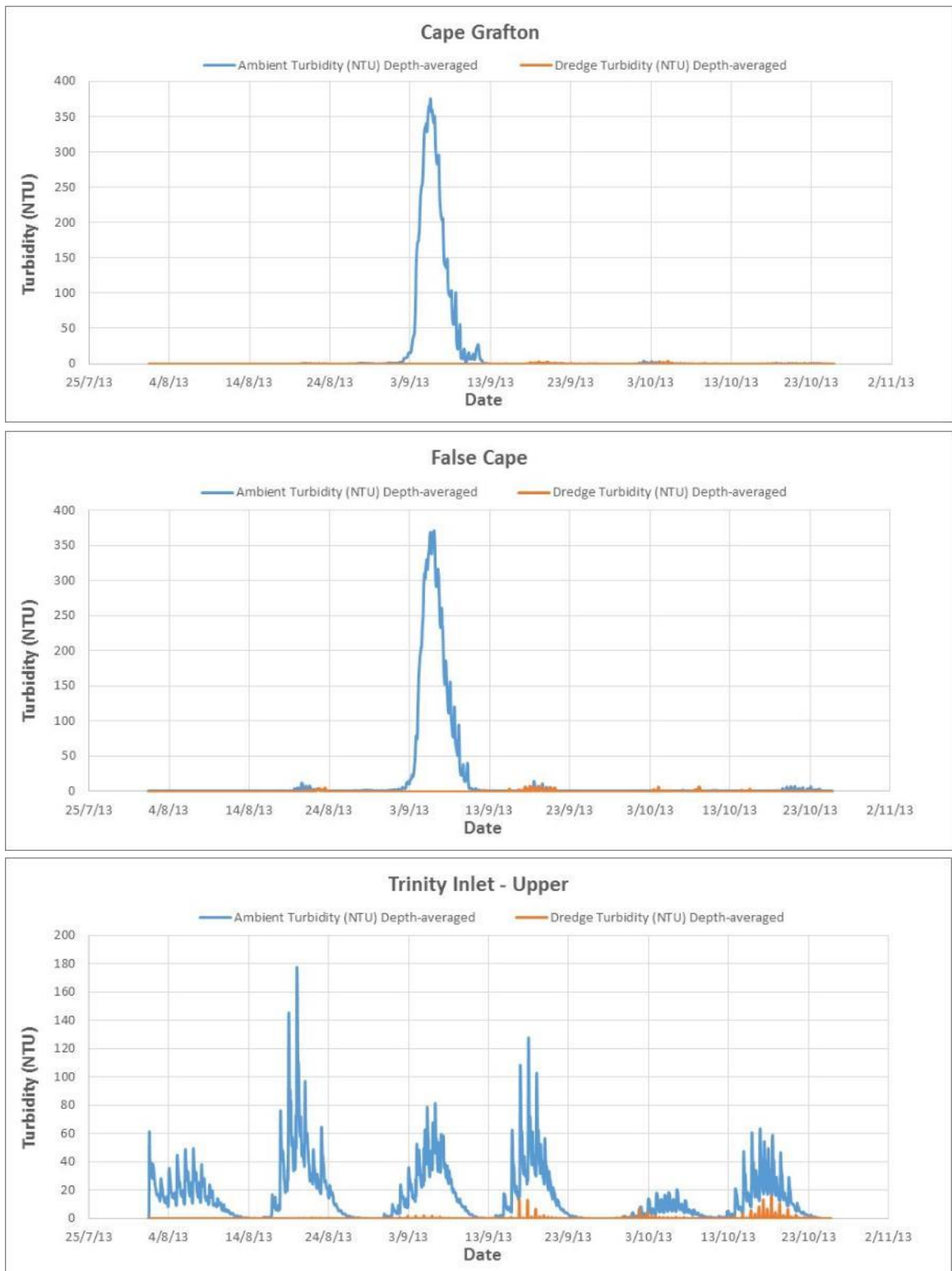


Figure 2-10 Natural re-suspension (ambient sediments) vs. dredge sediments – Cape Grafton (top), False Cape (middle) and Trinity Inlet (bottom)

2.4.1.4 Zones of Impact

In accordance with the methodology presented earlier, spatial zones of predicted impact were developed using site-specific impact threshold values from the baseline monitoring data (described in Section 2.2). These impact zone maps indicate areas where modelled turbidity is higher than the relevant impact threshold value. The impact zone map is shown in Figure 2-11, with the likely best case and likely worst case shown to provide an indication of the lower and upper bounds of impact predictions for capital dredging. The impact zones are described as follows:

- Zone of Influence - extent of detectable plume, but no predicted ecological impacts.
- Zone of Low to Moderate Impact – water quality may be pushed beyond natural variation potentially resulting in sub-lethal impacts to ecological receptors and/or mortality with recovery between six months (lower end of range) to 24 months (upper end of range).
- Zone of High Impact – water quality would most likely be pushed beyond natural variation (excluding extreme weather events) potentially resulting in mortality of ecological receptors with recovery greater than 24 months.

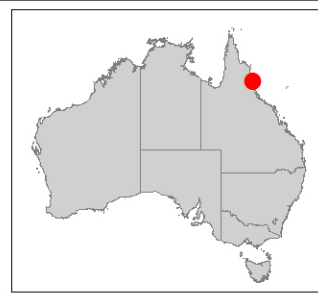
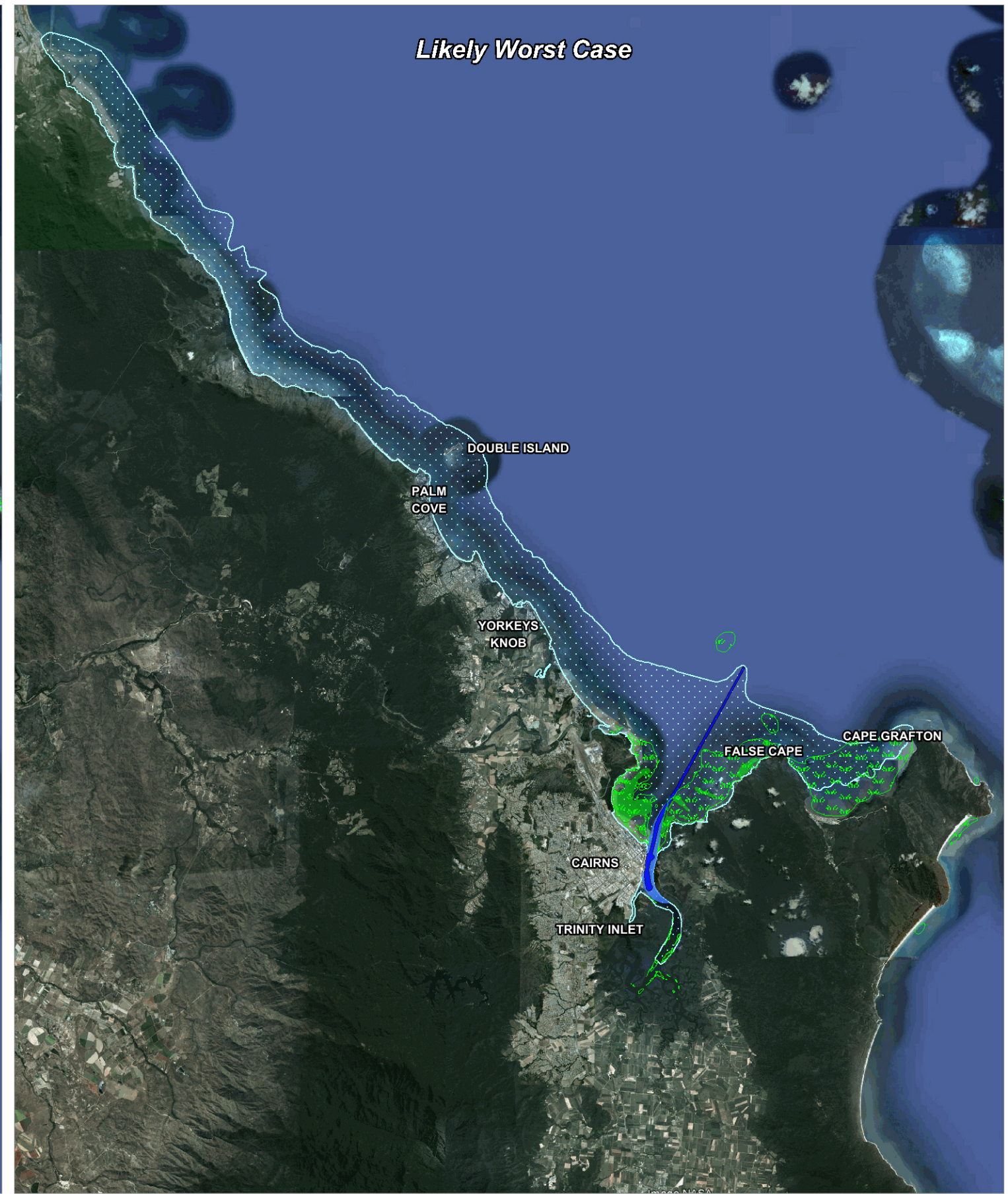
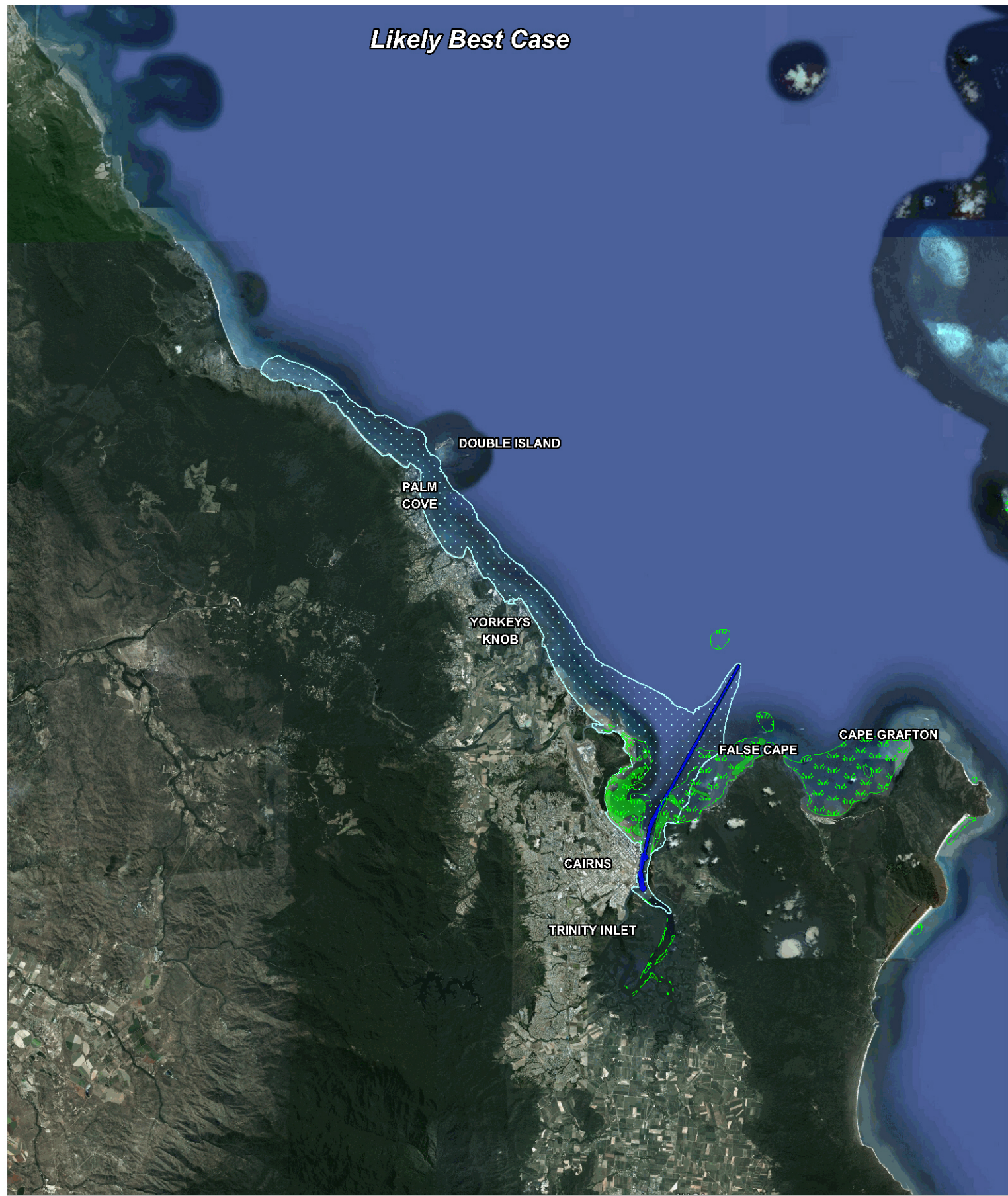
Also shown on the zone of impact figures are seagrass extents (from annual monitoring undertaken by JCU). These seagrass extents are shown as the historical maximum seagrass extent (from monitoring data collected between 1984 and 2015) and the most recently available seagrass extent from 2015. Note that 2016 seagrass data was not available at the time of writing, but preliminary indications are that the extent is similar to 2015.

Figure 2-11 indicates that the zone of influence (i.e. extent of detectable plumes but no predicted ecological impact) extends from the outer channel dredging area northwards along the coastline to approximately 10 km past Double Island for the likely best case, and approximately 30 km past Double Island for the likely worst case. Under a likely worst case scenario, the zone of influence is also predicted to extend in an easterly direction to Cape Grafton.

From the inner port dredging area, the zone of influence extends up Trinity Inlet along the eastern extent of Admiralty Island, with the zone of influence extending up to the seagrass areas under a likely worst case scenario (Figure 2-12).

For the likely best case, the zones of impact (not including the zone of influence) are limited to the dredging footprint (high impact zone). For the likely worst case, a zone of low to moderate impact zone is predicted to extend southwards along Trinity Inlet for approximately 2 km, and northwards for approximately 2 km adjacent to the channel out to the channel bend. The zones of impact are not predicted to occur within historic seagrass meadows (Figure 2-12).

It should be noted that the zones of impact in Figure 2-11 only relate to potential impacts from increased turbidity in the water column. Other impacting processes which may affect sensitive ecological receptors (such as sediment deposition and benthic habitat disturbance) are discussed further in Section 2.4.2 and the Marine Ecology Chapter of the EIS.



LEGEND

Historic Seagrass Extent (1984 - 2015)
 2015 Seagrass Extent

Zones of Impact

Zone of Influence (no ecological impacts)
 Zone of Low to Moderate Impact
 Zone of High Impact

Title: **Zones of Impact - Turbidity - Capital Dredging**
Likely Best Case (left) and Likely Worst Case (right)

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.

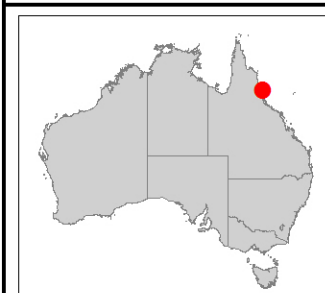
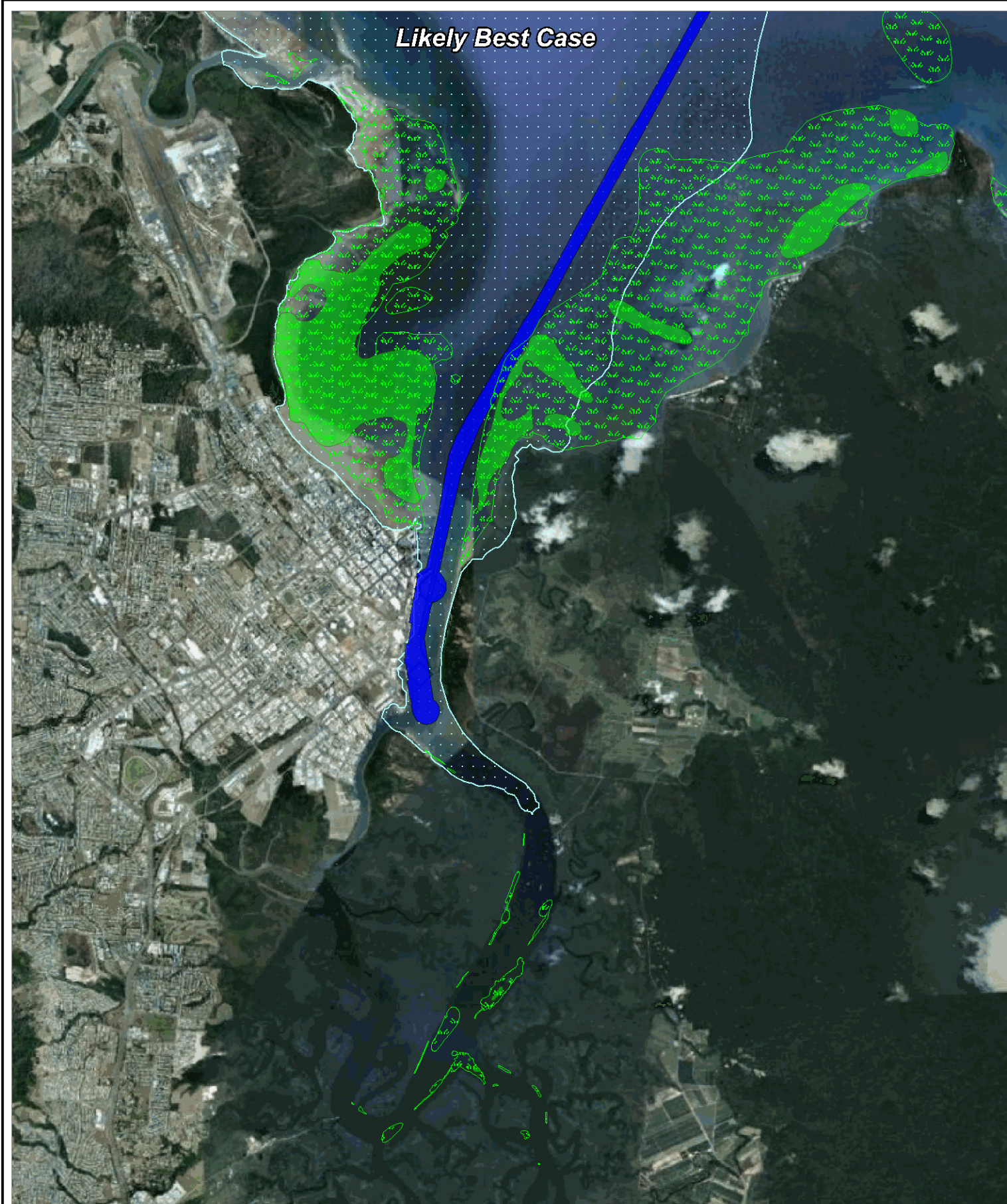
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Figure: **2-11**

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LEGEND

- Historic Seagrass Extent (1984 - 2015)
- 2015 Seagrass Extent
- Zones of Impact**
 - Zone of Influence (no ecological impacts)
 - Zone of Low to Moderate Impact
 - Zone of High Impact

Title:

Zones of Impact - Turbidity - Capital Dredging (Trinity Inlet) Likely Best Case (left) and Likely Worst Case (right)

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.



0 2.5 5 km
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2-12

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A



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2.4.1.5 Prop Wash

The TSHD will be steaming between the channel dredging area and the dredge pump-out mooring location (refer to Figure 2-16) during each dredge cycle to pump the dredge material onshore. While there will be no prop wash while the dredge is moored and pumping, there may be some prop wash while the dredge steams across the shallower nearshore areas. This prop wash has the potential to disturb bed sediments resulting in turbid plumes.

A sensitivity case was modelled which simulated this prop wash as a sediment source in the nearshore areas during each dredge cycle. The results are presented in BMT WBM (2017), and indicate that turbid plumes from the prop wash are predicted to be negligible.

In terms of BHD dredging, there may be minor and infrequent prop wash during will be BHD positioning. Also, there may be minor prop wash from barge and tug movements along Smiths Creek to the Tingira Street DMPA. It is likely that the effect of such activities would be of a similar scale to what currently occurs from existing tug and barge operations to that area, with small and localised short term events, primarily around the shallow areas of the proposed unloading area. Therefore, any that turbid plumes from the BHD dredging (and associated activities) prop wash are predicted to be negligible.

2.4.1.6 Summary of Key Findings – Capital Dredging Turbid Plumes

The predicted impacts for each scenario have been determined based on the impact significance criteria defined in Section B5.5 and can be summarised as follows.

Dredging of Inner Port

Based upon the high-level assessment against the QWQG, median turbidity levels are predicted to increase by up to 4% (Trinity Upper) and 13% (Trinity Lower) during the best case, and up to 18% (Trinity Upper) and 24% (Trinity Lower) during the worst case for a short-term duration of up to 12 weeks.

Assessment of ambient turbidity from natural re-suspension versus dredge-related turbidity indicated that Trinity Inlet is predicted to have some noticeable spikes in dredge-related turbidity (note that ambient turbidity is much lower at this site and therefore dredge-related turbidity is more noticeable). However, spikes in dredge-related turbidity at this site are predicted to correspond to spikes in ambient turbidity during spring tides (conditions which typically resuspend sediment within Trinity Inlet).

The percentile contour plots indicated that median turbidity is predicted to increase slightly (up to 4 NTU) within Trinity Inlet. 95th percentile turbidity is predicted to increase up to 10 NTU above background 95th percentile conditions in Trinity Inlet for a period of 12 weeks.

Using the zone of impact methodology, a zone of influence (i.e. extent of detectable plumes but no predicted ecological impacts) is predicted to extend from the inner port southwards along Trinity Inlet to areas of historical seagrass. A zone of low to moderate impact is predicted to extend approximately 2 km southwards along Trinity Inlet and approximately 2 km northwards adjacent to the channel (but not within historic seagrass meadows) only under a likely worst case scenario.

Therefore, based on these assessments overall, short-term minor impacts (Table 2-1) are expected from turbid plumes generated from capital dredging in the inner port.

Dredging of Outer Channel

Based upon the high-level assessment against the QWQG, median turbidity levels are expected to increase by up to 15% in Trinity Bay during the likely best case scenario, and up to 45% in Trinity Bay during the likely worst case scenario. However, the Trinity Bay site is located approximately 150 m away from the channel dredging area (Figure 2-2).

Assessment of ambient turbidity from natural re-suspension versus dredge-related turbidity predicted that sensitive ecological receptor sites (Figure 2-2) would receive a much larger proportion of natural sediment re-suspension compared to dredged sediment.

The percentile contour plots indicated that median turbidity is predicted to increase slightly (up to 6 NTU) due to dredging of the outer channel. 95th percentile turbidity is predicted to increase by approximately 10-30 NTU above background 95th percentile conditions.

Using the zone of impact methodology, a relatively small zone of low to moderate impact is predicted to occur near the bend in the channel close to the inner port area. A zone of influence is predicted to occur for the remaining areas in the vicinity of the outer channel dredging.

The model outputs suggest that under the likely worst case scenario, turbid dredge plumes are predicted to be slightly increased in the near shore environment along the coastline to the north of the dredging area and to the east towards Cape Grafton (these plumes would be detectable with instrumentation but may not be visible to the naked eye). However, marine water quality is not predicted to change significantly.

Therefore, based on these assessments overall, short-term minor impacts (Table 2-1) are expected from turbid plumes generated from the capital dredging in the outer channel.

2.4.2 Sediment Deposition from Capital Dredging

While the previous section assessed impacts to water quality from suspended sediments in the water column as a result of turbid dredge plumes, this section assesses the potential impacts in terms of sediment deposition from the settlement of these suspended sediments.

Details on the predicted sediment deposition impacts throughout the study area are provided in BMT WBM (2017). In brief, sedimentation resulting from the deposition of suspended solids from dredging plumes are predicted to occur as shown in Figure 2-13 and Figure 2-14 for the likely best and worst cases for capital dredging.

The impact significance of the sediment deposition results as they relate to corals is interpreted using sediment deposition zones of impact as described in Section 2.2.6. The zones of impact for corals are shown in Figure 2-15, which indicates that while there is predicted to be zones of impact within and adjacent to the channel, the zones of impact do not coincide with areas containing coral reefs within the study area (including Double Island and Rocky Island). While a zone of influence is predicted to extend near to Rocky Island reef during the likely worst case scenario, there are no ecological impacts predicted within this zone of influence. Potential impacts to coral reefs from sediment deposition are assessed further in the Marine Ecology Chapter of the EIS.

Assessment of Potential Impacts

While the zones of impact are likely to extend over some historical seagrass areas, seagrasses are typically less sensitive to sediment deposition. However, as the thresholds are less certain (refer to Section 2.2.6), zones of impact as they relate to seagrass are not presented in this report, but potential impacts to seagrass from sediment deposition is discussed in Marine Ecology Chapter of the EIS.

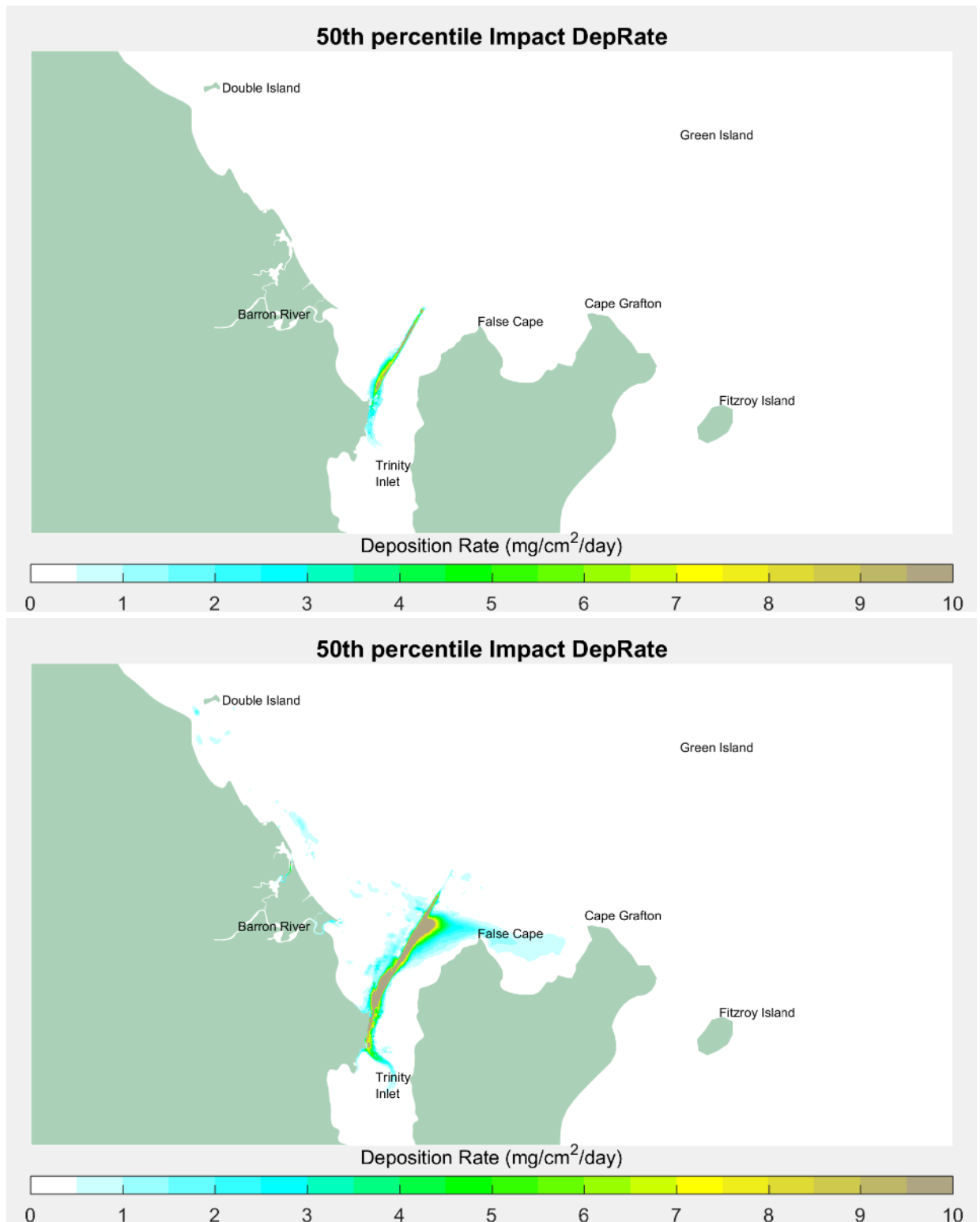


Figure 2-13 Impact of dredging on 50th percentile sediment deposition – likely best case (top) and likely worst case (bottom) (scale: 0.5 to 10 $\text{mg}/\text{cm}^2/\text{day}$)

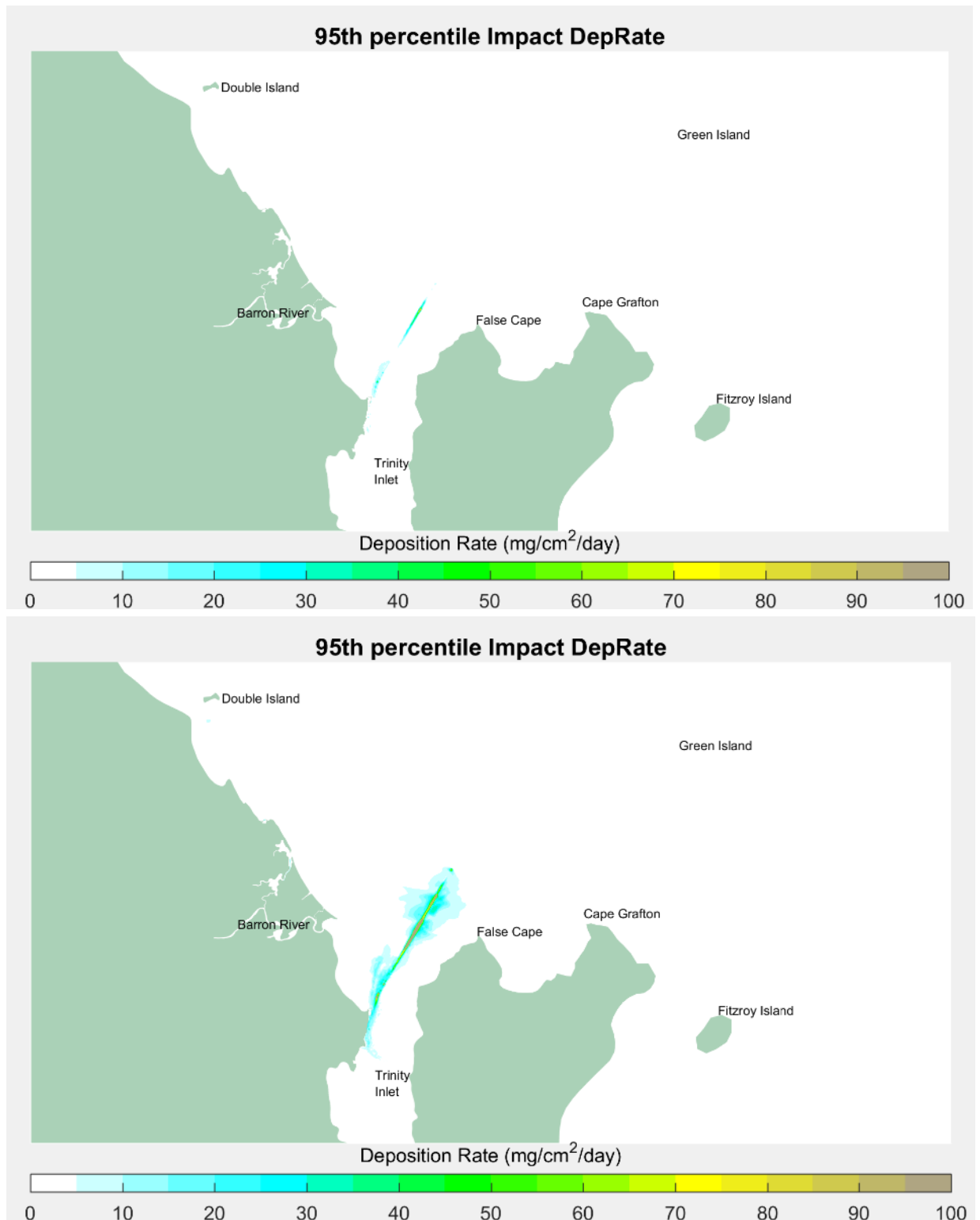
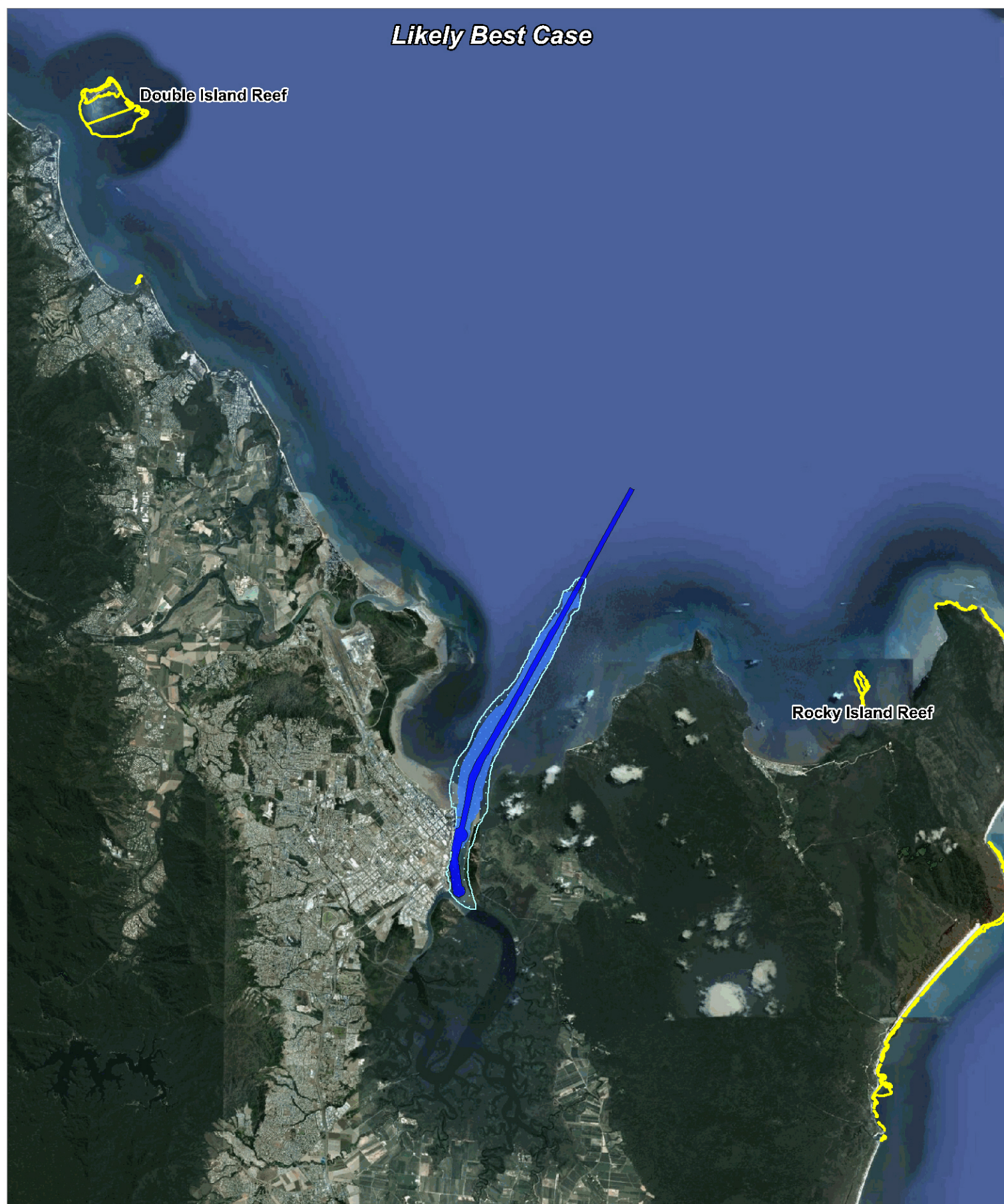
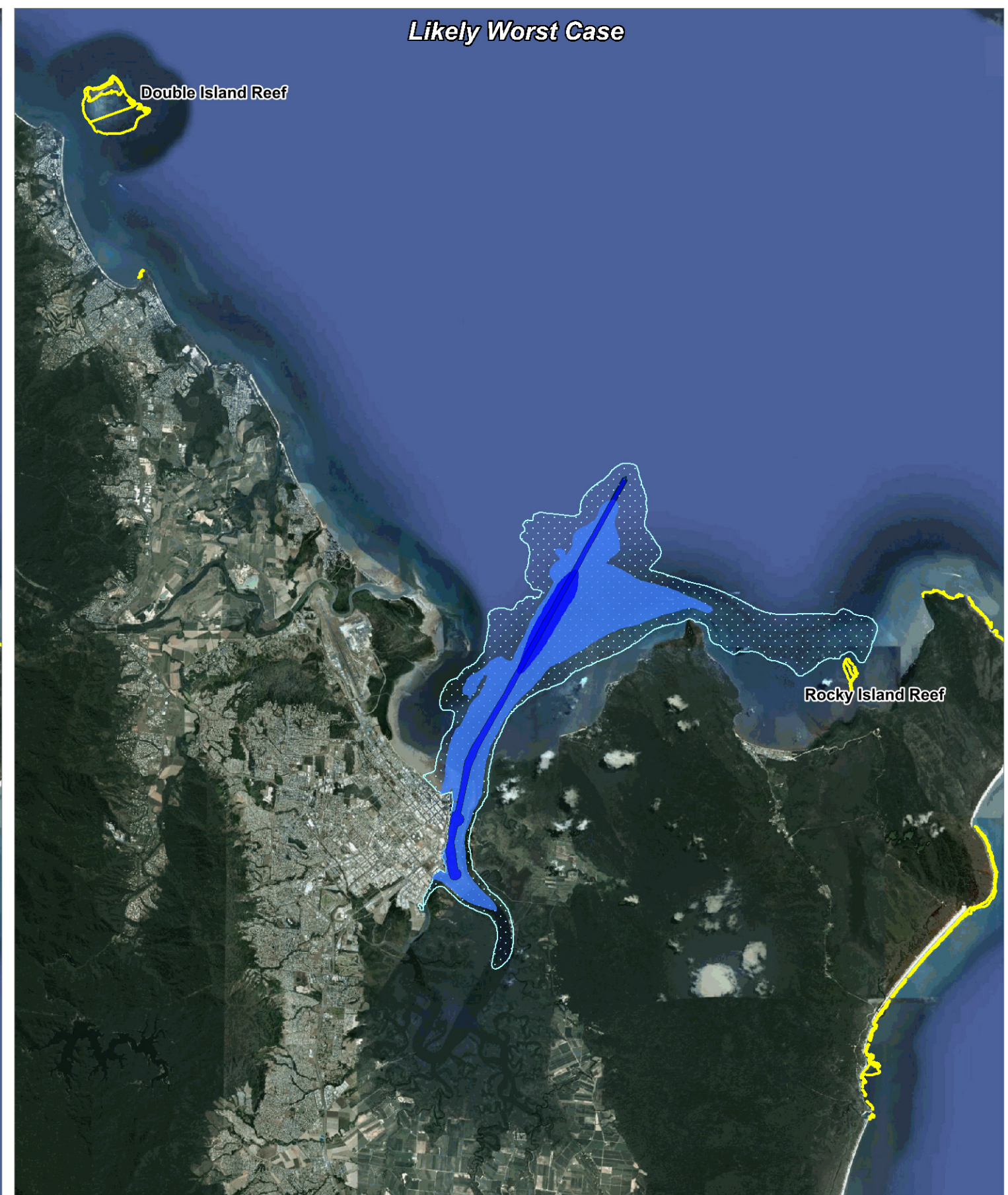


Figure 2-14 Impact of dredging on 95th percentile sediment deposition – likely best case (top) and likely worst case (bottom) (scale: 5 to 100 $\text{mg}/\text{cm}^2/\text{day}$)

Likely Best Case



Likely Worst Case



LEGEND

- Coral Reefs
- Zones of Impact**
- Zone of Influence (no ecological impacts)
- Zone of Low to Moderate Impact
- Zone of High Impact

Title:

**Zones of Impact (Corals) - Sediment Deposition
Likely Best Case (left) and Likely Worst Case (right)**

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0 km 5 10
Approx. Scale

Figure:

2-15

Rev:

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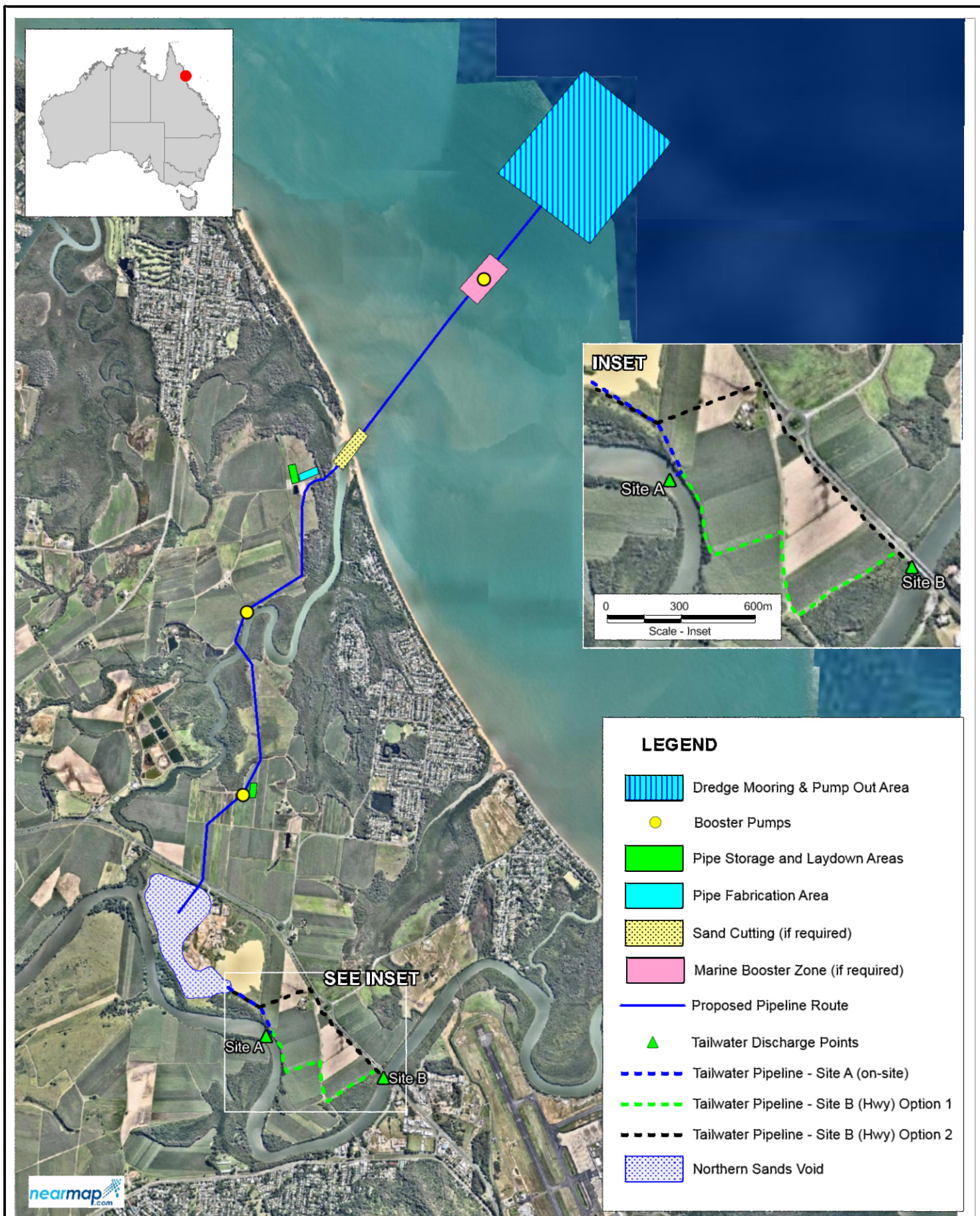
2.4.3 Tailwater Impacts – Northern Sands DMPA

Dredge material placement is proposed to be placed at the Northern Sands dredge material placement area (DMPA). Dredge material will be pumped to shore via a pipeline from the dredge mooring and pump-out area to the Northern Sands DMPA located in the Barron River delta (Figure 2-16).

As shown in Figure 2-16, it is proposed that tailwater from the DMPA will be discharged into the Barron River via either of two discharge locations – Discharge Point A (adjacent to the DMPA) and Discharge Point B (near the Captain Cook highway bridge located approximately 2.5 km downstream of the DMPA).

For the tailwater modelling, it was assumed that tailwater would be discharged at a constant rate of 1 m³/s, with a salinity of 35 ppt (or 35 PSU) and total suspended solids (TSS) of 100 mg/L (approximately equivalent to a turbidity of 60 NTU). Conservatively, only the likely worst case tailwater discharge scenario was modelled, which assumes the upper range of tailwater discharge volume based on the upper range of expected dredge material volumes.

To assess potential impacts to the Barron River and Thomatis / Richters Creek from tailwater discharges, model outputs were provided for turbidity and salinity, and are discussed in the following sections.



Title:
Northern Sands Dredge Material Placement Configuration

Figure:

2-16

Rev:

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0 800 1,600m
Approx. Scale



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2.4.3.1 Turbidity

Contour Plots

Contour plots showing the changes to 50th percentile turbidity are presented in Figure 2-17. These contour plots represent changes to median turbidity (50th percentile) due to the tailwater discharges from both discharge options.

The 50th percentile contour plots indicate that the tailwater discharges are predicted to increase median turbidity by up to 4 NTU in a localised area within approximately 100 m of the discharge locations. Turbidity increases up to 3 NTU above median ambient turbidity are predicted to extend approximately 500 m upstream and downstream of Discharge Point A and approximately 200 m upstream and downstream of Discharge Point B.

Turbidity increases up to 1 NTU are predicted to extend up to the confluence with Thomatis / Richters Creek for Discharge Point A, and up to adjacent to the DMPA for Discharge Point B. While turbidity increases extend further downstream for Discharge Point B, median turbidity is not expected to increase at the mouth of the Barron river.

Zones of Influence

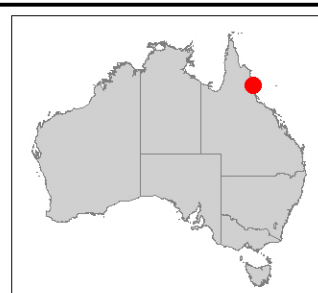
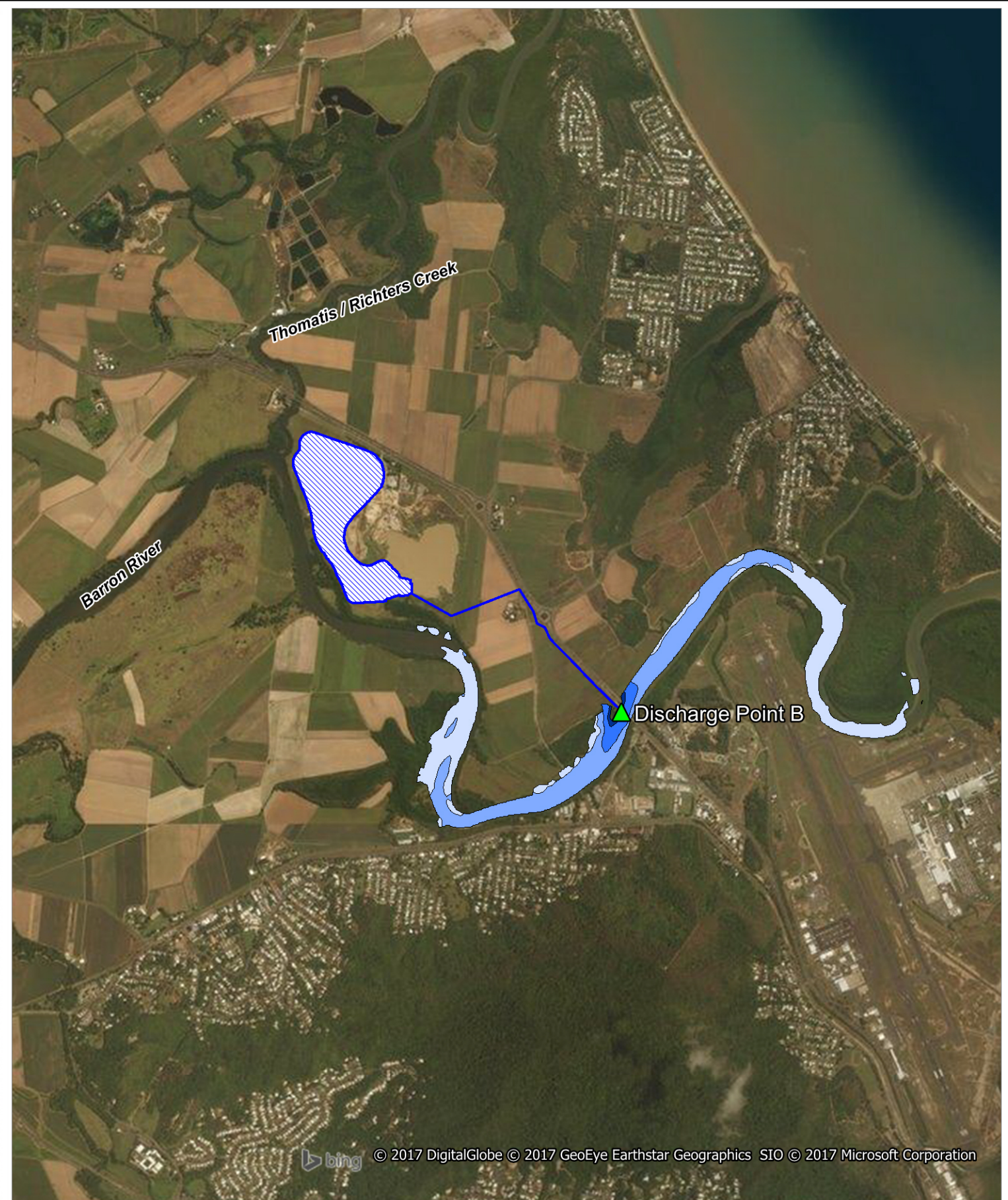
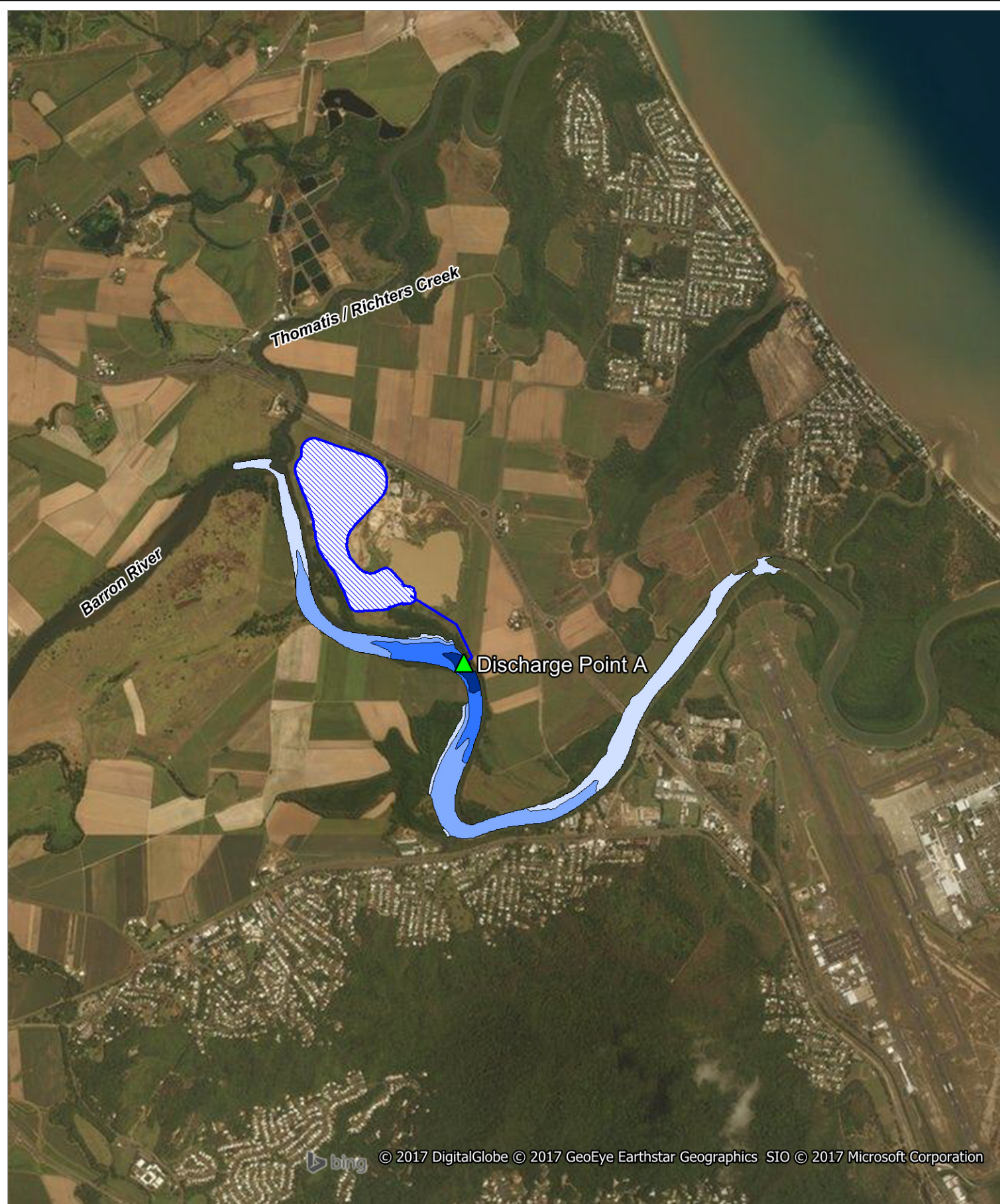
The significance of the tailwater discharges in terms of turbidity impacts is interpreted using zones of impact. These zones of impact are described in Section 2.2, and are shown in Figure 2-18 for both options for tailwater discharge.

The zones of impact indicate that only a zone of influence is predicted in the Barron River for both discharge options. There are no zones of low to moderate impact, or zones of high impact, predicted in the receiving waters.

As shown in Figure 2-18, for Discharge Point A (adjacent to DMPA) the zone of influence extends up to the confluence with Thomatis / Richters Creek, but plumes do not extend into Thomatis / Richters Creek. For Discharge Point B (Captain Cook Highway bridge), the zone of influence extends up to the DMPA and down to near the mouth of the Barron River.

Overall, the difference between the two discharge options is minimal, with negligible impacts predicted for both options. With median ambient turbidity in the Barron River of approximately 20 NTU, a tailwater discharge of approximately 60 NTU, and the volume of discharge (1 m³/s) compared to typical dry season Barron River flows (~ 5 m³/s), these negligible impacts are not unexpected.

However, with seagrass meadows found historically at the Barron River mouth (refer to Figure 2-12), the discharge location further upstream (i.e. Discharge Point A) would pose the least risk to seagrass meadows at the mouth of the Barron River (if they were present during tailwater discharge).



LEGEND

-  Northern Sands DMPA
-  Tailwater Discharge Point

Change to 50%ile
Ambient Turbidity (NTU)

-  0.5 to 1
-  1 to 2
-  2 to 3
-  3 to 4

Title:

Tailwater Discharge - Turbidity Impacts - 50%ile Discharge Point A (left) and Discharge Point B (right)

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0 450 900m
Approx. Scale

Figure:

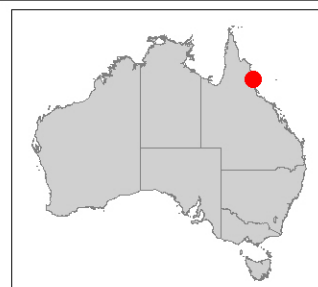
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LEGEND



Northern Sands DMPA



Tailwater Discharge Point

Zones of Impact



Zone of Influence (no ecological impacts)



Zone of Low to Moderate Impact



Zone of High Impact

Title:

Zones of Impact (Turbidity) - Tailwater Discharge

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0 450 900m
Approx. Scale

Figure:

2-18

Rev:

A



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2.4.3.2 Salinity

Instead of zones of impact, the significance of the tailwater discharges in terms of salinity impacts is interpreted using contour plots (showing the change to salinity due to tailwater discharges) and time series graphs.

Contour Plots

Contour plots showing the changes to 50th percentile salinity are presented in Figure 2-19, while contour plots showing the change to 99th percentile salinity are presented in Figure 2-20. These contour plots represent changes to 'typical' salinity (50th percentile) and changes to acute short-term maximum salinity (99th percentile) due to the tailwater discharges from both discharge options.

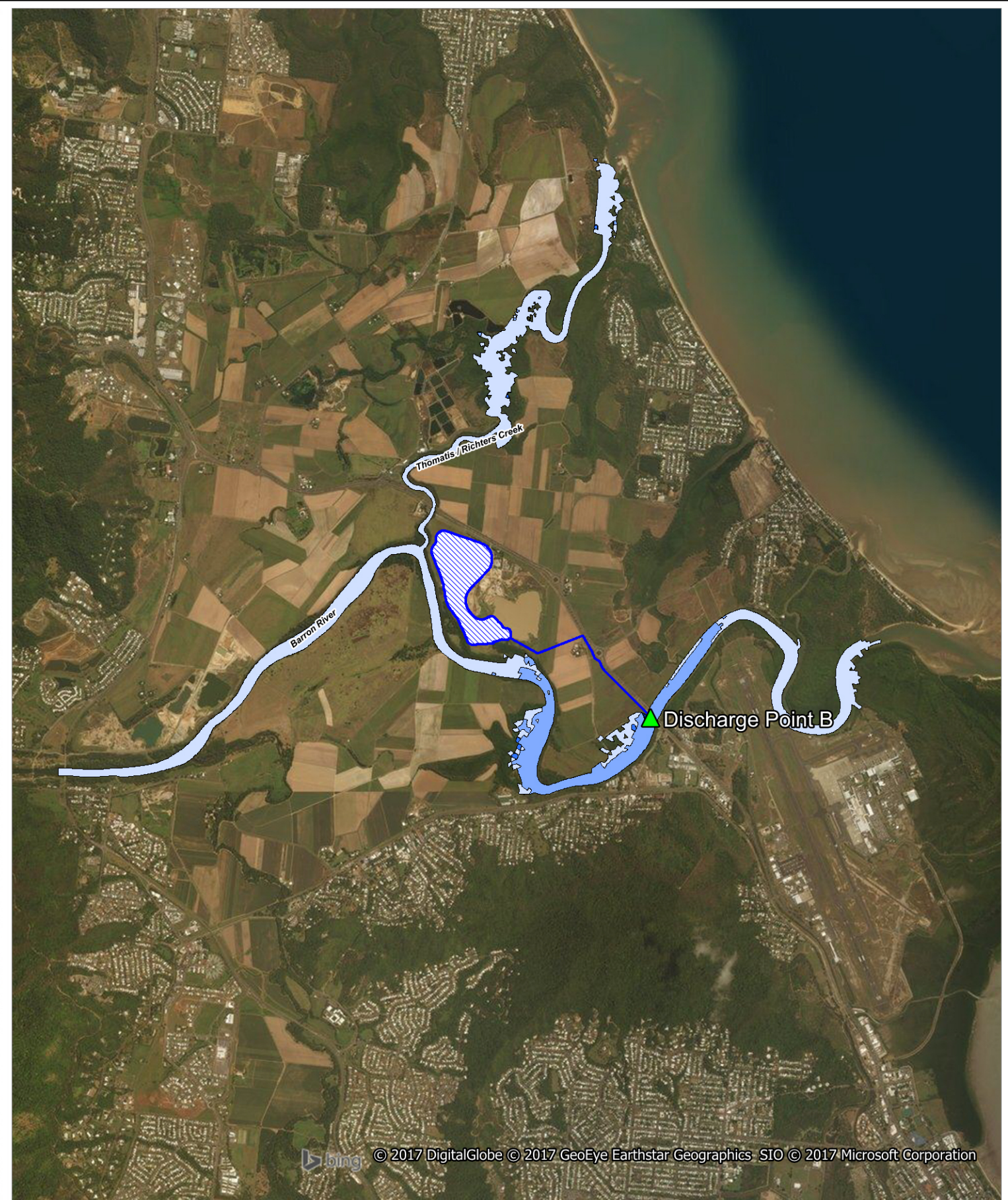
The 50th percentile contour plots (Figure 2-19) indicate that the spatial extent of predicted salinity changes would be similar between the two discharge options, with slight salinity changes up to the tidal limit in the Barron River (near Lake Placid Road), down past the Captain Cook Highway bridge, and down Thomatis / Richters Creek to the mouth.

For Discharge Point B, the change in 50th percentile salinity is expected to remain below 1 ppt for most areas, with an area (~2 km reach) near the discharge point where salinity is expected to be increase up to 2 ppt (Figure 2-19). For Discharge Point A, the change in 50th percentile salinity is expected to be up to 3 ppt in river reaches within approximately 1 km of the discharge point. Changes up to 2 ppt are expected approximately 2 km further upstream and downstream of the discharge point and down Thomatis / Richters Creek. The change in 50th percentile salinity is expected to remain below 1 ppt for remaining areas.

Discharge of tailwater from Discharge Point A is expected to change 99th percentile salinity by up to 3 ppt near the confluence with Thomatis / Richters Creek, up to 2 ppt in other areas upstream of the discharge point (approximately 3 km upstream), and less than 1 ppt in all other areas. Tailwater discharge from Discharge Point B is expected to change 99th percentile salinity by up to 2 ppt in areas upstream of the discharge point to the confluence with Thomatis / Richters Creek, and less than 1 ppt in all other areas.

The changes to salinity are less pronounced further downstream as the ambient salinity is higher in the lower reaches of the Barron River.

The significance of salinity changes requires an understanding of ambient salinity. That is, changes of 1-2 ppt for freshwater would be more significant than for brackish to saline waters. This is explored further using the time series graphs in the following section.



LEGEND



Northern Sands DMPA



Tailwater Discharge Point

Change to 50%ile
Ambient Salinity (ppt)

- 0 to 1
- 1 to 2
- 2 to 3
- 3 to 4

Title:

Tailwater Discharge - Salinity Impacts - 50%ile Discharge Point A (left) and Discharge Point B (right)

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0 450 900m
Approx. Scale

Figure:

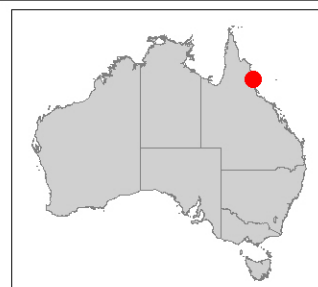
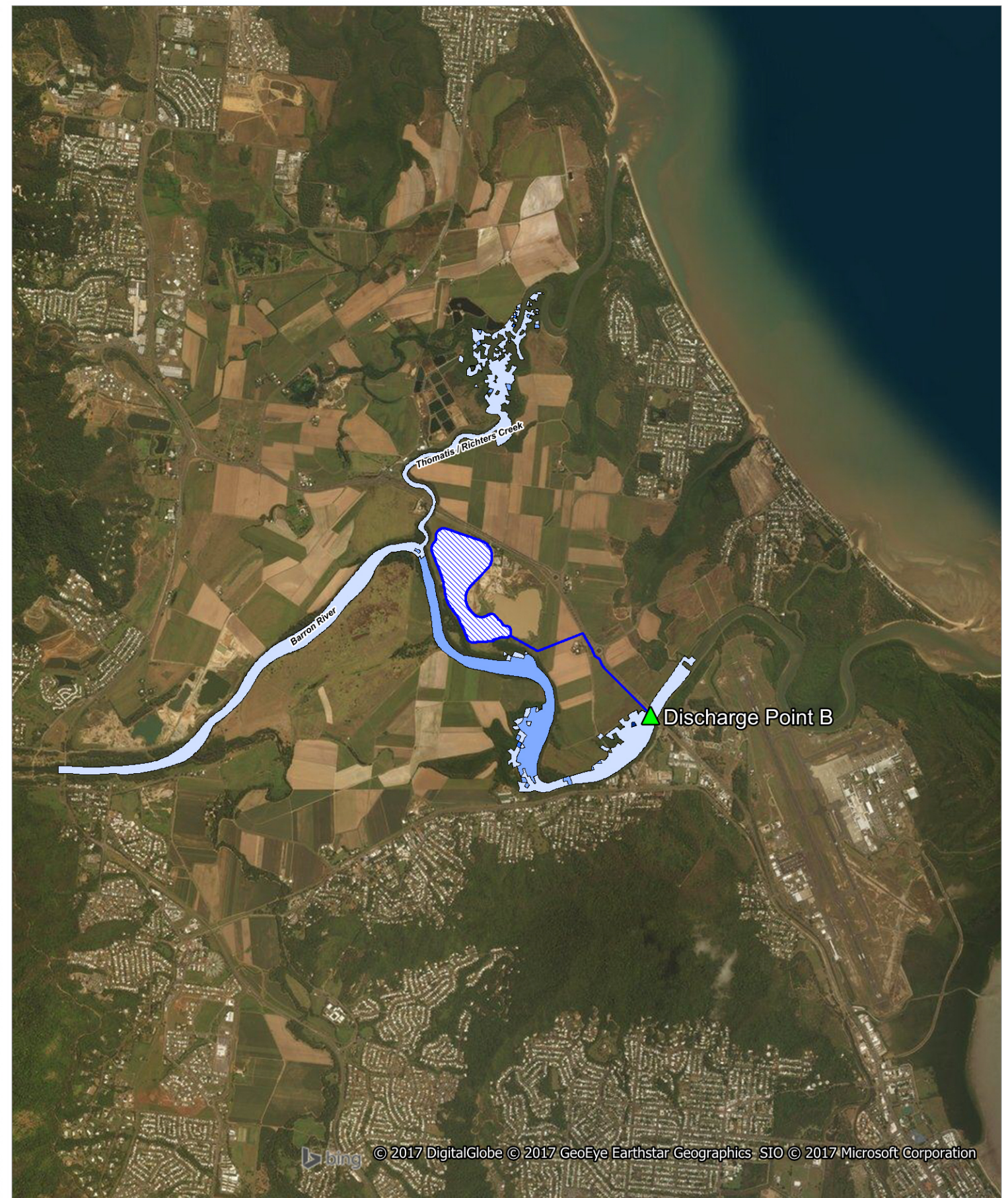
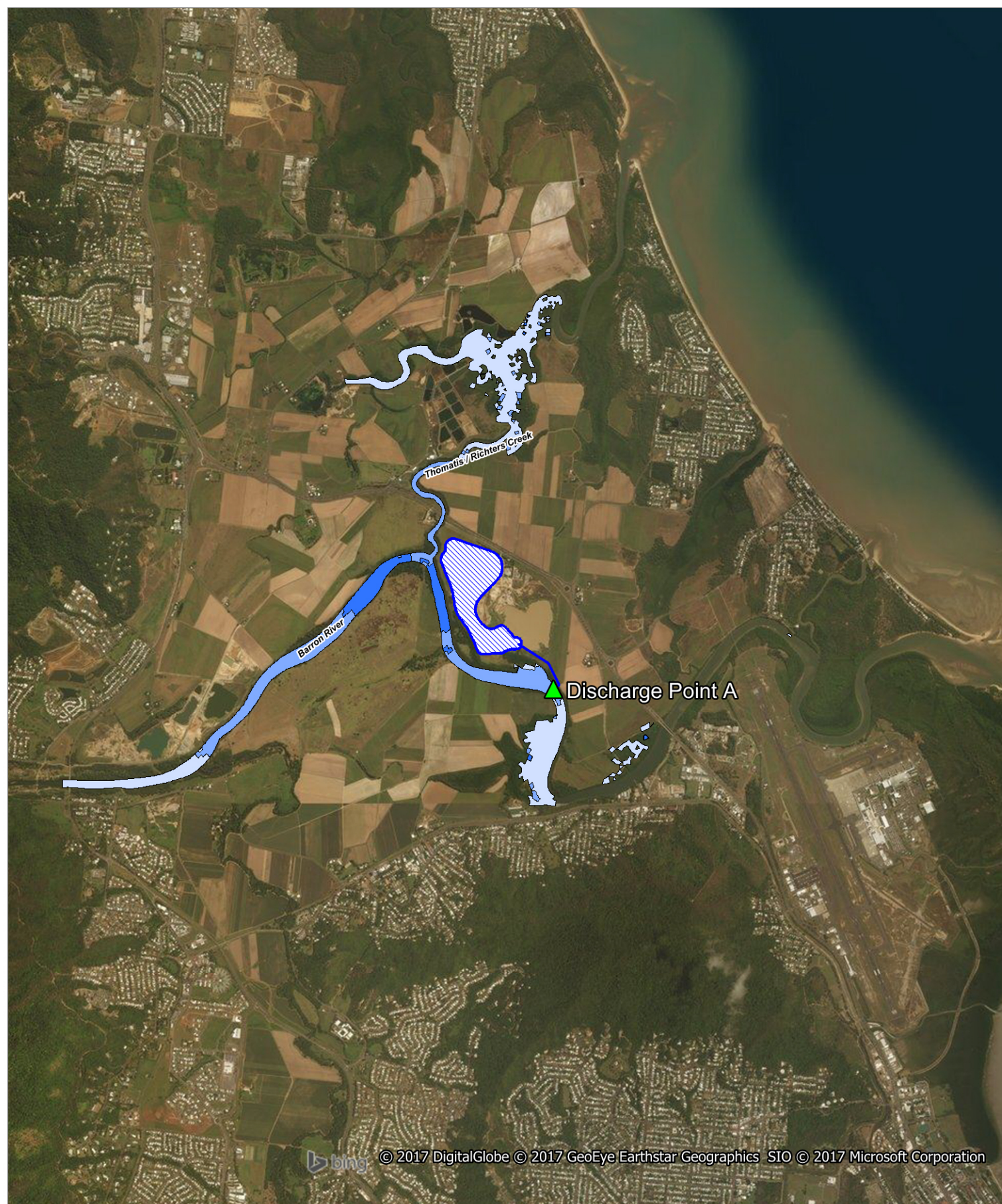
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LEGEND



Northern Sands DMPA



Tailwater Discharge Point

Change to 99%ile
Ambient Salinity (ppt)

- 0 to 1
- 1 to 2
- 2 to 3
- 3 to 4

Title:

Tailwater Discharge - Salinity Impacts - 99%ile Discharge Point A (left) and Discharge Point B (right)

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0 450 900m
Approx. Scale

Figure:

2-20

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Time Series Graphs

Time series graphs provide context to the predicted changes shown in the contour plots, as they show ambient salinity and tailwater discharge salinity at various points along the Barron River.

Time series data of ambient and tailwater salinity was extracted from the model at a number of locations in the Barron River and Thomatis / Richters Creek as shown in Figure 2-21. This data was used to produce time series graphs showing surface salinity (top metre) and bottom salinity (bottom metre) from model simulation start to finish.

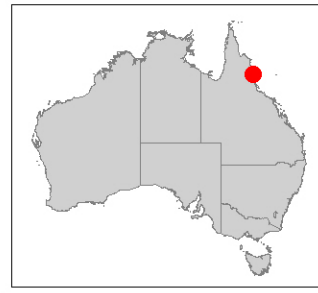
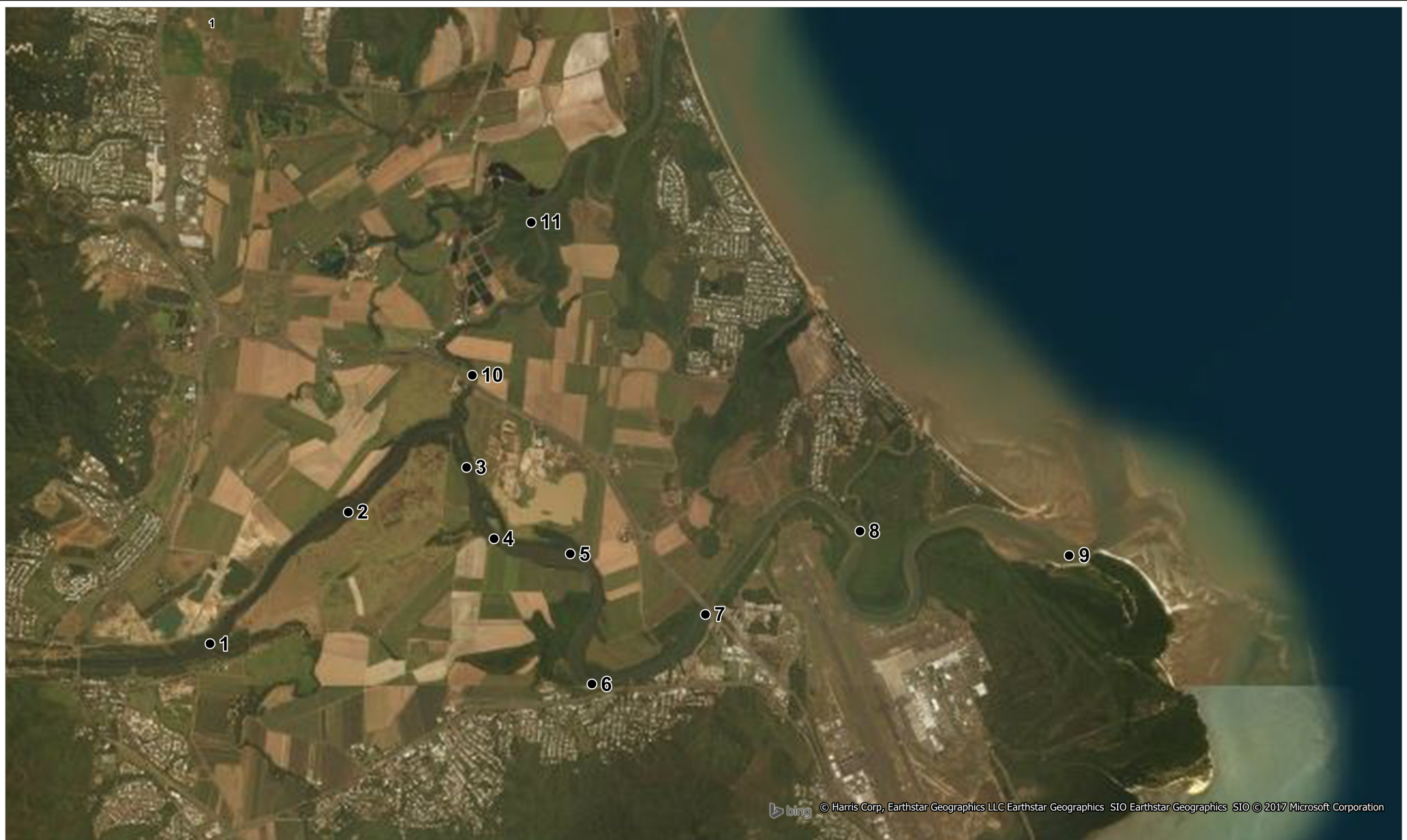
Time series graphs from all locations are included in Appendix B. A select number of graphs (showing surface salinity) are presented in Figure 2-22 to Figure 2-26 to illustrate the impacts to salinity at key locations. These graphs indicate the following:

- In the upper Barron River (Site 2), ambient salinity during the modelling period is up to around 8 ppt. Tailwater discharges are predicted to increase this salinity by less than 1 ppt for Discharge Point B and up to 2 ppt for Discharge Point A, representing an increase of approximately 13 % and 25% respectively.
- At Site 5 near Discharge Point A, ambient salinity is up to around 20 ppt. With tailwater discharges predicted to increase salinity by up to 2-3 ppt, this represents an increase of approximately 10-15%.
- At Site 7 near Discharge Point B, ambient salinity is up to around 30 ppt. With tailwater discharges predicted to increase this salinity by up to 2 ppt, this represents an increase of approximately 7%. Figure 2-24 illustrates these relatively minor increases in salinity at this location.
- At Site 8 in the lower reaches of the Barron River, where ambient salinity is typically around 30-35 ppt, increases in salinity due to tailwater discharges are almost imperceptible (less than 1 ppt), as illustrated in Figure 2-25.
- In the upper reaches of Thomatis / Richters Creek (Site 10), ambient salinity is up to around 14 ppt. Tailwater discharges are predicted to increase this salinity by less than 1 ppt for Discharge Point B and up to 2 ppt for Discharge Point A, representing an increase of approximately 7 % and 14% respectively.

The time series graphs demonstrate that predicted salinity increases are relatively minor in the upper reaches of the Barron River and Thomatis / Richters Creek (increases of approximately 7% - 25%), and almost imperceptible in the lower reaches of the Barron River. Salinity changes further downstream are less pronounced as the ambient salinity is higher in the lower reaches of the Barron River. Conversely, salinity changes further upstream are more pronounced (although still relatively minor) as ambient salinity is lower in the upper reaches of the Barron River. For this reason, the discharge location further downstream (i.e. Discharge Point B) would pose the least risk to the salinity regime in the upper reaches of the Barron River and Thomatis / Richters Creek.

As can be seen in the time series graphs, the Barron River and Thomatis / Richters Creek are typically subjected to fluctuating salinity levels due to a strong tidal influence. Therefore, the relatively minor salinity increases from tailwater discharges pose minimal risk to the salinity regime of these waterways, particularly considering the short-term duration of tailwater discharge (~10 weeks).

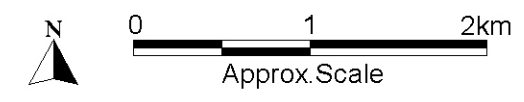
Furthermore, as dredging and tailwater discharges are proposed to occur during the dry season when there are less freshwater flows, ambient salinity would be expected to be higher. Tailwater salinity would therefore be likely to have less impact during this period.



LEGEND

Title:
Time Series Model Extraction Points

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2-21

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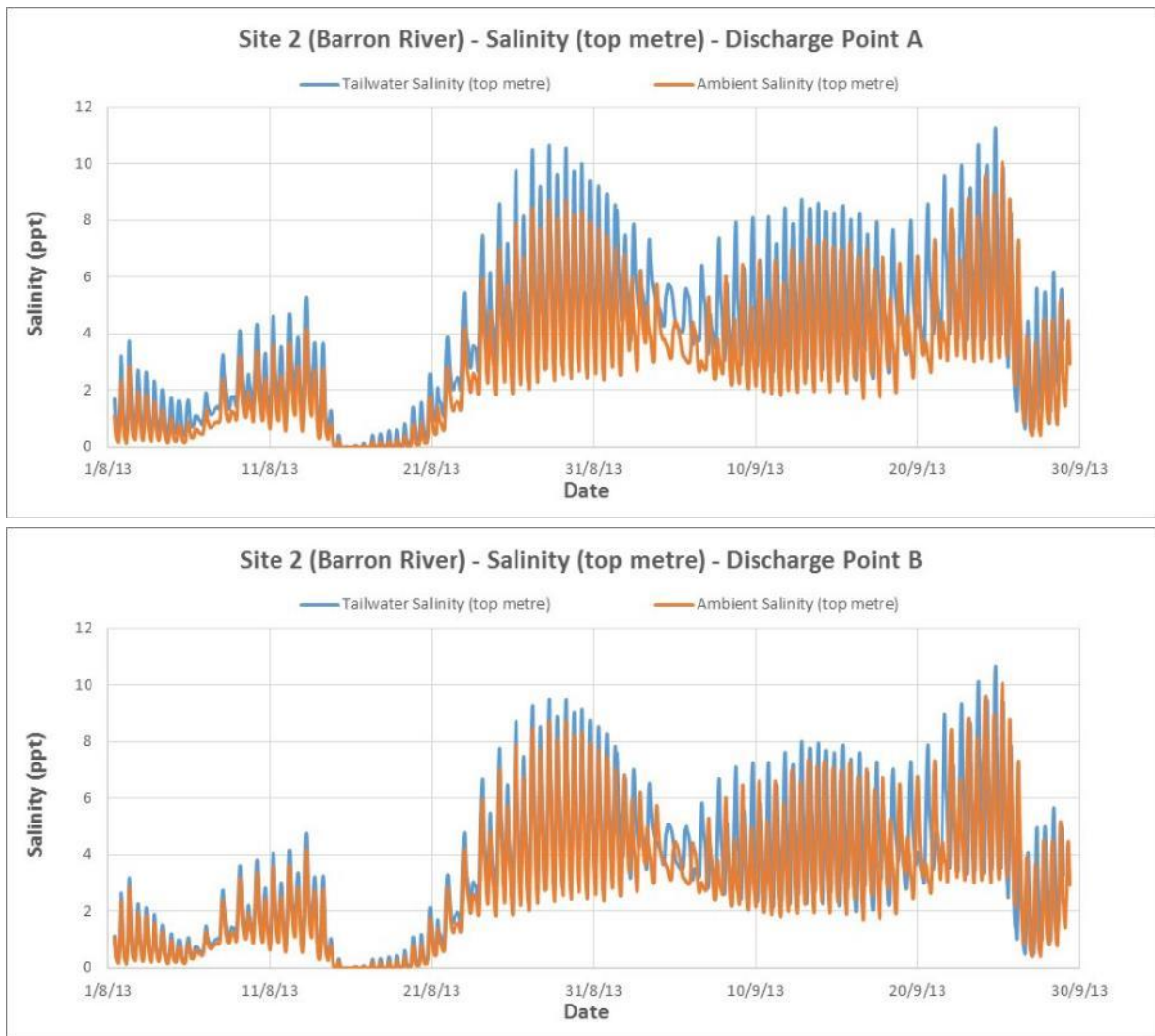


Figure 2-22 Salinity at Site 2 (Upper Barron River) – Discharge Point A (top) and Discharge Point B (bottom)

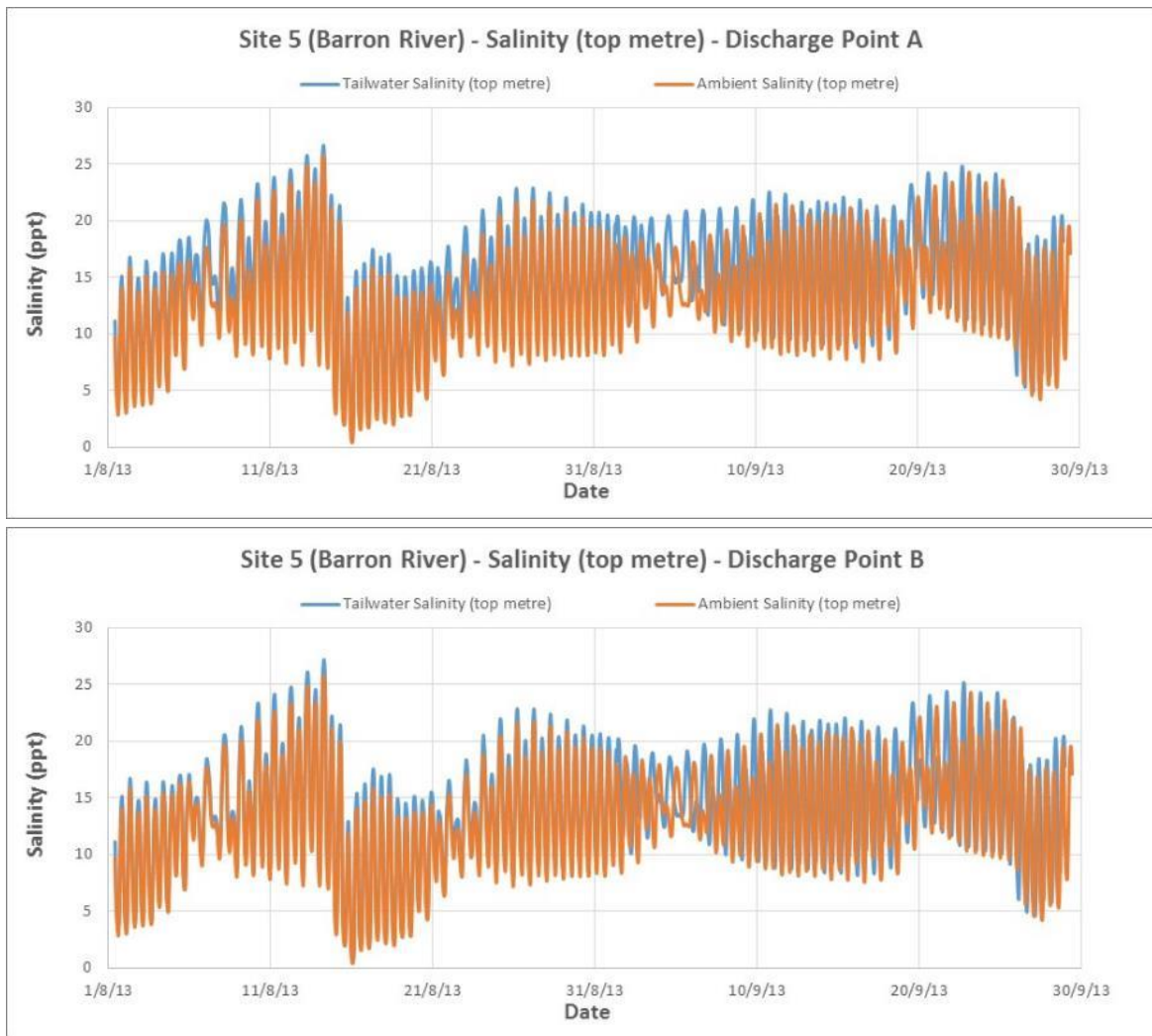


Figure 2-23 Salinity at Site 5 (near Discharge Point A) – Discharge Point A (top) and Discharge Point B (bottom)

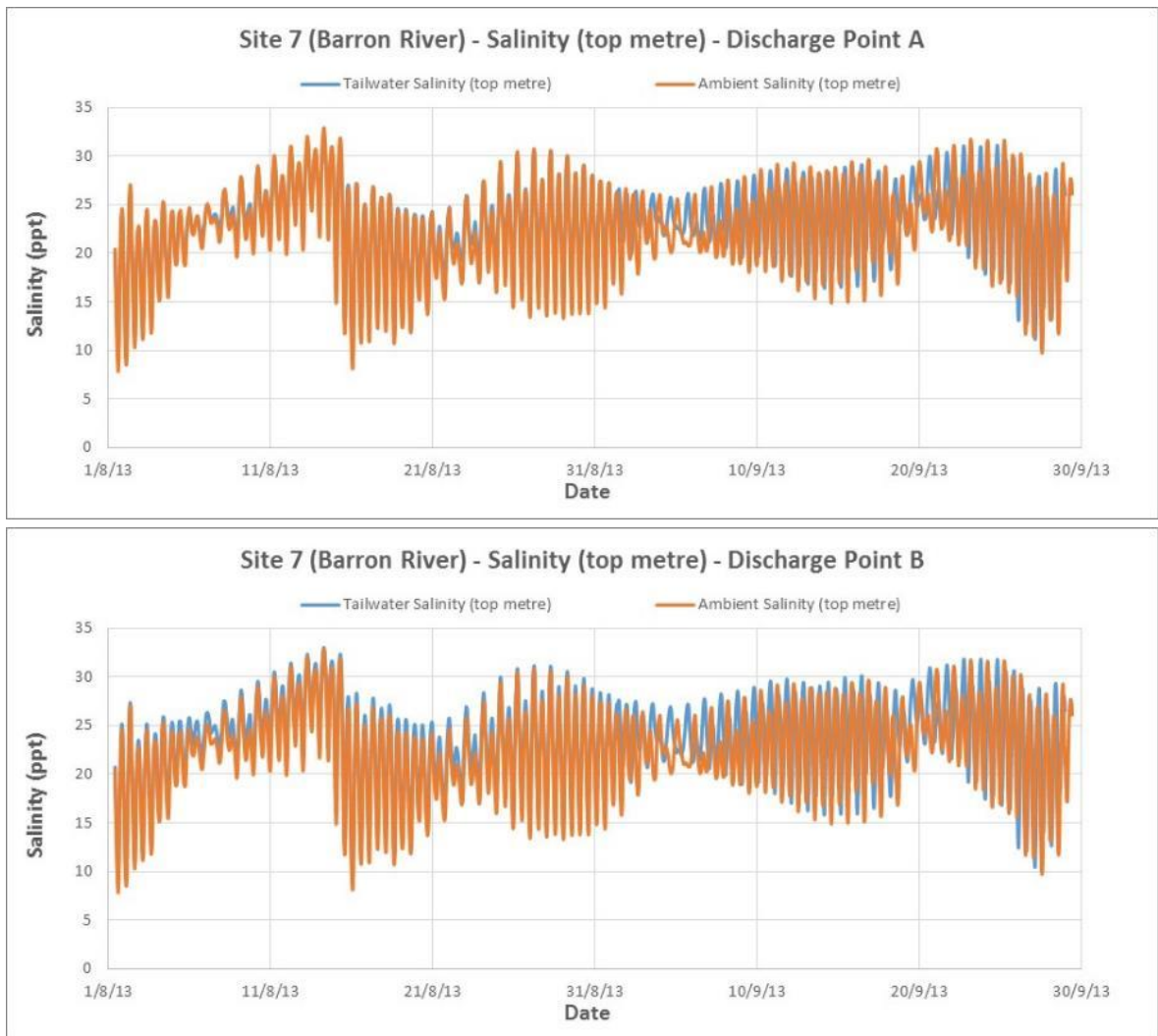


Figure 2-24 Salinity at Site 7 (near Discharge Point B) – Discharge Point A (top) and Discharge Point B (bottom)

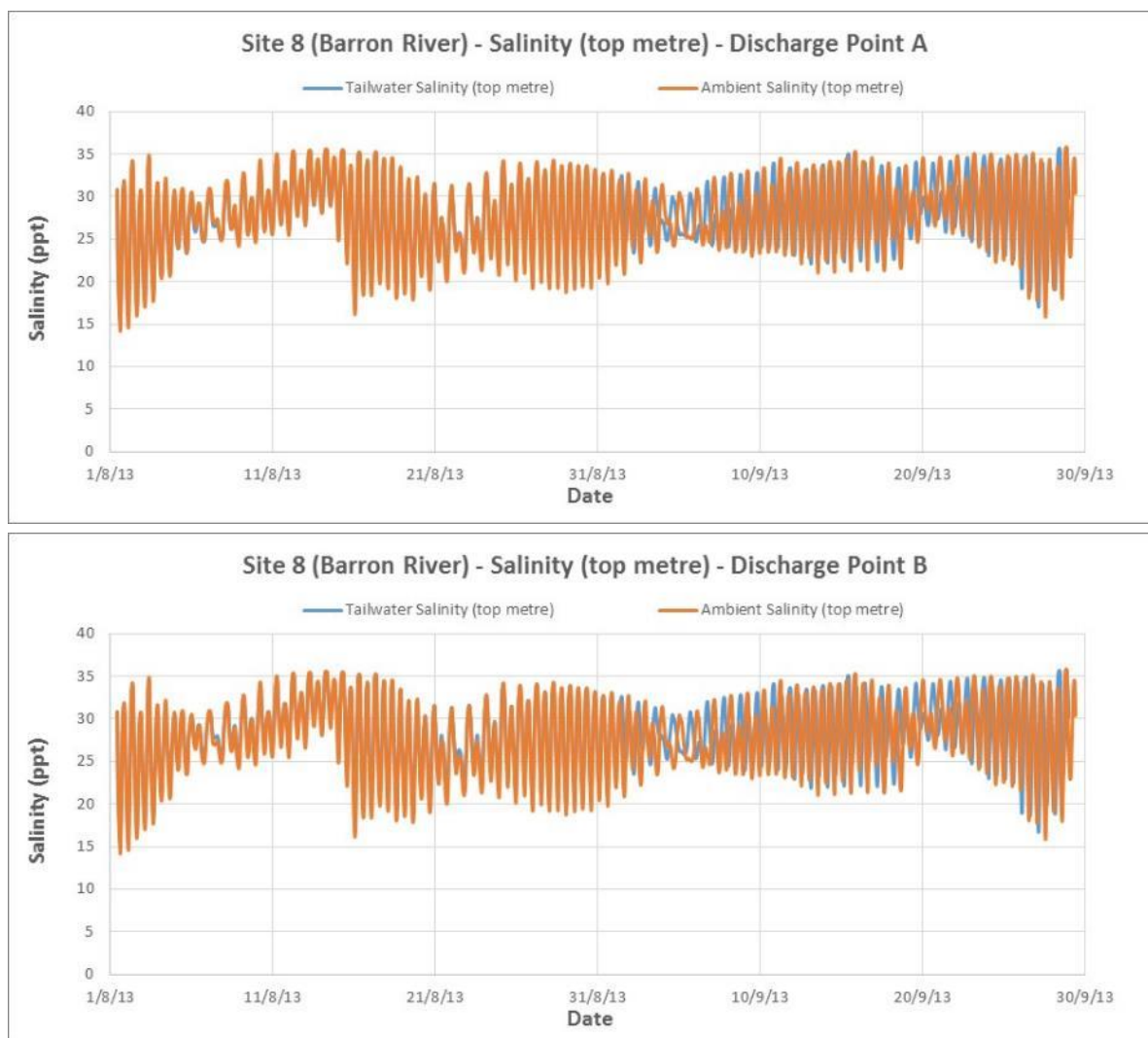


Figure 2-25 Salinity at Site 8 (Lower Barron River) – Discharge Point A (top) and Discharge Point B (bottom)

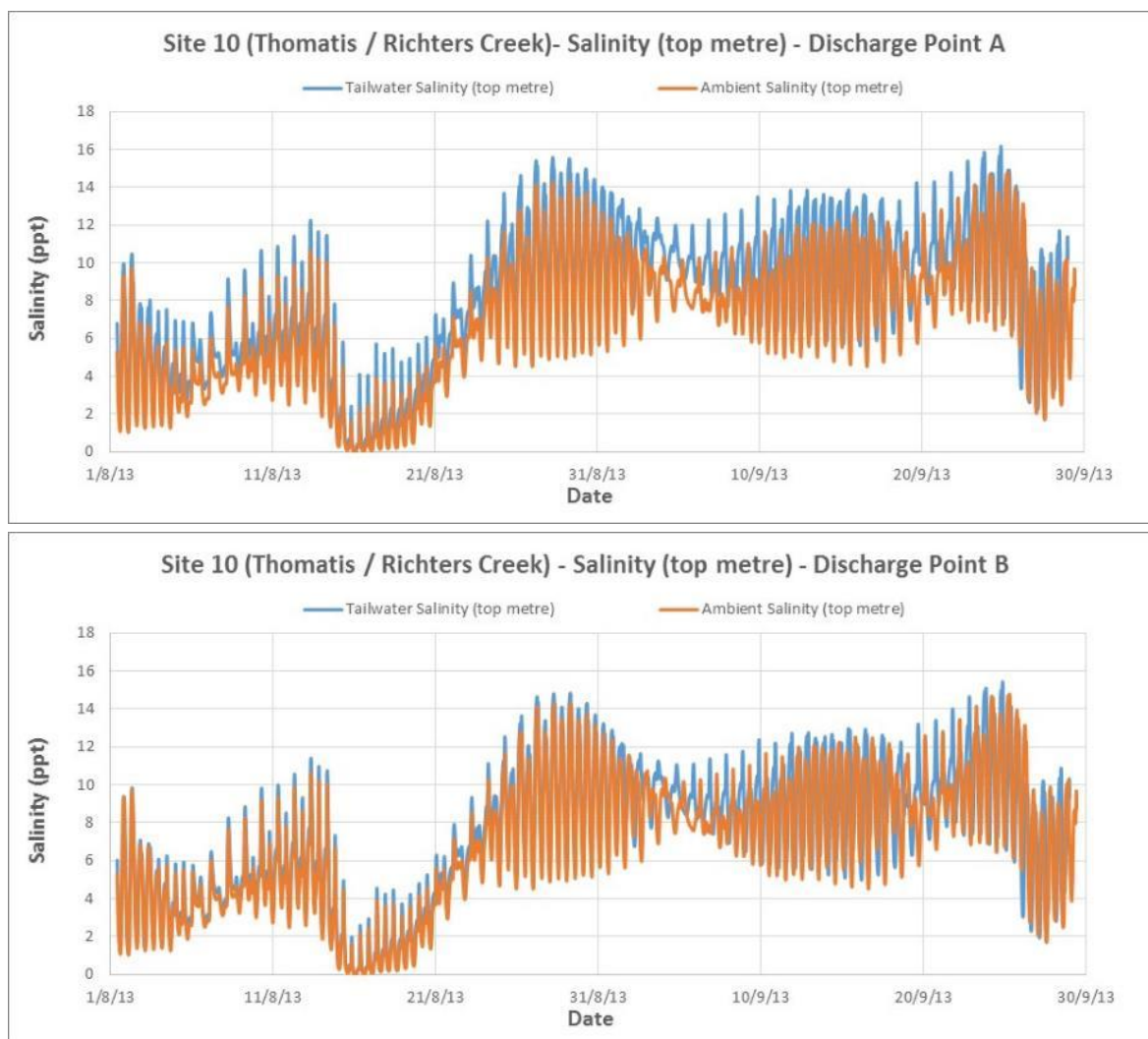


Figure 2-26 Salinity at Site 10 (Thomatis / Richters Creek) – Discharge Point A (top) and Discharge Point B (bottom)

2.4.3.3 Summary of Key Findings – Northern Sands DMPA Tailwater

In terms of turbidity impacts, the discharge of tailwater is expected to result in only a zone of influence in the Barron River for both discharge options. There are no zones of low to moderate impact, or zones of high impact, predicted in the receiving waters.

The difference between the two discharge options is minimal, with negligible impacts predicted for both options. However, with seagrass meadows found historically at the Barron River mouth, the discharge location further upstream (i.e. Discharge Point A) would pose the least risk to seagrass meadows at the mouth of the Barron River (if they were present during tailwater discharge).

In terms of salinity, the spatial extent of predicted salinity changes would be similar between the two discharge options, with slight salinity changes up to the tidal limit in the Barron River (near Lake Placid Road), down past the Captain Cook Highway bridge, and along Thomatis / Richters Creek to the mouth. The change to salinity would be slightly higher (up to 3 ppt) for Discharge Point A located

adjacent to the DMPA, compared to Discharge Point B (up to 2 ppt) located further downstream at the Captain Cook Highway bridge.

Time series graphs indicate that while the tailwater discharge scenarios are predicted to increase salinity by about 1-3 ppt, this magnitude of increase is relatively minor in the upper reaches of the Barron River and Thomatis / Richters Creek (increases of approximately 7% - 25%), and almost imperceptible in the lower reaches of the Barron River. Salinity changes further downstream are less pronounced as the ambient salinity is higher in the lower reaches of the Barron River, while salinity changes further upstream are more pronounced (although still relatively minor) as ambient salinity is lower in the upper reaches of the Barron River. For this reason, the discharge location further downstream (i.e. Discharge Point B) would pose the least risk to the salinity regime in the upper reaches of the Barron River and Thomatis / Richters Creek.

In summary, Discharge Point A poses the least risk in terms of turbidity impacts (due to the greater distance to the Barron River mouth) but greater risk in terms of upstream salinity impacts, while Discharge Point A poses a higher risk in terms of turbidity and a lower risk in terms of salinity.

However, as the Barron River and Thomatis / Richters Creek are typically subjected to fluctuating salinity levels due to a strong tidal influence, the relatively minor salinity increases from tailwater discharges (from both discharge options) pose minimal risk to the salinity regime of these waterways, particularly considering the short-term duration of tailwater discharge (~10 weeks).

Therefore, based on this assessment, the potential impacts to marine water quality from tailwater discharges from the Northern Sands DMPA are expected to be short-term and minor.

2.4.4 Tailwater Impacts – Tingira Street DMPA

Stiff clays dredged using a backhoe dredge will be taken to the Tingira Street DMPA and mechanically placed without the need for tailwater discharges. Potential impacts from stormwater runoff from the Tingira Street DMPA site both during and following placement will be managed onsite through implementation of a stormwater management and erosion and sediment control plan. Assuming the implementation of this plan, the potential impacts to marine water quality within the Smiths Creek area are expected to be short-term and negligible.

2.4.5 Dredge Mooring Point Impacts

Potential generation of turbid plumes at the dredge mooring point is discussed previously in Section 2.4.1.5.

There is potential for additional turbidity to be generated in the event of a dredge material spill at the mooring point, or a pipeline failure. It is expected that standard dredge operational measures (in the Dredge Management Plan) will minimise the likelihood of this occurring, and if it does, measures will be implemented to contain any spills. Therefore, the potential impacts are expected to be short-term and negligible.

2.4.6 Pipeline Crossing – Richters Creek

The onshore pipeline from the dredge pump-out to the Northern Sand DMPA is required to cross Richters Creek as shown in Figure 2-16 and in Figure 2-27.

It is proposed that the pipeline crossing would involve laying a submerged pipe on the bed of the creek. Installation would involve earthworks on each bank to create a ramp down to water level (to reduce any sharp/rapid bends in pipe). The pipe would be constructed on one side and then pulled (or floated and sunk depending on the length) across the creek and sunk onto the creek bed. The ramp will be approximately 10m wide (plus batters) to allow for the pipe and access for earthmoving equipment.

During earthworks and installation of the pipeline, there is potential for increased turbidity due to disturbance of bed and bank sediments, and runoff from exposed soils during earthworks. For works such as these, standard practice is to install erosion and sediment controls. As such, the potential impact of increased turbidity in Richters Creek during these works should be short-term and negligible.

Due to the need for construction plant and equipment to install the pipeline across Richters Creek, there is potential that fuel/oil spills and other contaminants may pollute marine waters if not appropriately managed.

Dredge operators and construction contractors must, by law, comply with established fuel/oil storage and handling standards and protocols to reduce the risk of incidents. Appropriate operational procedures are included in the Dredge Management Plan which sets out management measures to reduce that the risk of fuel/oil spills and contaminants, and if they occur, how they are managed to minimise impact. The potential for fuel/oil spills presents a short-term negligible impact.

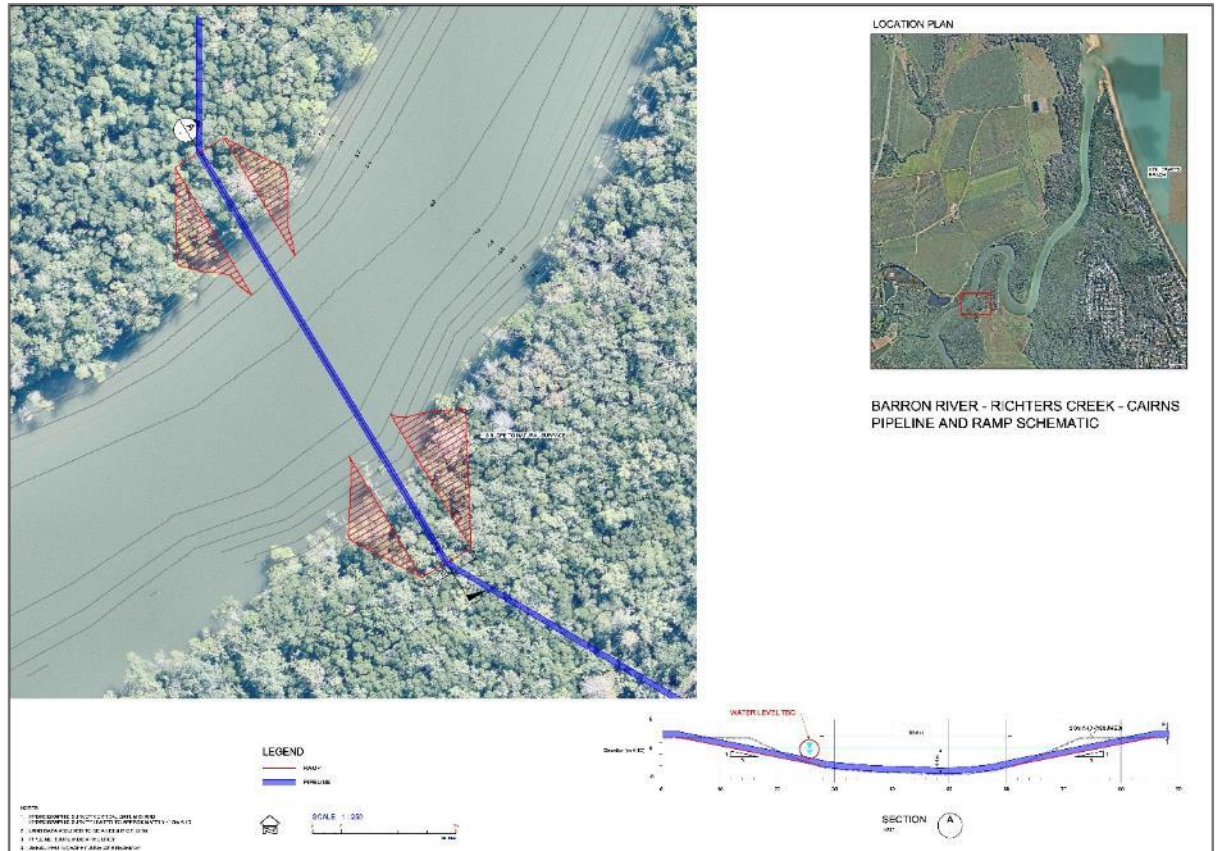


Figure 2-27 Sketch of prospective Richters Creek pipeline crossing

2.4.7 Mobilisation of Contaminants from Capital Dredging

Mobilisation of contaminants such as nutrients and metals/metalloids is a potential impact which could result from disturbance or dredging of marine sediments. While sediment quality is discussed further in Sediment Quality Chapter of the EIS, the mobilisation of contaminants into the water column from dredging is assessed in this report using pore water and elutriate testing results of sediments.

Pore water and elutriate concentrations of nutrients and metals/metalloids were analysed in additional sediment samples collected for the CSD Draft EIS (October 2013). These sites were located in the inner port dredge area, and include PWA (near Wharf 10), PWB (near Wharf 1) and PWC (Smith's Creek Swing Basin).

2.4.7.1 Pore water results

As an initial assessment, concentrations of contaminants in pore water were analysed. As stated in the National Assessment Guidelines for Dredging 2009 (NAGD), pore water is assumed to represent the major route of exposure to sediment contaminants by benthic organisms. Where pore water concentrations lie below the ANZECC/ARMCANZ (2000) marine water quality trigger values, it is considered unlikely that there would be adverse effects on such organisms.

In the case of nutrients, the key species of interest are ammonia and nitrogen oxides (NO_x), which have associated toxicity trigger values. The toxicity trigger value for nitrate, which forms the main form of oxidised nitrogen, is 13 mg/L (assuming 95% protection of species). For ammonia, the toxicity trigger value currently specified in ANZECC/ARMCANZ (2000) is 0.9 mg/L. However, the trigger value for ammonia in estuarine and marine waters has been revised by Batley and Simpson (2009) with the addition of new data. A new trigger value of 0.46 mg/L was derived for slightly to moderately disturbed systems (95% protection).

The pore water results for nutrients are included in Table 2-10, with highlighted cells indicating exceedance of trigger values. These results indicate that NO_x pore water concentrations were below the trigger level and therefore pose a short-term negligible risk.

Table 2-10 indicates that ammonia pore water concentrations were elevated above the Batley and Simpson (2009) water quality trigger level of 0.46 mg/L at two out of three sample sites. However, for sediment pore water, Batley and Simpson (2009) recommended a trigger value of 3.9 mg/L, which was derived from the 80th percentile of background data from Sydney Harbour. As the pore water ammonia concentrations are well below 3.9 mg/L, ammonia is considered to pose short-term negligible impacts, especially considering elutriate testing results discussed in the following section.

Table 2-10 Nutrients in Pore Water

Parameter	PWA	PWB	PWC	Water Quality Trigger Levels
	Inner Port (Wharf 10)	Inner Port (Wharf 1)	Inner Port (Smith's Creek Swing Basin)	
Ammonia (mg/L)	1.64	1.37	0.46	3.9 *
NOx (mg/L)	<0.01	<0.01	<0.01	13 **
Total Nitrogen (mg/L)	2.2	1.4	0.8	-
Reactive Phosphorus (mg/L)	0.07	0.04	0.05	-
Total Phosphorus (mg/L)	0.13	0.13	0.14	-

Notes:

* Derived from Batley and Simpson (2009)

** Derived from ANZECC/ARMCANZ (2000)

The pore water results for metals/metalloids are included in Table 2-11. This table includes dissolved concentrations only, which are comparable to the ANZECC/ARMCANZ (2000) trigger levels. As shown in Table 2-11, there were no dissolved metal/metalloid concentrations elevated above trigger levels in pore water in any of the sediment samples. These results indicate that metal/metalloids in pore water pose negligible impacts.

Table 2-11 Dissolved Metals/Metalloids in Pore Water

Parameter	PWA	PWB	PWC	Water Quality Trigger Levels *
	Inner Port (Wharf 10)	Inner Port (Wharf 1)	Inner Port (Smith's Creek Swing Basin)	
Antimony (µg/L)	<0.5	<0.5	<0.5	-
Arsenic (µg/L)	5.5	2.7	3	50
Cadmium (µg/L)	<0.2	<0.2	<0.2	0.7
Chromium (µg/L)	<0.5	<0.5	<0.5	4.4
Copper (µg/L)	<1	<1	<1	1.3
Lead (µg/L)	<0.2	<0.2	<0.2	4.4
Nickel (µg/L)	<0.5	<0.5	<0.5	7.0
Silver (µg/L)	<0.1	<0.1	0.2	1.4
Zinc (µg/L)	<5	<5	<5	15
Mercury (µg/L)	<0.0001	<0.0001	<0.0001	0.1

Note:

* Derived from ANZECC/ARMCANZ (2000)

Notwithstanding the negligible risk from contaminants in pore water as discussed above, this risk is further reduced due to the expectation that these pore water concentrations would become rapidly diluted during the dredging process. This dilution effect is assessed further with elutriate testing results discussed in the following section.

2.4.7.2 Elutriate results

The elutriate test investigates desorption of contaminants from sediment particulates to waters, and is designed to simulate release of contaminants from sediment typically during marine placement. However, as land placement is proposed for the project, elutriate test results are analysed in this section for release of contaminants from sediments during the dredging process.

Elutriate tests assess whether contaminant concentrations in the water column are likely to exceed relevant ANZECC/ARMCANZ (2000) water quality trigger values. NAGD (2009) states that the relevant ANZECC/ARMCANZ (2000) marine water quality trigger values should not be exceeded after allowing for initial dilution, defined as 'that mixing which occurs within four hours of dumping'. Initial dilution will depend on a number of factors, such as depth, layering in the water column, and current velocities and directions.

The laboratory elutriate analysis uses a dilution of 1:4 - one part wet sediment to four parts seawater. NAGD (2009) states that this will greatly overestimate water quality impacts given that, within the initial four-hour dilution period following dredging (and disposal), dilutions in the order of a hundred times or more (and often much more) would normally be expected. To address this, NAGD (2009) states that the test data should be corrected for the calculated dilution factor after the four-hour mixing period (i.e. after taking account of the laboratory dilution of 1:4) to assess whether or not the water quality trigger values will be exceeded following dredging.

As per NAGD (2009), dilution may be approximated as the liquid and suspended particulate phases of the dredge material assumed to be evenly distributed after four hours over a reasonably assumed column of water. For the dredging process, it was conservatively assumed that the dredge would release approximately 2,450 m³ of sediment continuously over four hours (170 kg/s from dredge head, prop wash and overflow), and the volume of water in the immediate dredge footprint is approximately 88,000 m³ (100 m wide x 100 m long x 8.8 m deep), the approximate dilution is calculated as 1:36.

Therefore, as the elutriate test results involved a laboratory dilution of 1:4, these results were further diluted by a factor of 36 to approximate the effects of mixing and dilution of contaminants released from sediment into the water column during dredging. The elutriate results for nutrients and metals/metalloids, which represent a final dilution factor of 1:144, are included in Table 2-12 and Table 2-13 respectively.

As shown in Table 2-12 and Table 2-13, elutriate testing results are well below the relevant water quality trigger levels. Therefore, the mobilisation of contaminants poses short-term negligible impacts to marine water quality.

Table 2-12 Elutriate Nutrient Concentrations (1:144 dilution)¹

Parameter	PWA	PWB	PWC	Water Quality Trigger Levels
	Inner Port (Wharf 10)	Inner Port (Wharf 1)	Inner Port (Smith's Creek swing Basin)	
Ammonia (mg/L)	0.11	0.12	0.03	3.9 *
NOx (mg/L)	<0.01	<0.01	<0.01	13 **
Total Nitrogen (mg/L)	0.17	0.12	0.03	-
Reactive Phosphorus (mg/L)	0.0003	0.0003	0.0006	-
Total Phosphorus (mg/L)	0.0011	0.0008	0.0008	-

Notes:

¹ Values below the laboratory limit of reporting (e.g. <0.01) did not have the further dilution factor of 36 applied. These values represent a dilution of 1:4.

* Derived from Batley and Simpson (2009)

** Derived from ANZECC/ARMCANZ (2000)

Table 2-13 Elutriate Metal / Metalloid Concentrations (1:144 dilution)¹

Parameter	PWA	PWB	PWC	Water Quality Trigger Levels *
	Inner Port (Wharf 10)	Inner Port (Wharf 1)	Inner Port (Smith's Creek swing Basin)	
Antimony (µg/L)	0.017	0.050	<0.5	-
Arsenic (µg/L)	0.039	0.092	<0.5	50
Cadmium (µg/L)	<0.2	<0.2	<0.2	0.7
Chromium (µg/L)	<0.5	<0.5	<0.5	4.4
Copper (µg/L)	<1	<1	<1	1.3
Lead (µg/L)	<0.2	<0.2	<0.2	4.4
Nickel (µg/L)	0.014	0.042	<0.5	7.0
Silver (µg/L)	<0.1	<0.1	<0.1	1.4
Zinc (µg/L)	<5	<5	<5	15
Mercury (µg/L)	<0.0001	<0.0001	<0.0001	0.1

Note:

¹ Values below the laboratory limit of reporting (e.g. <0.1) did not have the further dilution factor of 36 applied. These values represent a dilution of 1:4.

* Derived from ANZECC/ARMCANZ (2000)

2.4.8 Potential Acid Sulfate Soil Impacts from Capital Dredging

Disturbance and exposure of potential acid sulfate soils (PASS) in the dredge material can lead to water quality impacts from changes in pH if the material is allowed to oxidise. The potential ASS is expected to be present in the very soft to soft clay and silt materials below a sediment depth of approximately one metre (the top one metre had shell or other neutralising material). The PASS volume represents approximately ~250,000 to 320,000 m³ of the proposed dredge volume, with the remaining material (~460,000 to 580,000 m³) expected to be self-neutralising material.

PASS material (that is not self-neutralising) will potentially release acidity if exposed to air for extended periods. Under normal operating conditions of the TSHD, the dredge material remains

waterlogged in the hopper for a matter of hours, therefore the risk of oxidation is negligible. At the TSHD dredge pump-out location, the dredge material will be pumped via enclosed pipeline into a void filled with water, ensuring the dredge material is waterlogged at all times.

PASS will be managed in the Northern Sands DMPA such that tailwater discharges into the Barron River are at a neutral pH with short-term negligible impacts. Further details on how the PASS will be managed in the Northern Sands DMPA are discussed in the EIS.

2.4.9 Dredging and Construction Plant and Equipment

Upgrade to the wharf infrastructure will involve installation of independent dolphins requiring steel piles. These piles will be driven by a piling rig with crane and hammer from a barge. It is proposed there will be 21 independent dolphins, each requiring four piles. Therefore, 84 piles need to be installed during construction.

Due to the need for construction plant and equipment to upgrade the wharf infrastructure, and the use of dredging plant and equipment for the dredging works, there is potential that fuel/oil spills and other contaminants may pollute marine waters if not appropriately managed.

Dredge operators and construction contractors must, by law, comply with established fuel/oil storage and handling standards and protocols to reduce the risk of incidents. Appropriate operational procedures are included in the Construction Management Plan and the Dredge Management Plan which sets out management measures to reduce that the risk of fuel/oil spills and contaminants, and if they occur, how they are managed to minimise impact. The potential for fuel/oil spills as part of the construction phase of the project presents a short-term negligible impact.

2.5 Operational Phase Impacts

Potential impacts on the marine environment associated with the upgraded wharf will be addressed and mitigated with the implementation of the port's Environmental Management System for port operational activities. Further details are provided in the following sections for shipping operations and maintenance dredging, as these operations are considered to be two key areas with the potential to impact marine waters during the operational phase of the project.

2.5.1 Increased Shipping

Once operational, it is forecast as part of the Demand Study Update for the project (AEC, 2016) that cruise shipping activity (and associated refuelling activity) will increase by approximately 33 ships by 2031, with an overall upper bound estimate of 183 ship visits per year.

However, it should be noted that a much larger number of these overall ships will be able to access Trinity Wharves compared to the current situation where many of these vessels are only able to moor offshore from Yorkey's Knob.

The increase in shipping and refuelling activity may increase the potential for shipping-related contaminants to enter the marine environment. Current and increased shipping operations may introduce contaminants from:

- Hydrocarbons, from refuelling or vessel sourced discharges

- Ballast water
- Antifouling systems
- Black water and grey water release
- Other wastewater
- Airborne contaminants from exposed materials entering the water column
- Solid waste such as packaging materials.

Ballast water, antifouling, waste and wastewater are regulated by the following conventions and legislation which vessels operating in Australia need to comply with:

- International Obligations:
 - *Convention for the Prevention of Pollution from Ships 1973*
 - *Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (London Convention) 1972*
 - *Convention on the Control of Harmful Antifouling Systems on Ships (IMO-AFS Convention) 2001*
 - *Convention for the Control and Management of Ship's Ballast Water and Sediments 2004.*
- Commonwealth Legislation:
 - *Biosecurity Act 2016* for management of introduced pests in ballast water, managed by the Department of Agriculture
 - *Environment Protection (Sea Dumping) Act 1981.*
- State Legislation:
 - *Environmental Protection (Waste Management) Regulation 2000, and Environmental Protection (Water) Policy 2009*
 - *Transport Operations (Marine Pollution) Act 1995 and Transport Operations (Marine Pollution) Regulation 2008*
 - *Maritime Safety Queensland Act 2002.*

On 1 July 2001, Australia introduced mandatory ballast water management requirements to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ballast water from international vessels. These requirements are enforceable under the *Quarantine Act 1908*. The requirements are consistent with the International Maritime Organisation (IMO) Ballast Water Convention 2004 that aims to minimise the translocation of harmful aquatic species in ships' ballast water and ballast tank sediments.

The discharge of high-risk ballast water in Australian ports or waters is prohibited. All internationally plying vessels intending to discharge ballast water anywhere inside the Australian territorial sea must manage their ballast water in accordance with Australia's mandatory ballast water management requirements. This would apply to all international cruise ships visiting the Port of Cairns.

In Queensland's jurisdiction, the international conventions are given force through the *Transport Operations (Marine Pollution) Act 1995* and *Regulation 2008*, which aim to protect Queensland's marine and coastal environment from the adverse effects of ship-sourced pollution. Section 93A(2) of the Act appoints the General Manager, MSQ, as the Marine Pollution Controller to direct the marine pollution response in Queensland coastal waters. Other relevant Queensland legislation is the *Maritime Safety Queensland Act 2002* which establishes MSQ and empowers it to 'deal with the discharge of ship sourced pollutants into Queensland Coastal Waters'.

Fuel handling and storage procedures are currently part of the port's existing port operational activities. These procedures will be reviewed and revised as necessary to accommodate the change in shipping and Intermediate Fuel Oil (IFO) refuelling activity resulting from the project as well as the additional volume of ships that will be potentially using the port for fuel bunkering.

Assuming these procedures are effectively updated and implemented, the potential for introduced contaminants from increased shipping presents a long-term minor impact from the current situation. Mitigation of these potential impacts will be addressed by compliance with the above legislation administered by the above authorities, and implementation of the port's operational procedures.

2.5.2 Future Maintenance Dredging

Future maintenance dredging will be needed to ensure the project area remains at the required depths for safe navigation of ships. The widening and deepening of the outer channel will result in an increase in annual maintenance dredging volume in the order of 2-6%. The existing annual maintenance dredging volume of the inner port is not likely to change significantly as a result of the project as this area does not accumulate sediment as rapidly as the outer channel.

Channel maintenance dredging campaigns typically occur during the months of July and August and generally take about four weeks. On average, approximately 350,000 m³ of *in-situ* material is dredged annually from the outer channel by a trailer suction hopper dredge (TSHD), while approximately 40,000 m³ of *in-situ* material is dredged annually from the inner port using a grab bucket dredge. The additional volume associated with the expanded channel will likely extend these campaigns by a period of 1 to 3 days.

Modelling Assessment

To assess impacts from future maintenance dredging requirements, maintenance dredging and material placement simulations were performed for a maintenance dredging campaign with an increased volume of 6% above the average maintenance volume. Modelling was also performed with a subsequent 12-month re-suspension period following dredging. The results are presented as zones of impact maps for dredging and placement at the existing DMPA (Figure 2-28) and the 12-month resuspension period following placement at the existing DMPA (Figure 2-29). The zones of impact figures indicate the following:

- Increases in turbidity as a result of maintenance dredging and placement at the existing DMPA are not predicted to result in any 'zones of low to moderate impact', or 'zones of high impact'. In other words, turbidity is expected to remain within natural variability (i.e. maintaining 20th, 50th and 80th percentiles of natural turbidity).

- There is a 'zone of influence' extending out from the channel dredging area to the north-west up past Double Island and Palm Cove to Wangetti, and east out to Cape Grafton. While this zone indicates the predicted extent of detectable plumes, the turbidity in this zone is predicted to remain within natural variability and therefore ecological impacts are not predicted to occur.
- For dredge material placement at the existing DMPA, a 'zone of influence' is predicted to extend approximately 5 km north-west and 2 km south-east of the existing DMPA (Figure 2-28).
- 12 months following dredging, re-suspension from the existing DMPA is predicted to result in a 'zone of influence' extending approximately 15 km the north-west and 5 km to the south-east (Figure 2-29). Note that most placed material remains at the DMPA.

Compared to capital dredging, much smaller volumes of material are involved in maintenance dredging and the timeframes over which dredging will occur will be shorter. Impacts from maintenance dredging are considered to be localised and relatively short term, with limited increases in turbidity adjacent to sensitive environments. Previously, impacts on sensitive receptors from maintenance dredging have been assessed as being acceptable to regulatory agencies (as outlined in the Ports North 10-year maintenance dredging permit and LTMP).

While there is ample capacity at the existing approved DMPA for the maintenance dredging requirements associated with the project, a future alternative marine DMPA has been investigated and proved acceptable. This alternative site could be used once the existing site has expired and a new site is required.

Review of Monitored Data

To further assess potential impacts from maintenance dredging, water quality monitoring data was reviewed. Water quality monitoring for the Draft EIS was undertaken between July 2013 and July 2014 at a number of locations (BMT WBM 2014). During this monitoring period, annual maintenance dredging was undertaken (between 21 July 2013 and 17 August 2013). The monitoring data was assessed to determine if any discernible impacts due to maintenance dredging could be observed. The time series turbidity data, along with the maintenance dredging period, is presented in Figure 2-30 to Figure 2-32.

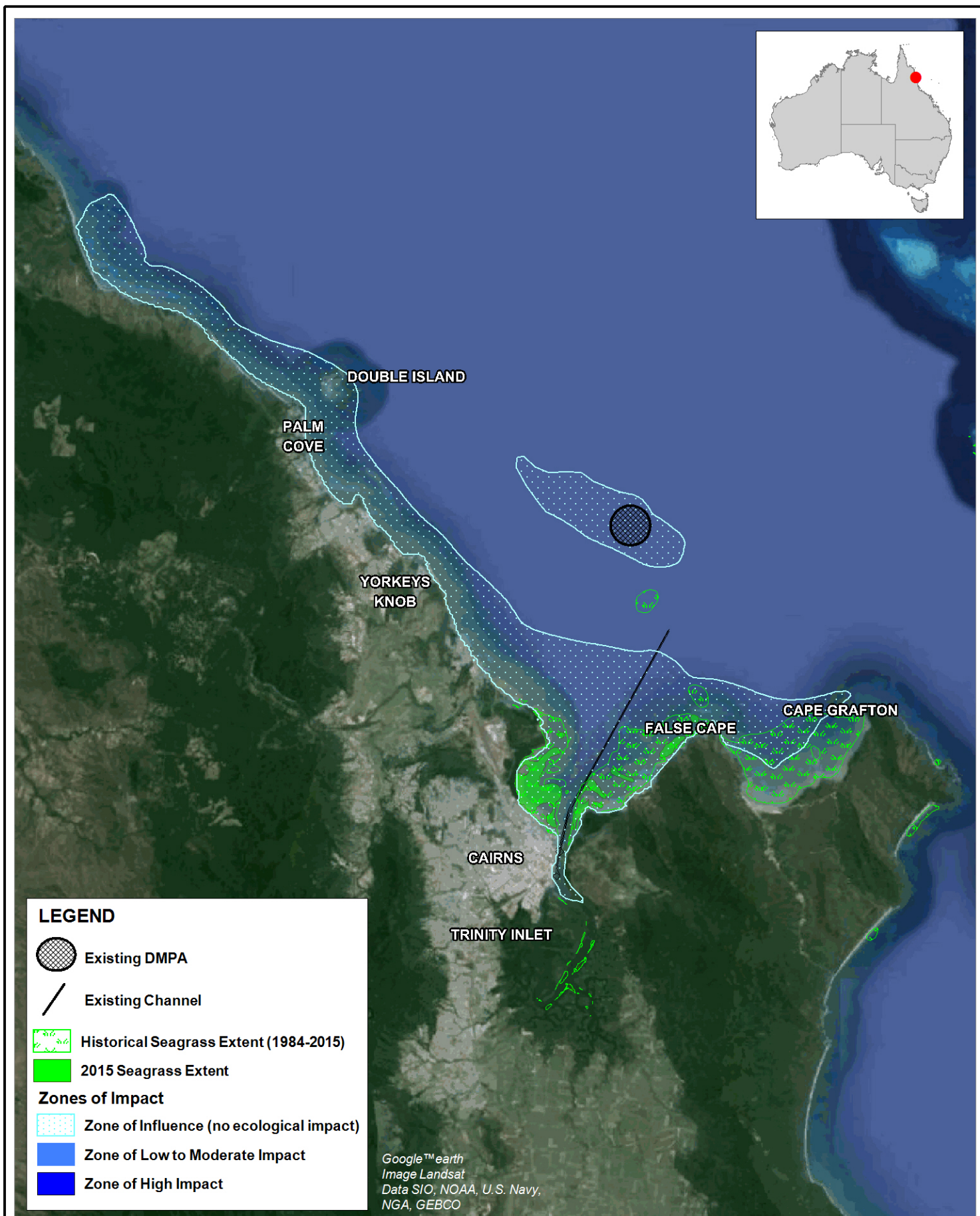
Figure 2-30 to Figure 2-32 indicate that all monitoring sites had a similar spike in turbidity which coincided with the commencement of maintenance dredging. However, during this period there were high winds and a spring tide. Once these high winds and spring tides abated, turbidity at all sites was greatly reduced, even while maintenance dredging continued. This indicates that turbidity measured at the six sensitive receptor locations is likely to have been driven primarily by weather events as opposed to any detectable effect of maintenance dredging plumes. This confirms the above-mentioned conclusion that turbid plumes from maintenance dredging are localised and short-term, and were not observable in the monitoring data at sensitive receptor locations (refer to Section 2.2.1 for description of monitoring locations).

Based on the above assessments, turbid plumes from future maintenance dredging are considered to pose a long-term minor impact to marine water quality.

In terms of potential mobilisation of contaminants from sediment during future maintenance dredging, it is expected that a sediment sampling and analysis plan (SAP) will be developed and implemented

Assessment of Potential Impacts

to determine the suitability of future maintenance dredge material for marine placement, as is the present process. Any contaminated material detected in future testing will need to be investigated and managed under the NAGD and sea dumping permit process. As such, mobilisation of contaminants from future maintenance dredging is expected to pose a long-term negligible impact to marine water quality.



Title:

Zones of Impact - Maintenance Dredging - Existing DMPA

Figure:

2-28

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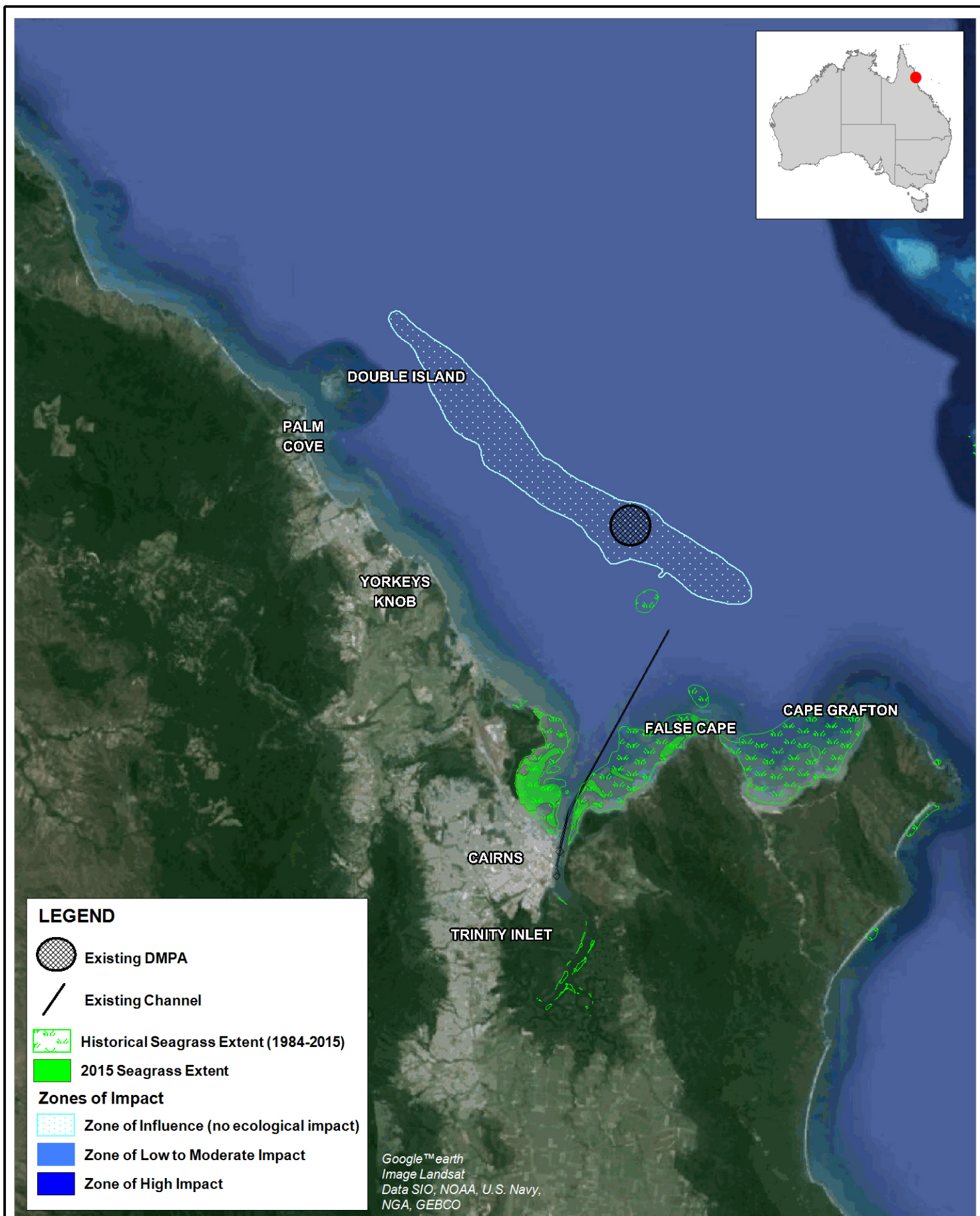
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Title:
**Zones of Impact - 12 Month Resuspension
Existing DMPA**

Figure:
2-29

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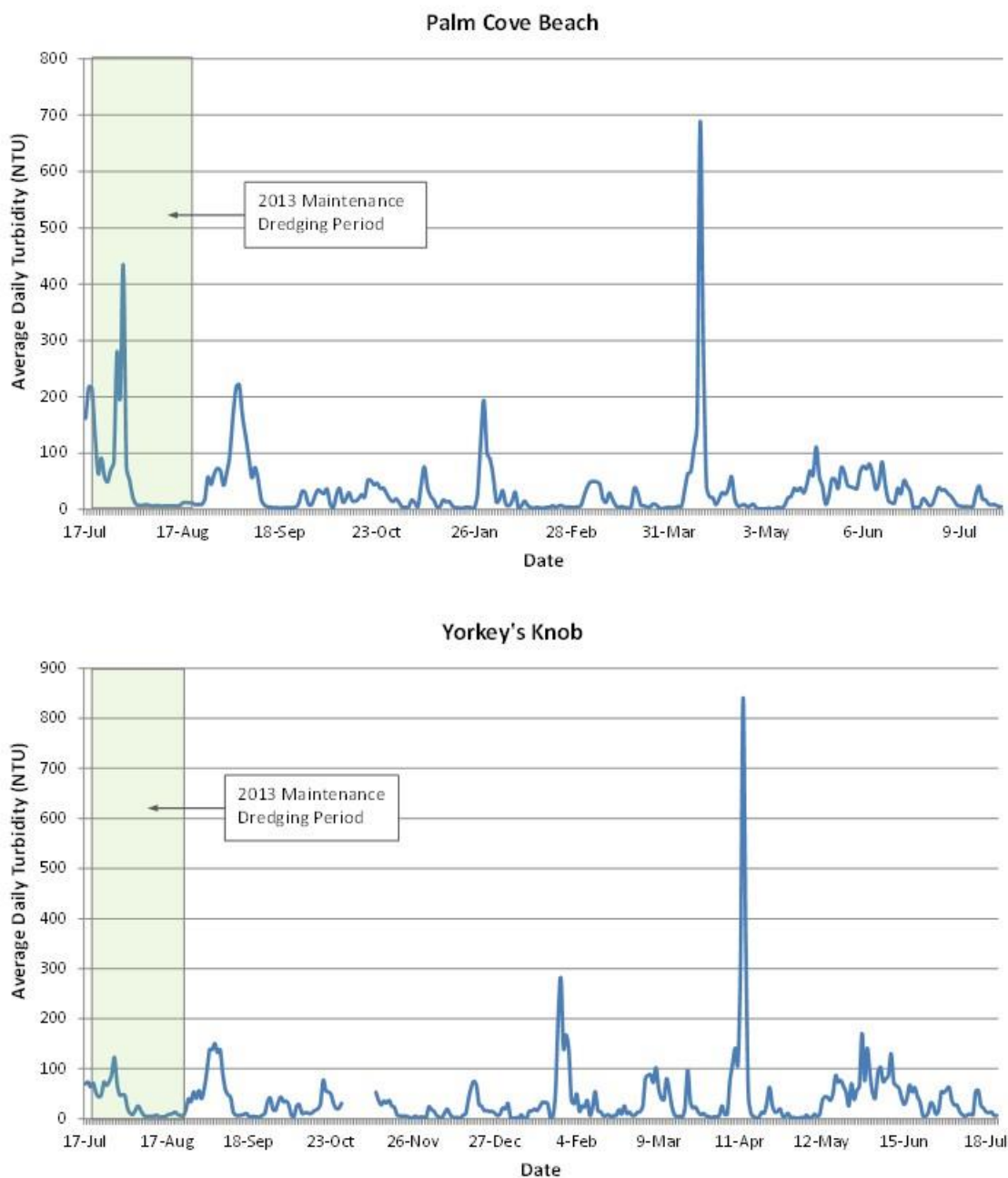


Figure 2-30 Turbidity data and maintenance dredging period at Palm Cove (top) and Yorkey's Knob (bottom)

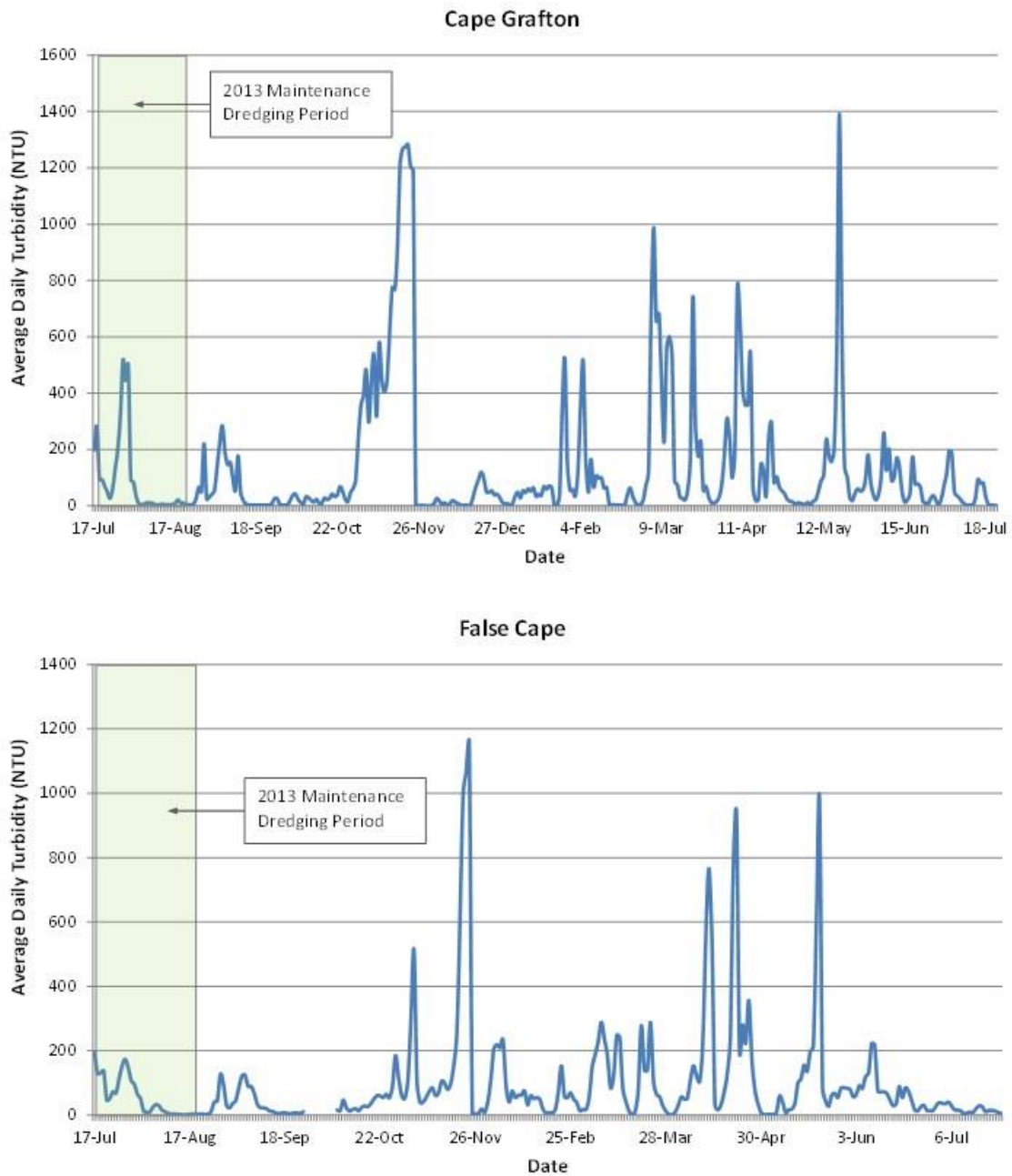


Figure 2-31 Turbidity data and maintenance dredging period at False Cape (top) and Cape Grafton (bottom)

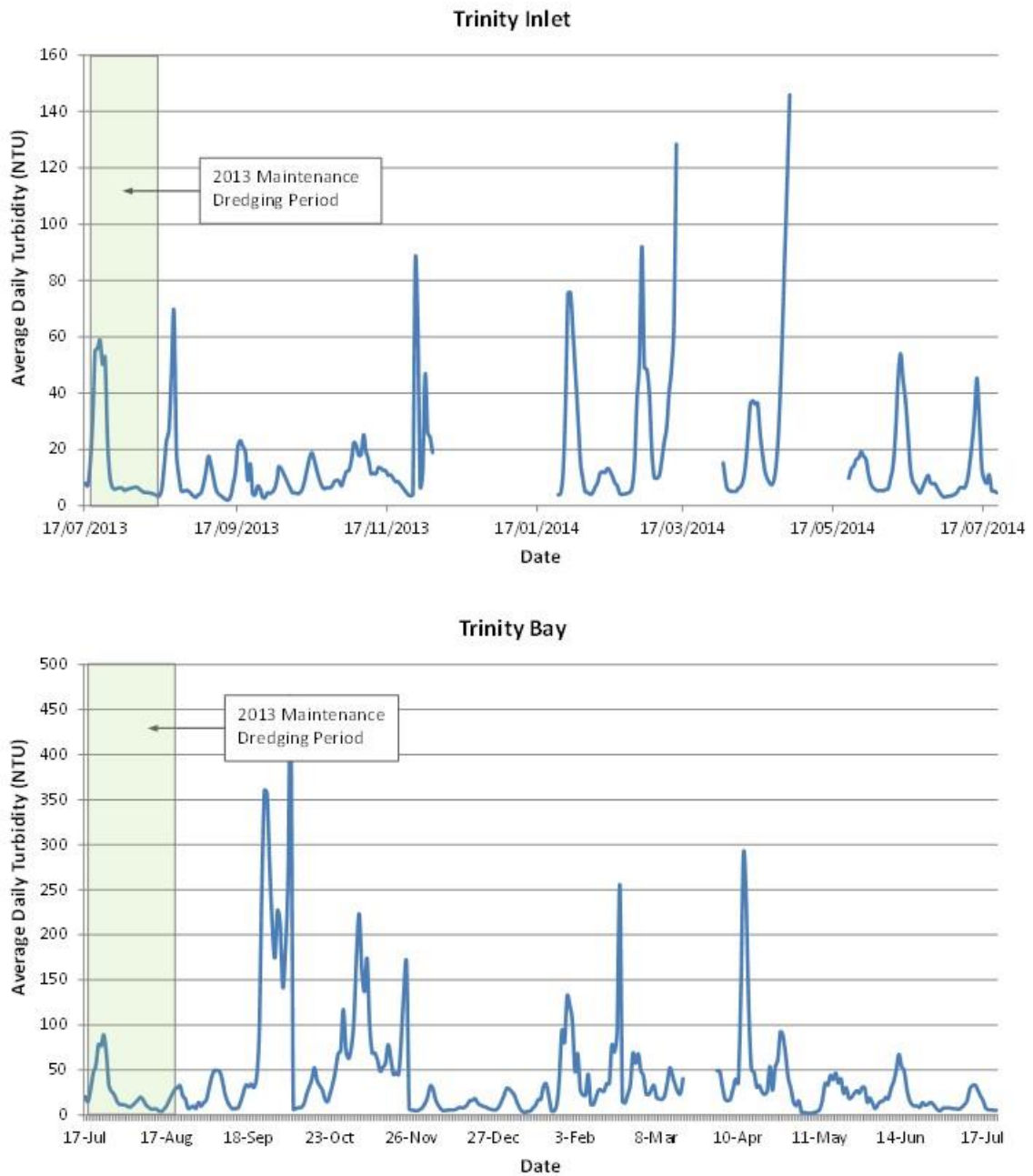


Figure 2-32 Turbidity data and maintenance dredging period at Trinity Bay (top) and Trinity Inlet (bottom)

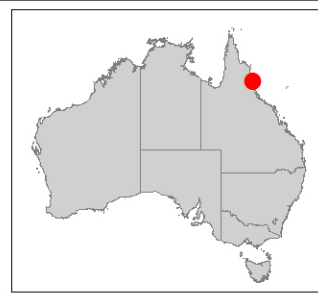
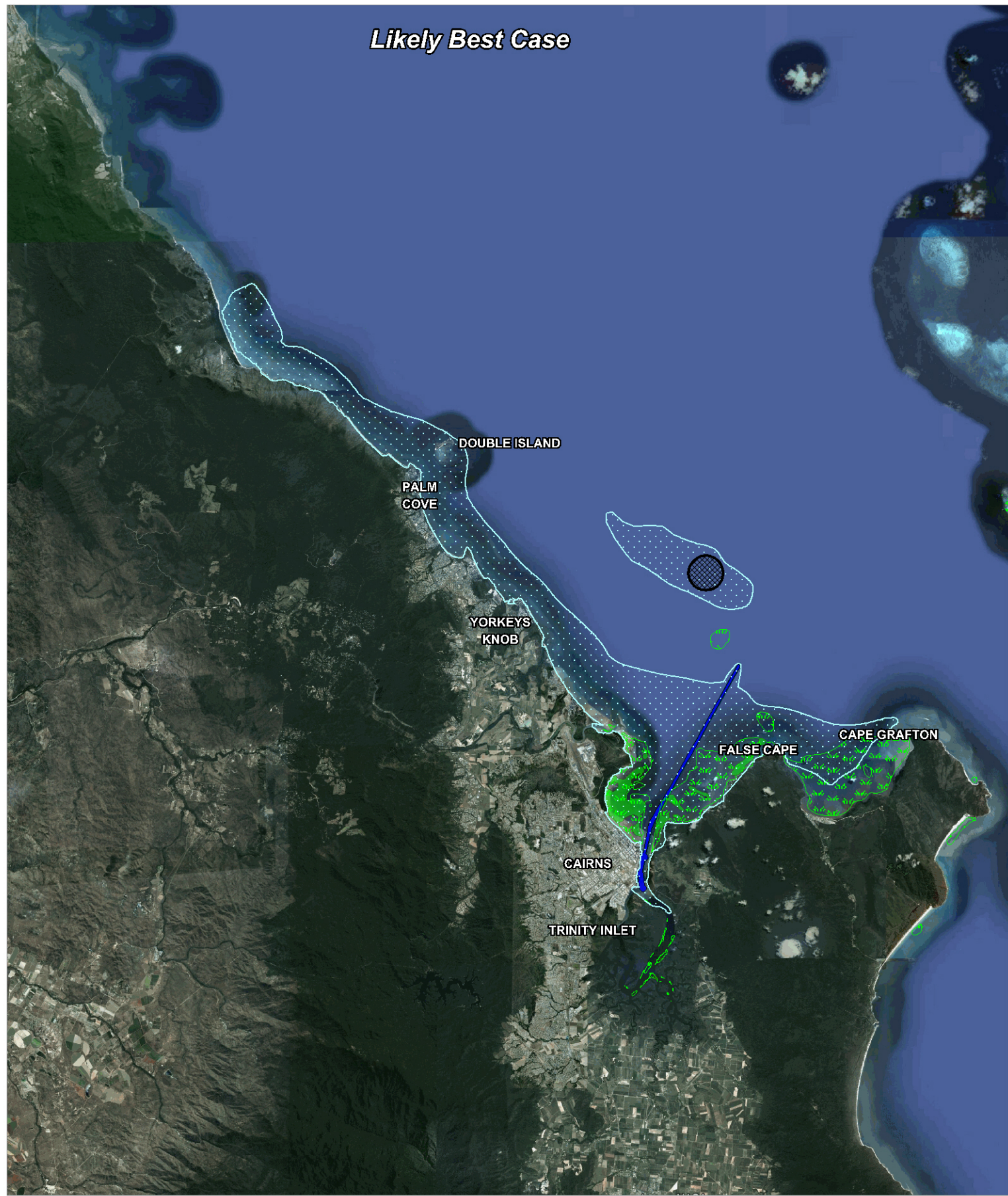
2.6 Cumulative Dredging Assessment

Due to capacity limitations of the Northern Sands DMPA, it is preferred that any overlying maintenance dredge material that is present in the channel prior to the capital dredge campaign is not placed into the Northern Sands DMPA. Therefore, it is likely that a maintenance dredging campaign will be undertaken immediately prior to the capital dredging campaign to remove this overlying material.

As such, a cumulative dredging assessment was undertaken whereby model outputs from a typical maintenance dredging campaign were assessed together with model outputs from the capital dredging campaign. This was undertaken using zones of impact for water quality, with the zones from maintenance dredging and the zones from capital dredging displayed on the one impact zone map (Figure 2-33). The rationale being that if there are any impact zones due to maintenance dredging, these zones may be under stress once capital dredging commences.

As discussed in Section 2.5.2, maintenance dredging is not expected to result in any zones of impact beyond the zone of influence, which indicates the predicted extent of detectable plumes but the turbidity in this zone is predicted to remain within natural variability. The zone of influence for maintenance dredging in the nearshore environment is similar to the capital dredging, extending out from the channel dredging area to the north-west up past Double Island and Palm Cove to Wangetti, and east out to Cape Grafton. The only significant difference between capital and maintenance dredging in terms of the zone of influence is due to dredge material placement at the existing DMPA during maintenance dredging. This results in a zone of influence extending approximately 10 km north-west and 2 km south-east of the existing DMPA (Figure 2-33).

As the turbid plumes generated from maintenance dredging are only expected to result in a zone of influence, it is expected that any residual turbidity still in the system once capital dredging commences is relatively insignificant. Therefore, the potential impacts from the cumulative dredging scenario are expected to be similar to that for the capital dredging scenario discussed in previous sections, with the addition of a zone of influence in the offshore environment due to placement at the existing DMPA during maintenance dredging. However, the plumes from placement of maintenance dredge material at the existing DMPA are likely to be short-term and will have dissipated prior to commencement of capital dredging.



LEGEND

-  Historic Seagrass Extent (1984 - 2015)
-  2015 Seagrass Extent
-  Existing Maintenance Dredging DMPA

Zones of Impact

-  Zone of Influence (no ecological impacts)
-  Zone of Low to Moderate Impact
-  Zone of High Impact

Title:

**Zones of Impact - Turbidity - Cumulative Dredging
Likely Best Case (left) and Likely Worst Case (right)**

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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3 Recommended Mitigation Measures

3.1 Mitigation Measures – Construction Phase

3.1.1 Capital Dredging

In this impact assessment, it has been assumed that a number of standard mitigation or best practice measures will be employed to minimise potential turbidity impacts generated by capital dredging works. These standard mitigation measures are as follows:

- Ensure the dredge operates within the approved dredge footprint at all times.
- Overflow dredging (dredging after a full hopper load has been achieved) by the TSHD is undertaken in accordance with the overflow regime detailed in the Dredge Management Plan.
- Dredge hopper compartment is to be kept water tight during all dredging activities.
- Ensure the top of overflow valves are not lowered during the transport component of the dredging cycle (dredging area to pump-out location).
- The dredge is to be fitted with a 'green valve' in order to minimise the areal extent of turbidity plumes generated by dredge operation. The 'green valve' ensures that overflow from the dredge vessel is released under the keel of the vessel rather than at the water surface with minimal energy.
- Washing the hopper compartment and pumping out of the hopper must not take place outside the pump-out location.
- Further to the above standard mitigation measures, a reactive water quality monitoring program will be implemented to reduce the potential impacts further. The reactive water quality monitoring program will involve the following:
 - The monitoring program will be implemented during the dredge campaign to monitor water quality at locations of sensitive receptors (including similar monitoring locations to those used in the impact assessment section).
 - Monitoring data will be collected and downloaded regularly and the data assessed against threshold triggers, with appropriate management actions implemented if threshold triggers are exceeded.
 - The monitoring program will be used in real time to guide the dredging campaign and to monitor the effectiveness of the above mitigation measures. If trigger levels are exceeded, the dredge contractor will be responsible for taking actions, in consultation with Ports North, to ensure impacts are avoided at sensitive receptors.
 - The reactive water quality monitoring program is detailed further in the Dredge Management Plan.

As demonstrated in the Potential Impacts section, potential impacts from other parameters (e.g. nutrients and metals) in sediment are negligible and no mitigation measures are required.

3.1.2 Tailwater Discharges from Northern Sands DMPA

It is assumed that appropriate management controls will be implemented within the DMPA such that tailwater discharges do not exceed specified water quality criteria, as follows:

- 48-hour rolling average TSS does not exceed 100 mg/L.
- 14 day rolling average TSS does not exceed 50 mg/L.

To further mitigate potential turbidity and salinity impacts in the Barron River, monitoring of sites within the Barron River will be undertaken as part of the reactive water quality monitoring program discussed in the previous section and detailed in the Dredge Management Plan.

3.1.3 Pipeline Crossing at Richters Creek

Standard mitigation measures are to be implemented to reduce the risk of increased turbidity and other contaminants entering the marine waters, including:

- Appropriate erosion and sediment controls installed around earthworks associated with the pipeline crossing works.
- To reduce the risk of fuel/oil spills from construction plant and equipment, standard procedures are included in the Dredge Management Plan.

3.1.4 Potential Acid Sulfate Soil (PASS) Impacts from Dredging

It is assumed that the following standard mitigation measure will be employed to minimise potential impacts from oxidation of PASS dredge material:

- Dredge material should ideally remain waterlogged and not be left within TSHD hopper or dump barges for periods longer than 24 hours to minimise the risk of PASS oxidation.

3.1.5 Dredging and Construction Plant and Equipment

Standard operational mitigation measures are to be implemented to reduce the risk of fuel/oil spills and other contaminants entering the marine waters, including:

- Development and Implementation of a Dredge Management Plan which includes management measures to be followed by dredge staff. This document is to be kept as on-board dredge equipment and readily accessible to dredge staff
- A hydrocarbon spill kit is to be located on the dredge and transport barges. This spill kit is to contain such items as absorbent material for spills on deck and also floating booms to contain hydrocarbon slicks if spills manage to enter the water. This spill kit is to be maintained regularly to ensure contents are fully stocked and in good condition
- Consistent with present practice, first strike spill response equipment and appropriately trained staff for the port are accessible and able to respond to events, and have access to more spill response resources if the event escalates

- All fuel and chemical supplies on the dredge and transport barges are to be stored in bunded areas as per the requirements of AS1940:2004 - The storage and handling of flammable and combustible liquids 2004, and applicable WHS Act requirements.

3.2 Mitigation Measures – Operational Phase

3.2.1 Future Maintenance Dredging

It is assumed that the following standard mitigation measures will be employed to minimise potential impacts from future maintenance dredging:

- Preparation and implementation of a sediment sampling and analysis plan (SAP) to determine suitability of future maintenance dredge material for marine placement consistent with GBRMPA requirements (noting maintenance material at Port of Cairns has always been suitable for at sea placement).
- Any contaminated material detected in future testing will be assessed and investigated to determine suitability and management options under the NAGD and sea dumping permit process.
- Existing maintenance dredging operations occur in accordance with Sea Dumping and Marine Park permit conditions including the approved Long Term Dredge Spoil Disposal Management Plan (LTDSMP) which contains management measures to reduce impacts on water quality from dredging and placement. This plan will be reviewed and updated in consultation with the established TACC for approval by the Determining Authority. This process will likely occur in parallel with a process to resolve a new Sea Dumping and Marine Park Permit.

Further to the above standard mitigation measures, the following additional mitigation measures are proposed to reduce the potential impacts further:

- Update the Sea Dumping and Marine Parks Permits and associated LTDSMP to address the additional volumes and duration of maintenance dredging required by the wider channel.

3.2.2 Increased Shipping

It is assumed that compliance with relevant legislation in regard to shipping will be employed as part of standard mitigation measures. To further reduce the potential future risk to marine water quality from refuelling activities associated with the provision of IFO at the port, additional mitigation proposed includes revision of fuel handling and spill response procedures in the port's operational procedures.

3.3 Monitoring

Water quality monitoring during the construction phase of the project will be undertaken in accordance with the reactive monitoring programs described above and detailed in the Dredge Management Plan.

4 Residual Impacts and Assessment Summary

In accordance with the methodology described in Section 2.1, Table 4-1 summarises the marine water quality issues identified by the impact assessment in the previous sections. This assessment table also includes the significance of each of the identified impacting processes, the likelihood of the impact occurring, and the resulting risk rating.

The standard and additional mitigation measures discussed in previous sections are also summarised in Table 4-1, with a risk rating indicated for the residual impacts after mitigation. As indicated in this assessment table, all residual impacts are rated as either a low or negligible risk. Construction phase residual impacts would be short-term (up to one year) in duration, while operational phase residual impacts would be long-term in duration extending over the life of the project.

Residual Impacts and Assessment Summary

Table 4-1 Risk assessment summary – marine water quality

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Primary impacting processes	Statutory mitigation measures required	Consequence of impact	Likelihood of impact	Risk rating	Additional mitigation measures proposed	Consequence of impact	Likelihood of impact	Residual Risk rating
Construction Phase								
Generation of turbid plumes and sediment deposition from capital dredging	- Ensure TSHD dredge operates within the approved dredge footprint at all times. - Overflow dredging by the TSHD is undertaken in accordance with the overflow regime in the Dredge Management Plan. - Dredge hopper compartment is to be kept water tight during all dredging activities, except emptying and washing of hopper at the pump-out location. - Ensure the top of overflow valves are not lowered during the transport component of the dredging cycle - No high pressure jets to be used on drag heads outside of the dredge footprint - Dredge to be fitted with a 'green valve'	Minor	Possible	Low	Implementation of a reactive water quality monitoring program, with management/corrective actions implemented if trigger levels are exceeded (as outlined in the Dredge Management Plan in Part C)	Minor	Unlikely	Low
Cumulative dredging of maintenance dredging followed by capital dredging	Same as above	Minor	Possible	Low	Implementation of a reactive water quality monitoring program, with management/corrective actions implemented if trigger levels are exceeded (as outlined in the Dredge Management Plan in Part C)	Minor	Unlikely	Low

Residual Impacts and Assessment Summary

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place	Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)						
Generation of turbid plumes and increased salinity from tailwater discharges from the Northern Sands DMPA	Tailwater discharges from the Northern Sands DMPA do not exceed specified water quality criteria.	Minor	Possible	Low	Implementation of a reactive water quality monitoring program, with management/corrective actions implemented if trigger levels are exceeded (as outlined in the Dredge Management Plan in Part C)	Minor	Unlikely	Low
Pipeline crossing of Richters Creek	Installation of erosion and sediment controls on land	Negligible	Possible	Negligible	Nil	Negligible	Possible	Negligible
Mobilisation of contaminants into water column	Dredge material has been assessed as being uncontaminated (as described in Chapter B4)	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible
Oxidisation of potential acid sulphate soil material	- Risks of oxidation are negligible assuming placement of the dredged material in waterlogged void - Dredge material should ideally remain waterlogged and not be left within TSHD hopper or dump barges for periods longer than 24 hours to minimise the risk of PASS oxidisation in the hopper.	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible

Residual Impacts and Assessment Summary

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Dredging and construction plant and equipment	- Development and implementation of a Dredge Management Plan by the Contractor (in accordance with the DMP contained in Part C). - Hydrocarbon spill kit is to be located on the dredge and transport barges. - First strike spill response equipment and staff are accessible and able to respond to events, and have access to more spill response resources if the event escalates. - All fuel and chemical supplies to be stored appropriately.	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible
Operational Phase								
Increased shipping	Compliance with relevant legislation	Minor	Possible	Low	Revise fuel handling and spill response procedures in the Port's operational procedures	Minor	Unlikely	Low

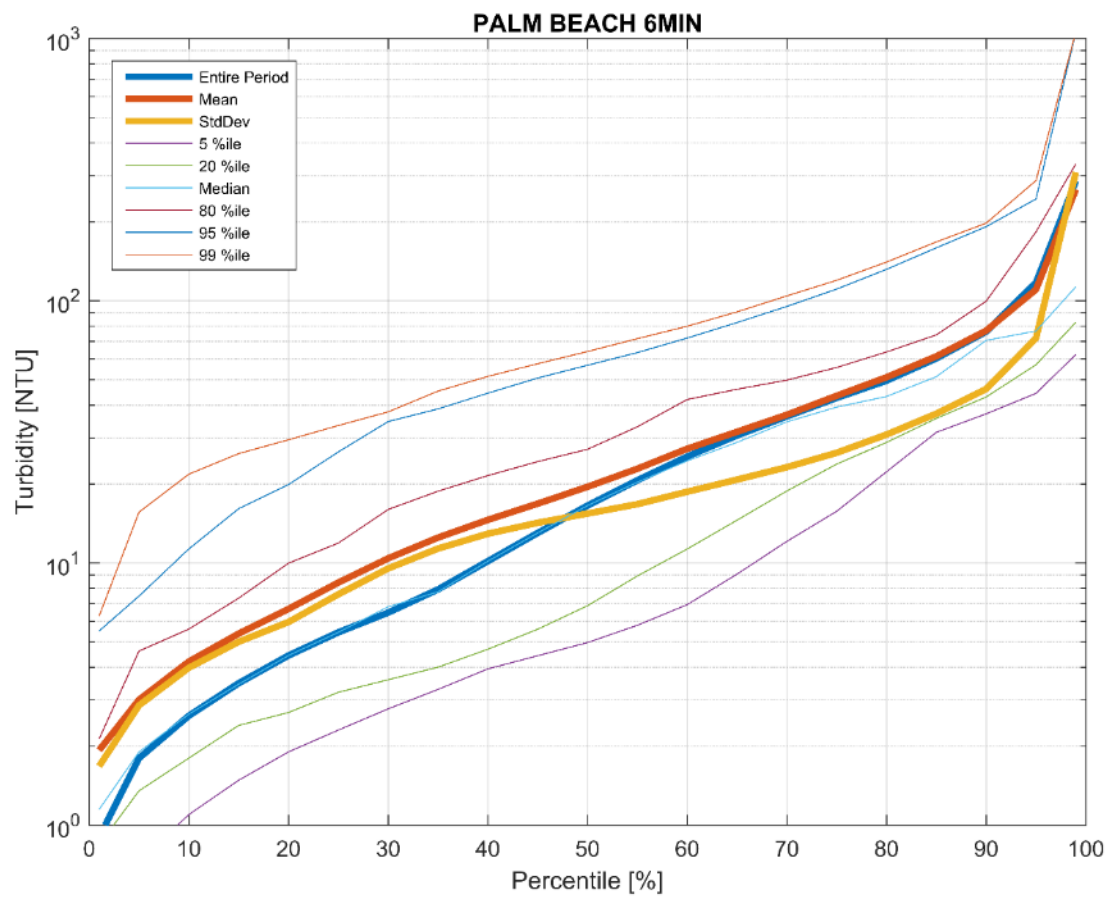
Residual Impacts and Assessment Summary

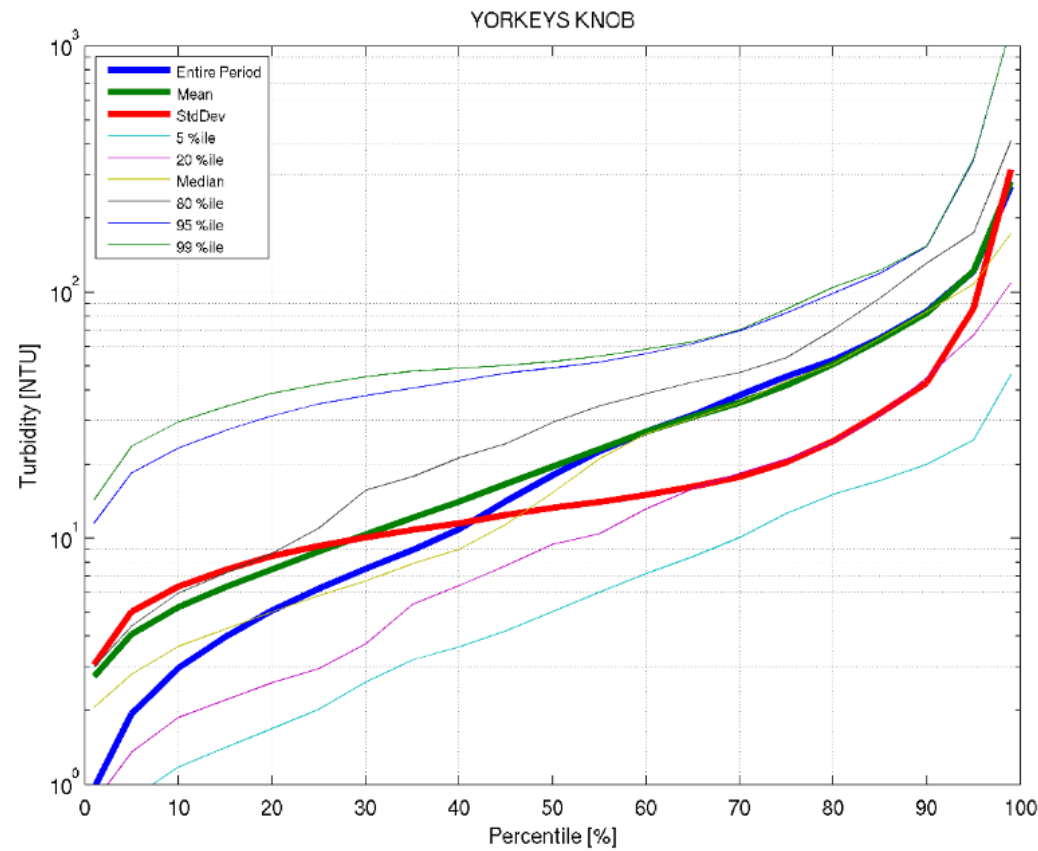
Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Future maintenance dredging – mobilisation of contaminants into water column	- Preparation and implementation of a sediment sampling and analysis plan (SAP) to determine suitability of future maintenance dredge material for marine placement (noting maintenance material at Port of Cairns has always been suitable for at sea placement) - Any contaminated material detected in future testing will be assessed and investigated to determine suitability and management options under the NAGD and sea dumping permit process	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible
Future maintenance dredging – water quality from dredge plumes	Existing maintenance dredging operations occur in accordance with an approved LTDSMP which contains management measures to reduce impacts on water quality from dredging and placement	Minor	Possible	Low	Update the LTDSMP to address the additional volumes and duration of maintenance dredging required by the wider channel	Minor	Possible	Low

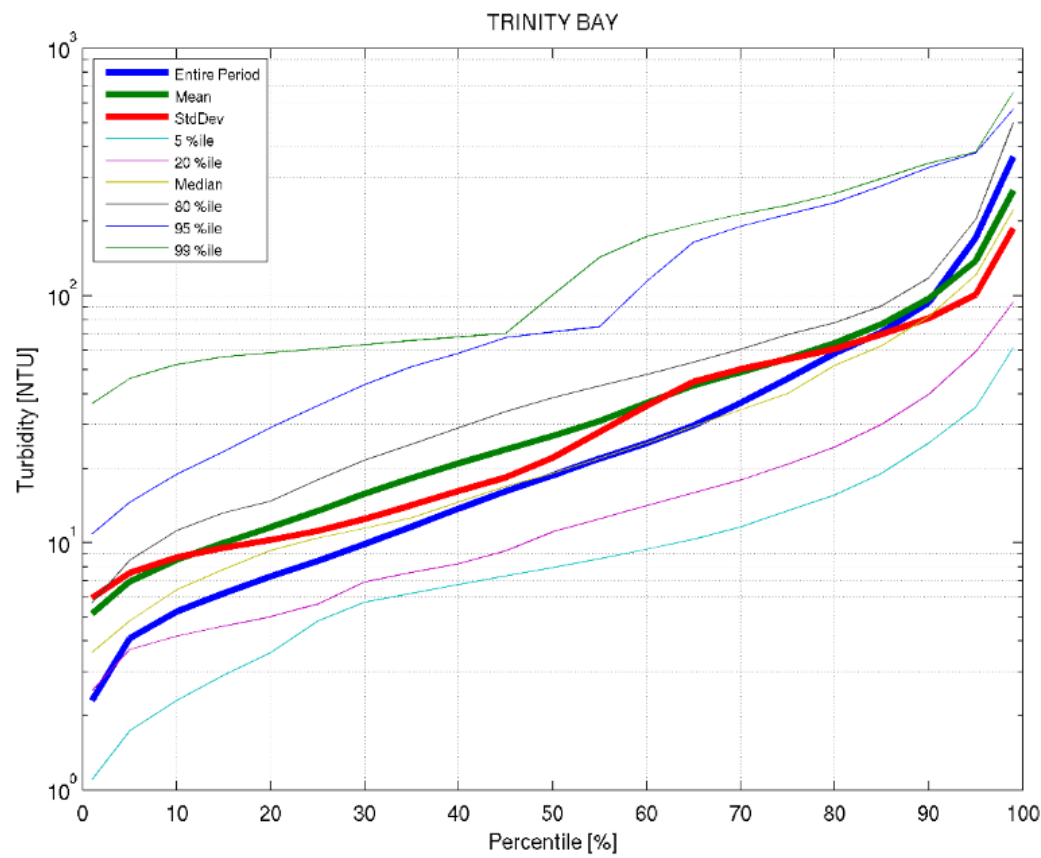
5 References

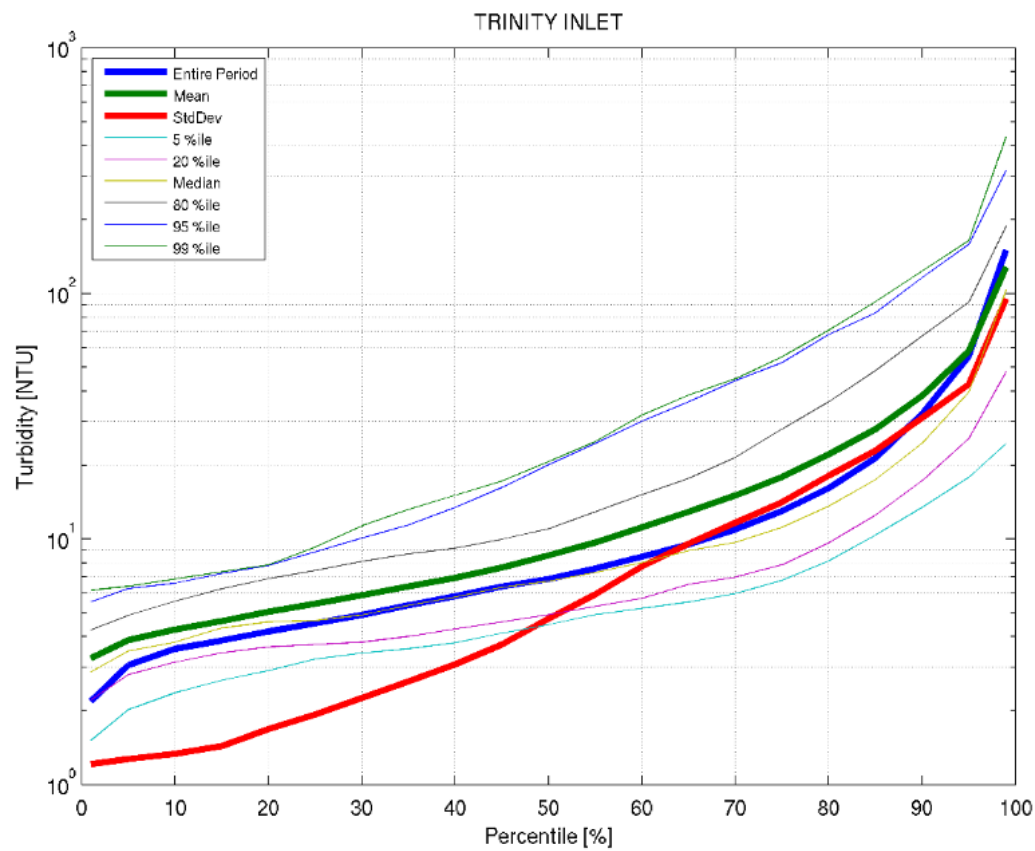
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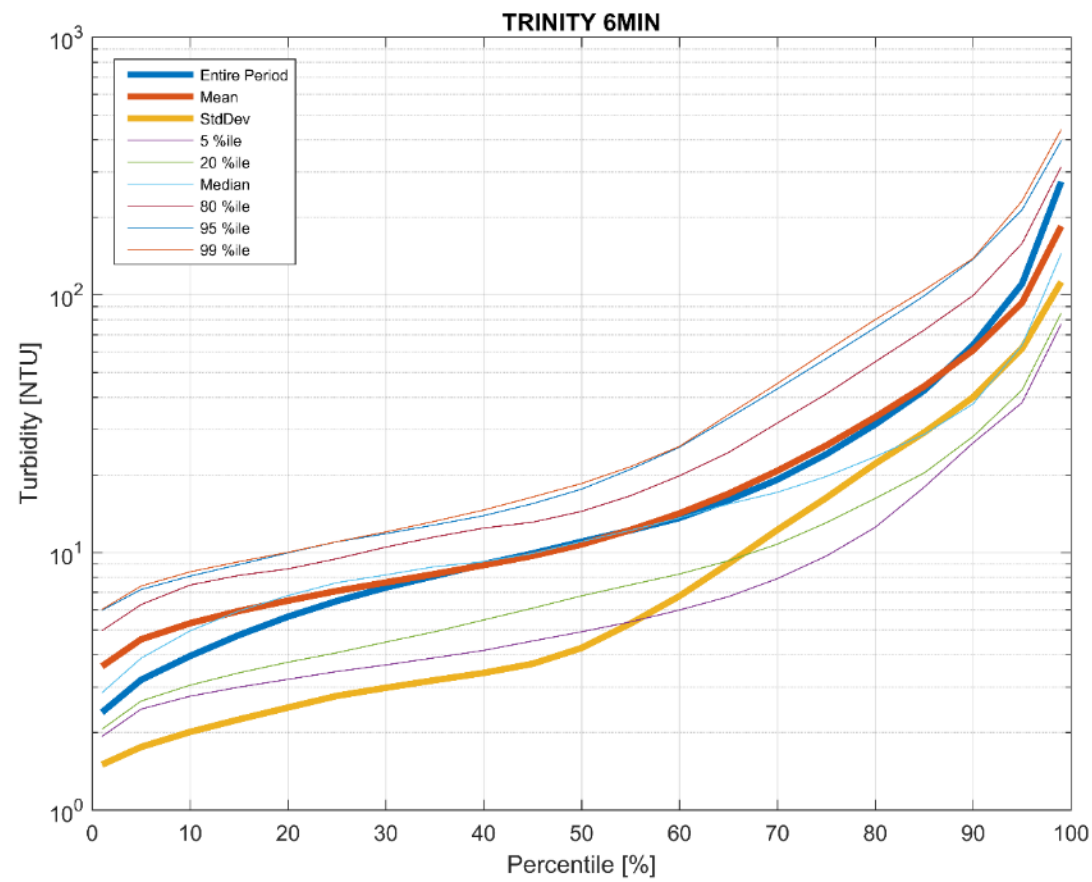
Appendix A Baseline Data Percentile Curves

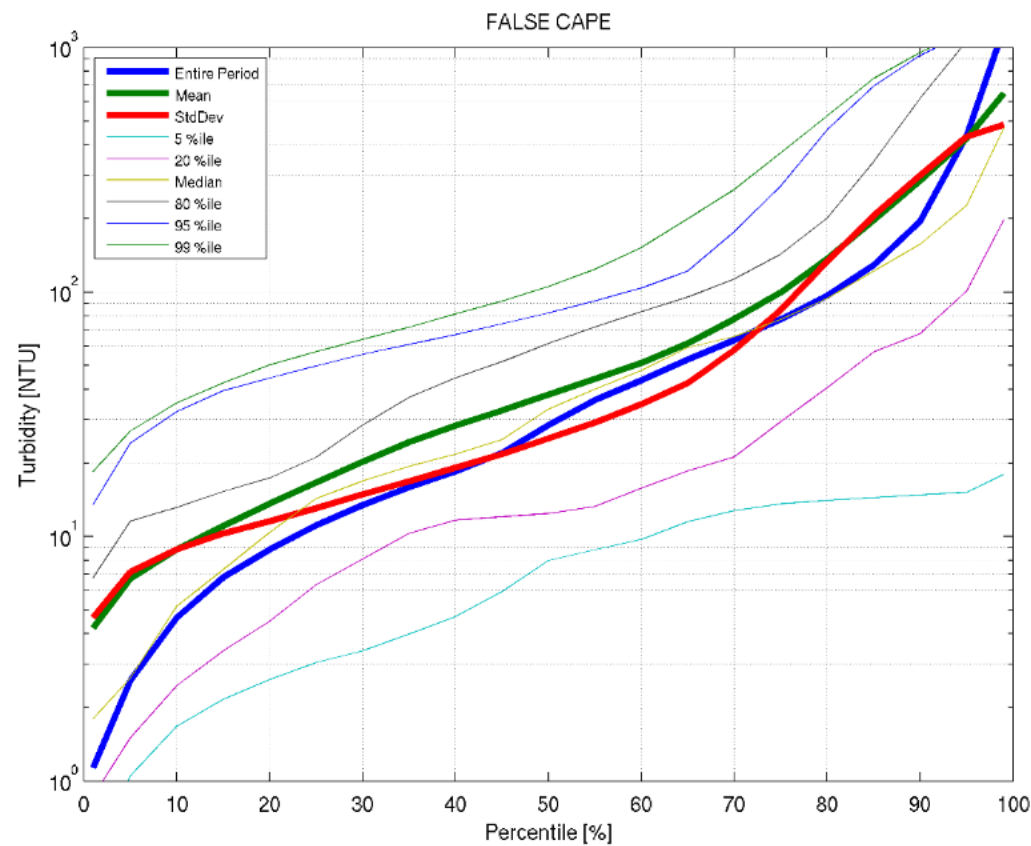


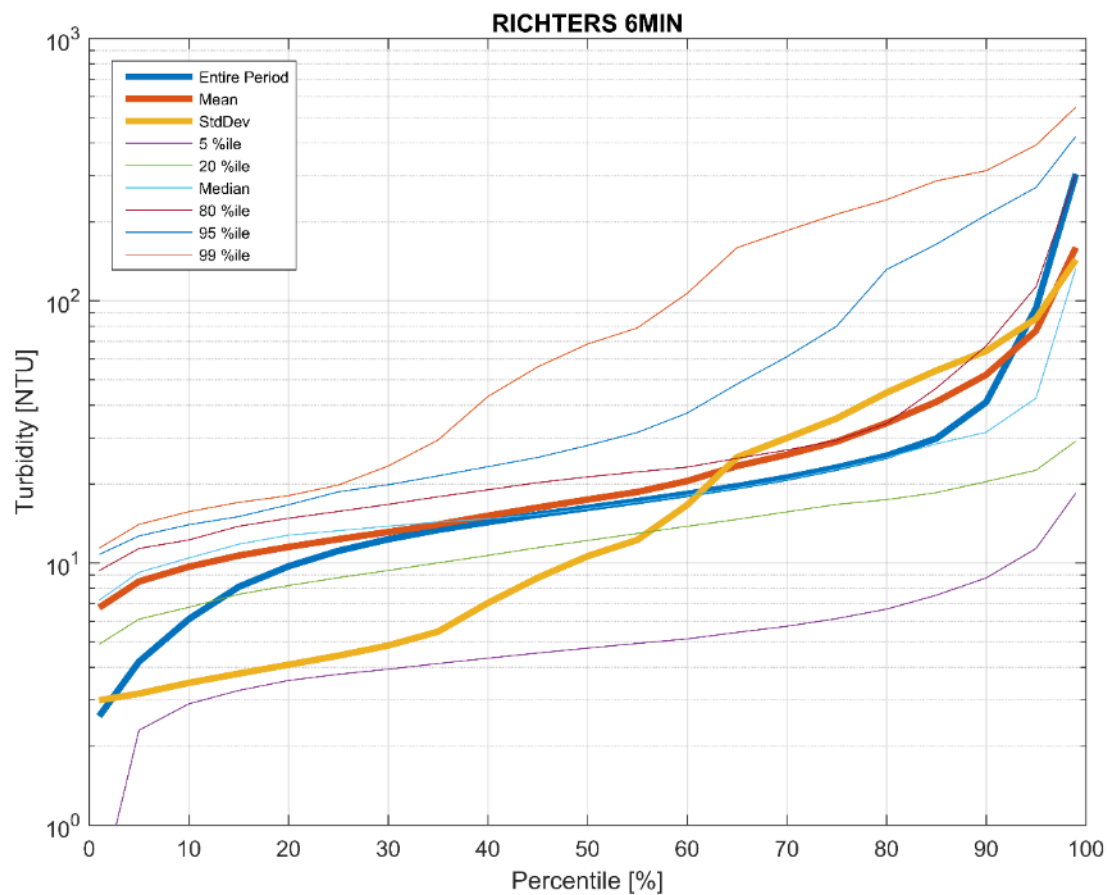


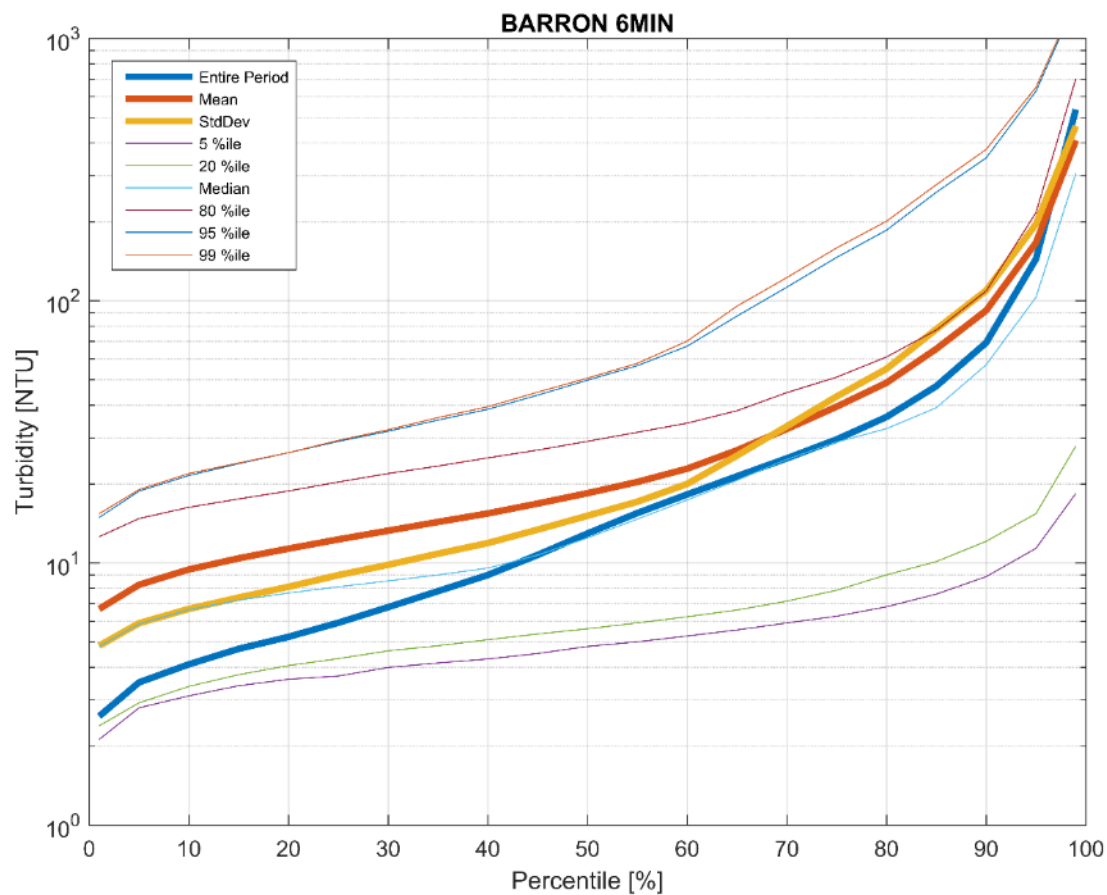




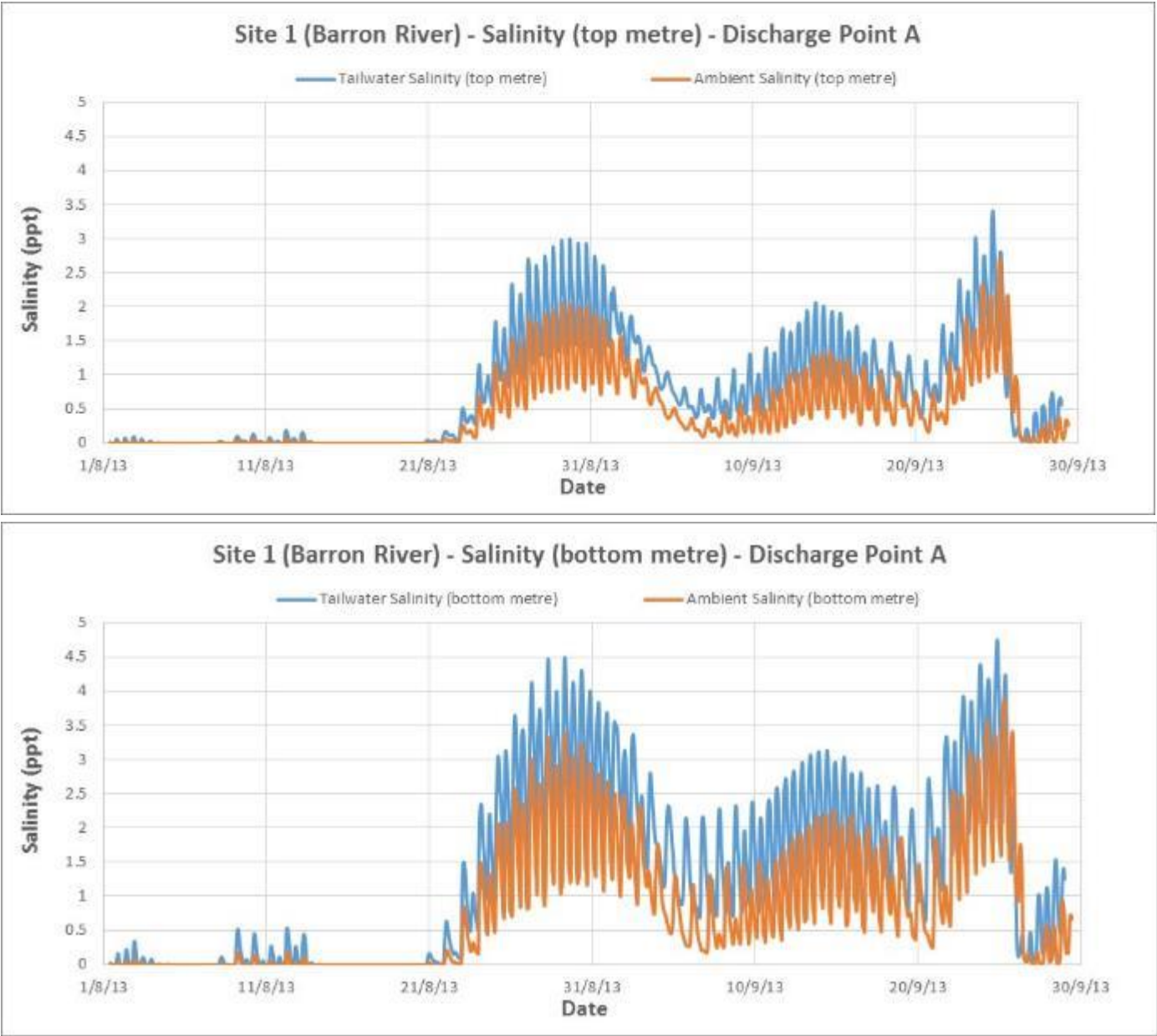


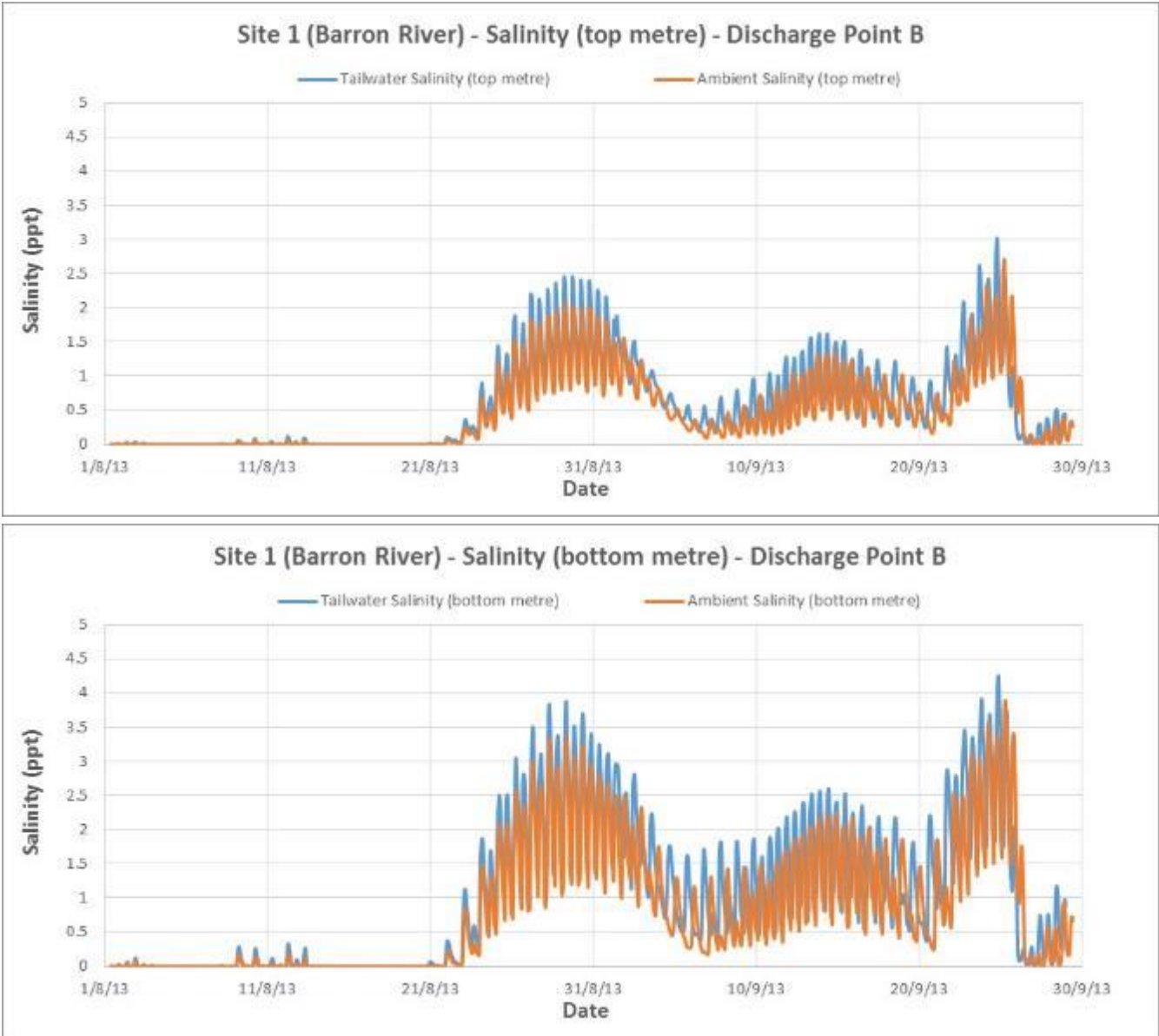


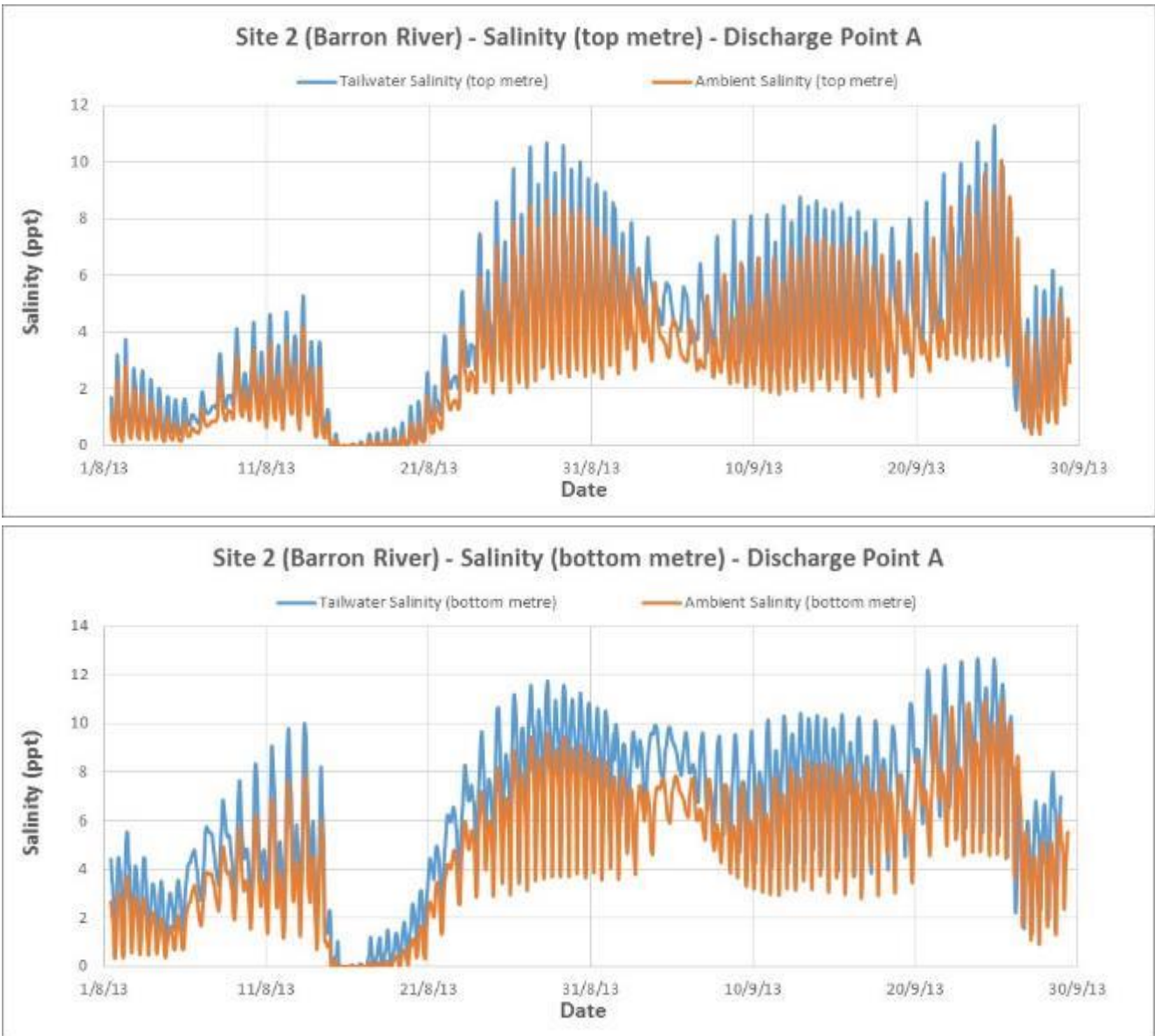


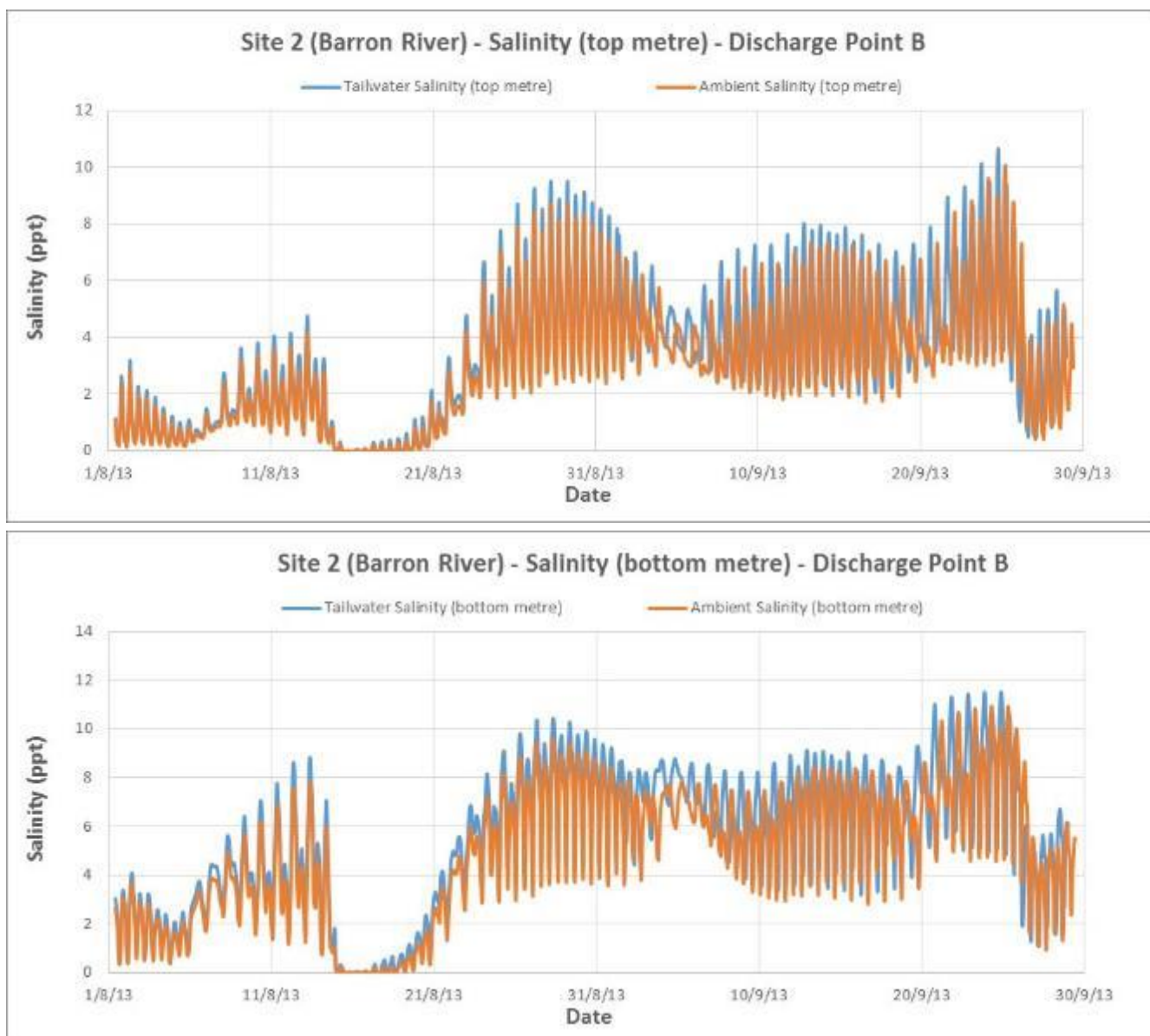


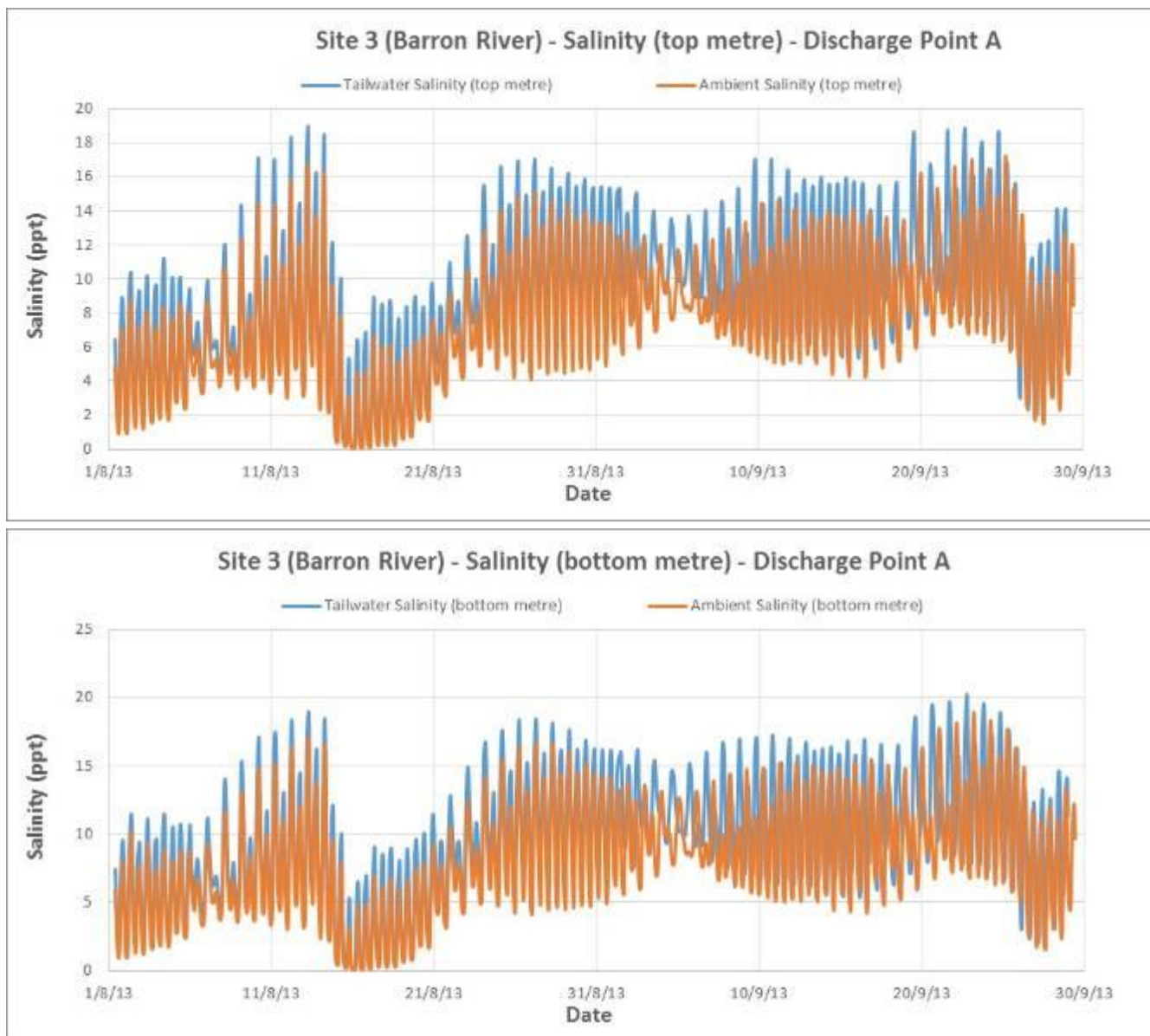
Appendix B Time Series Salinity Graphs

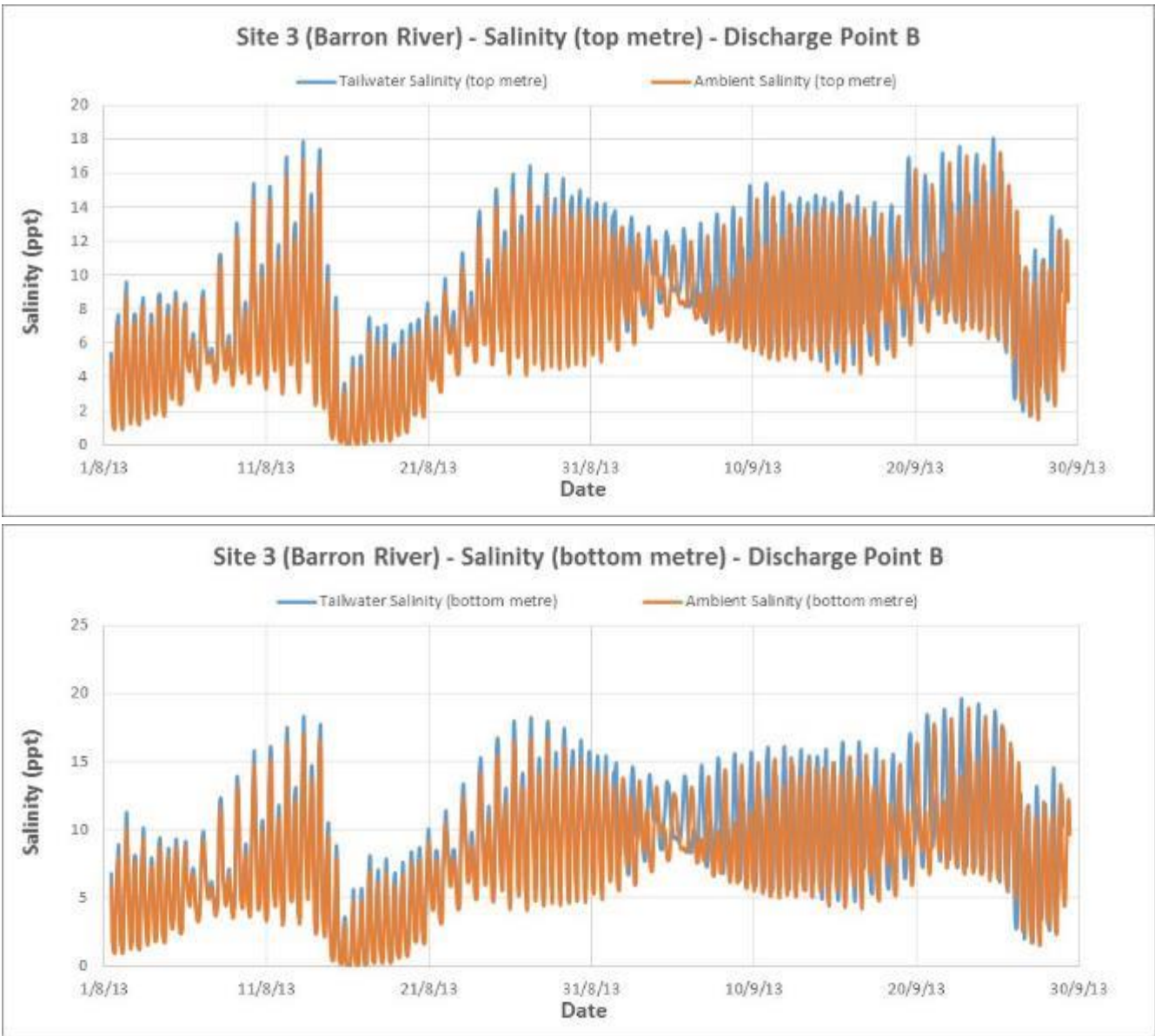


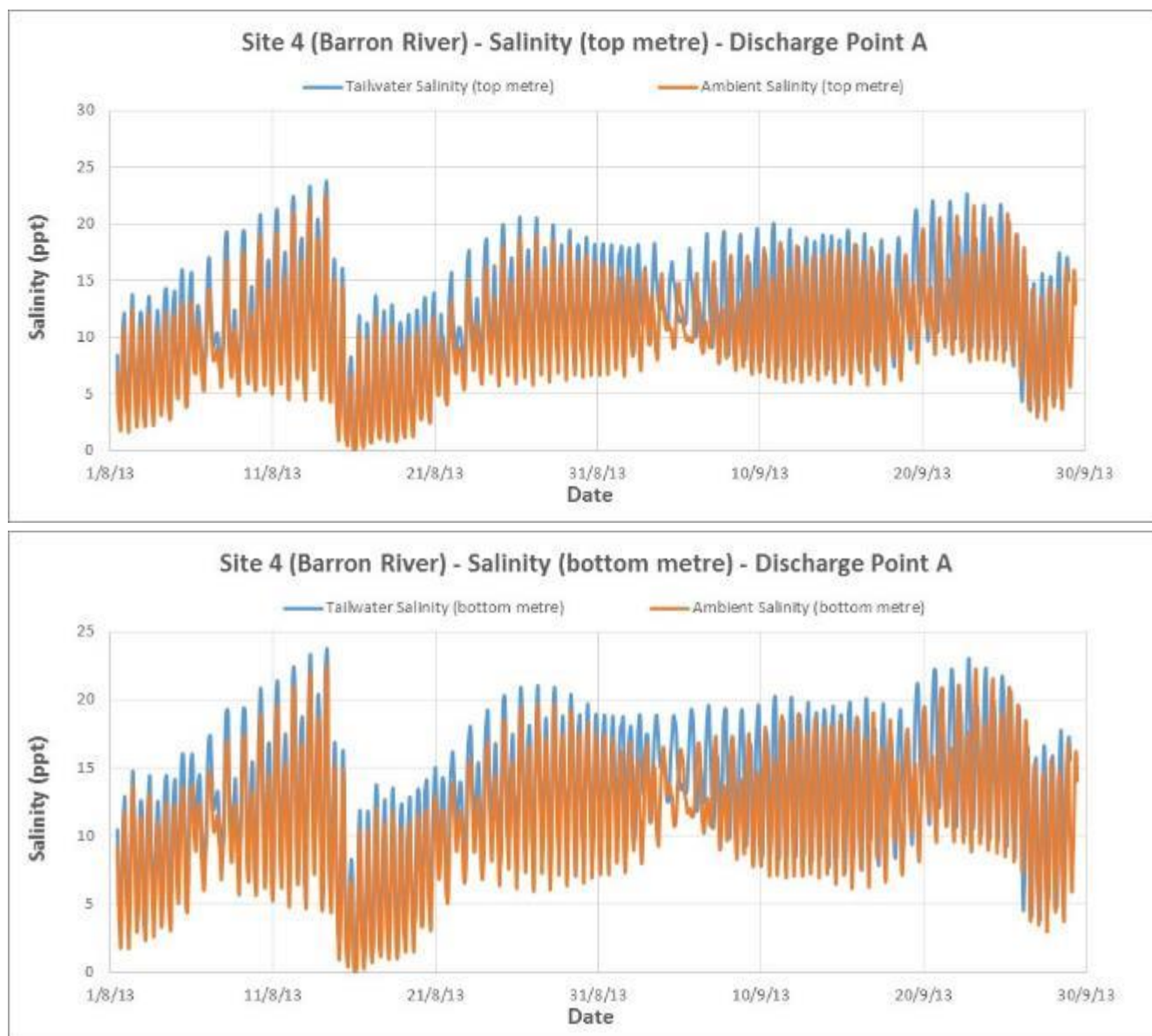


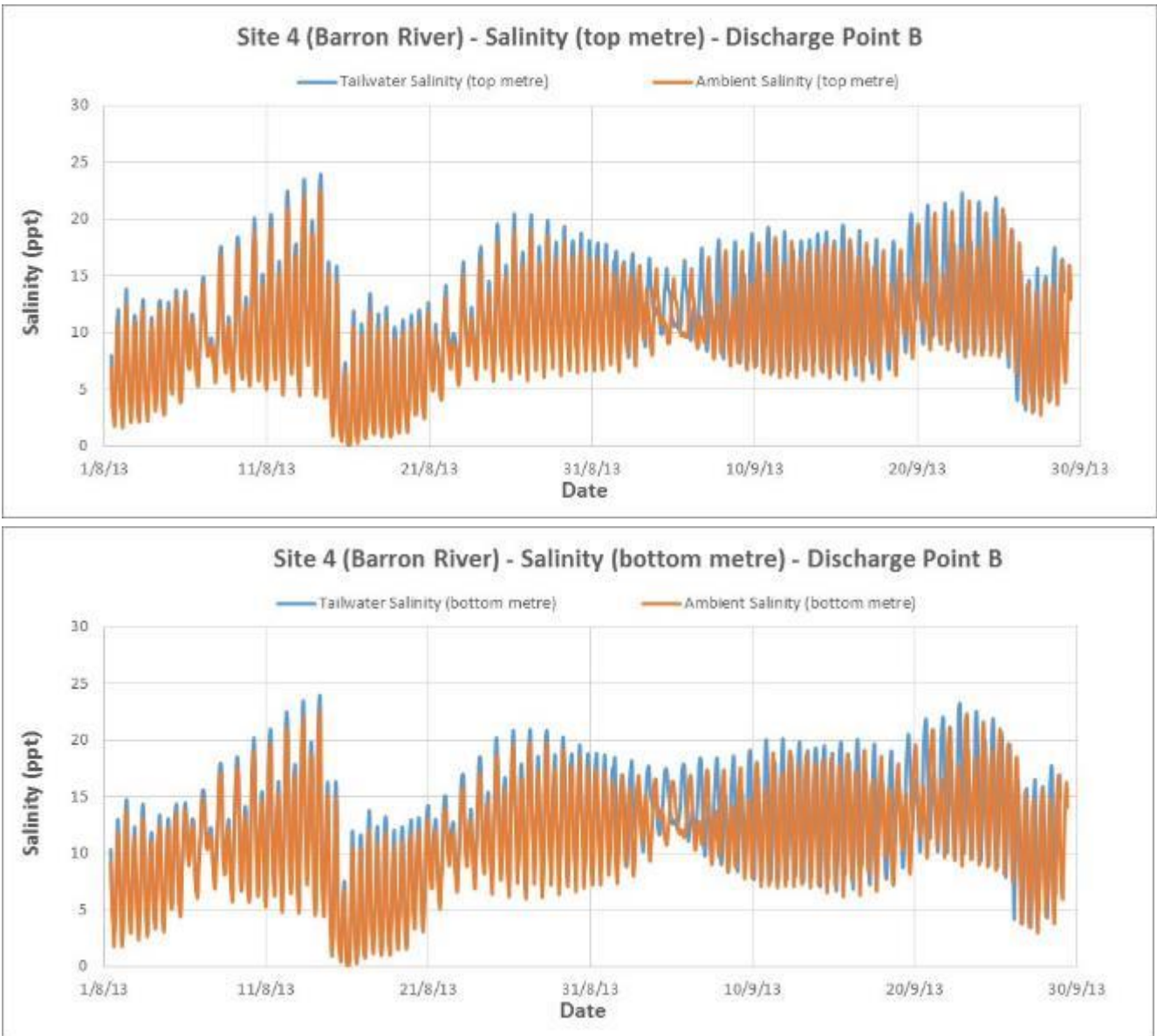


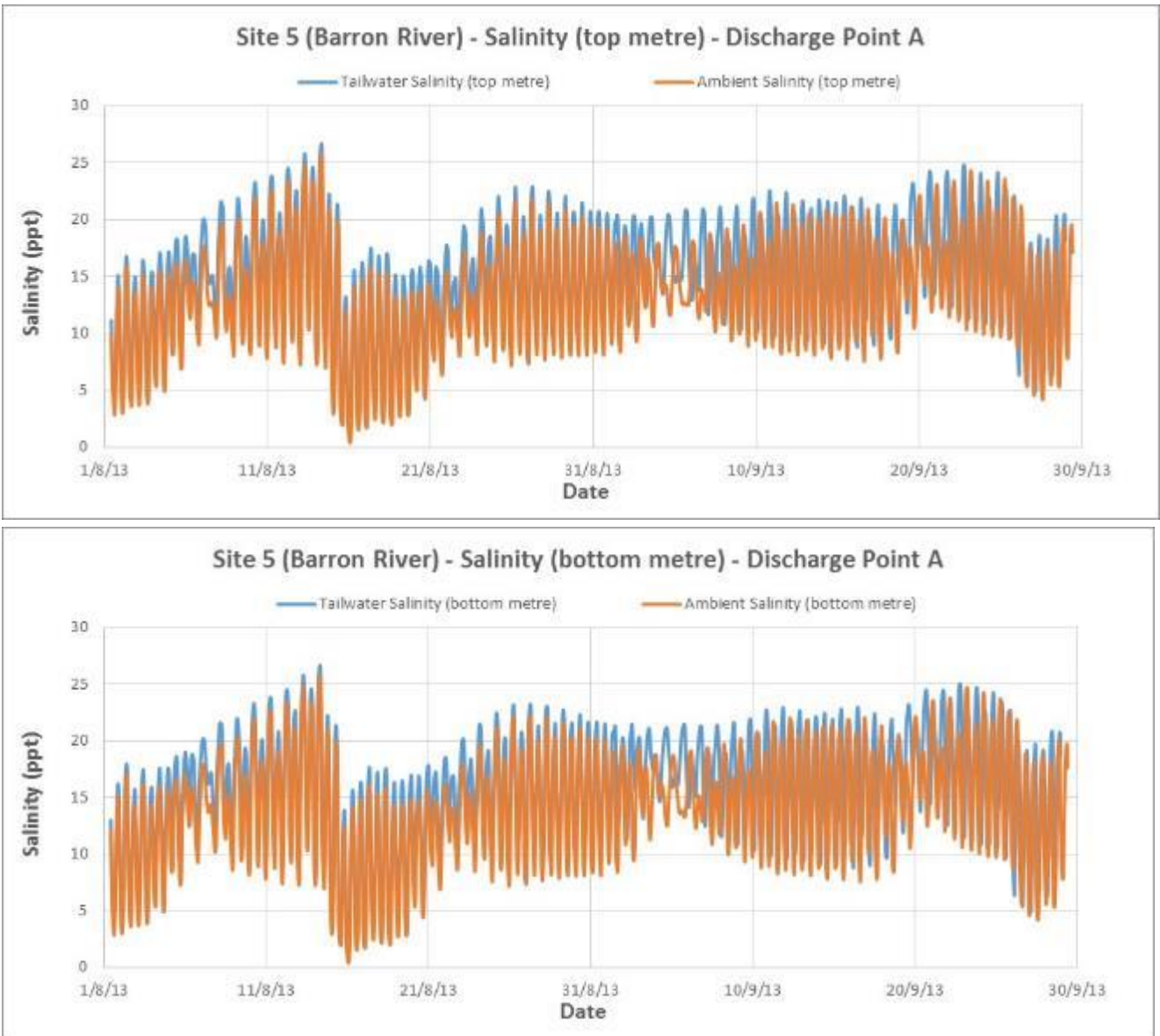


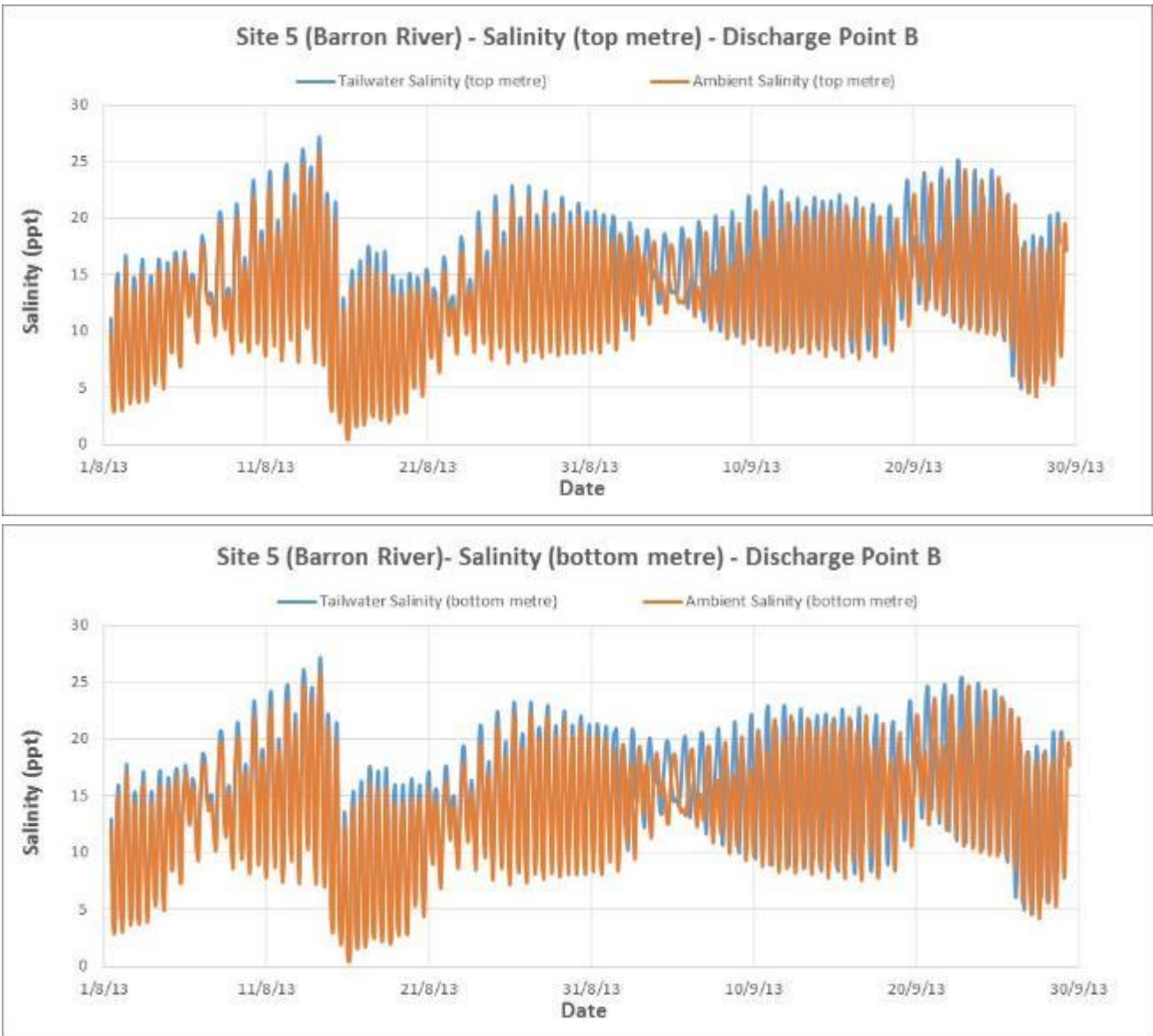


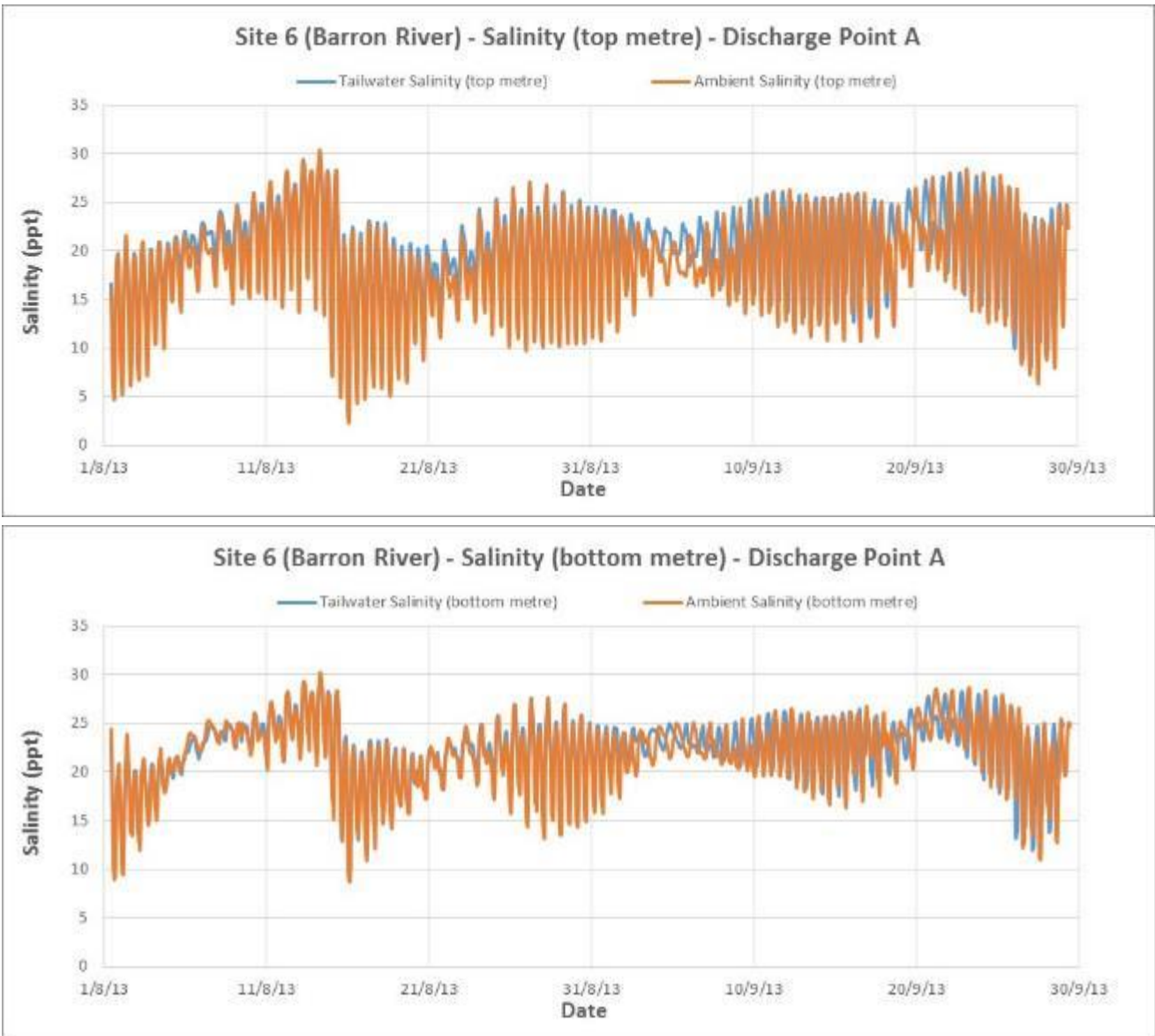


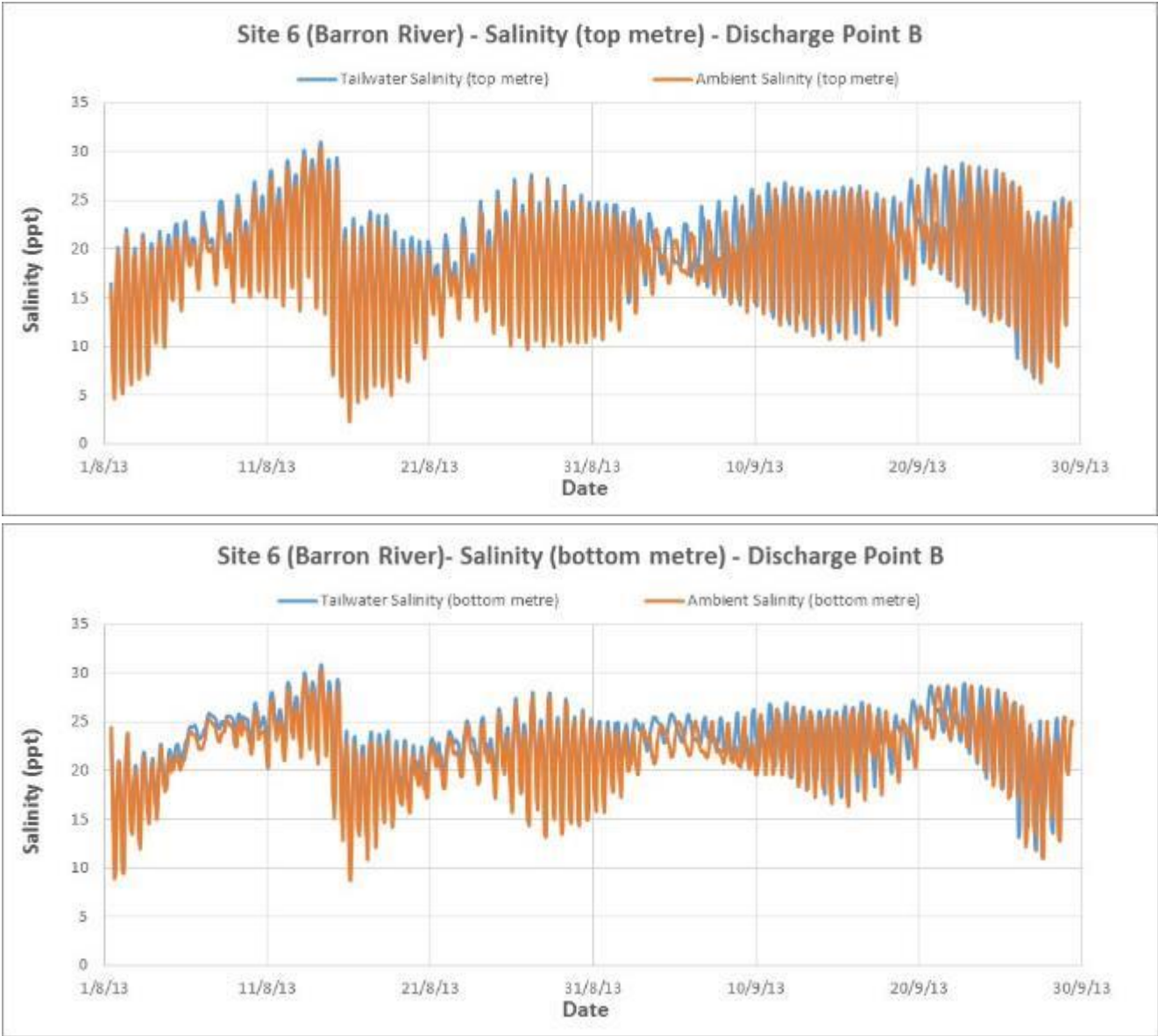


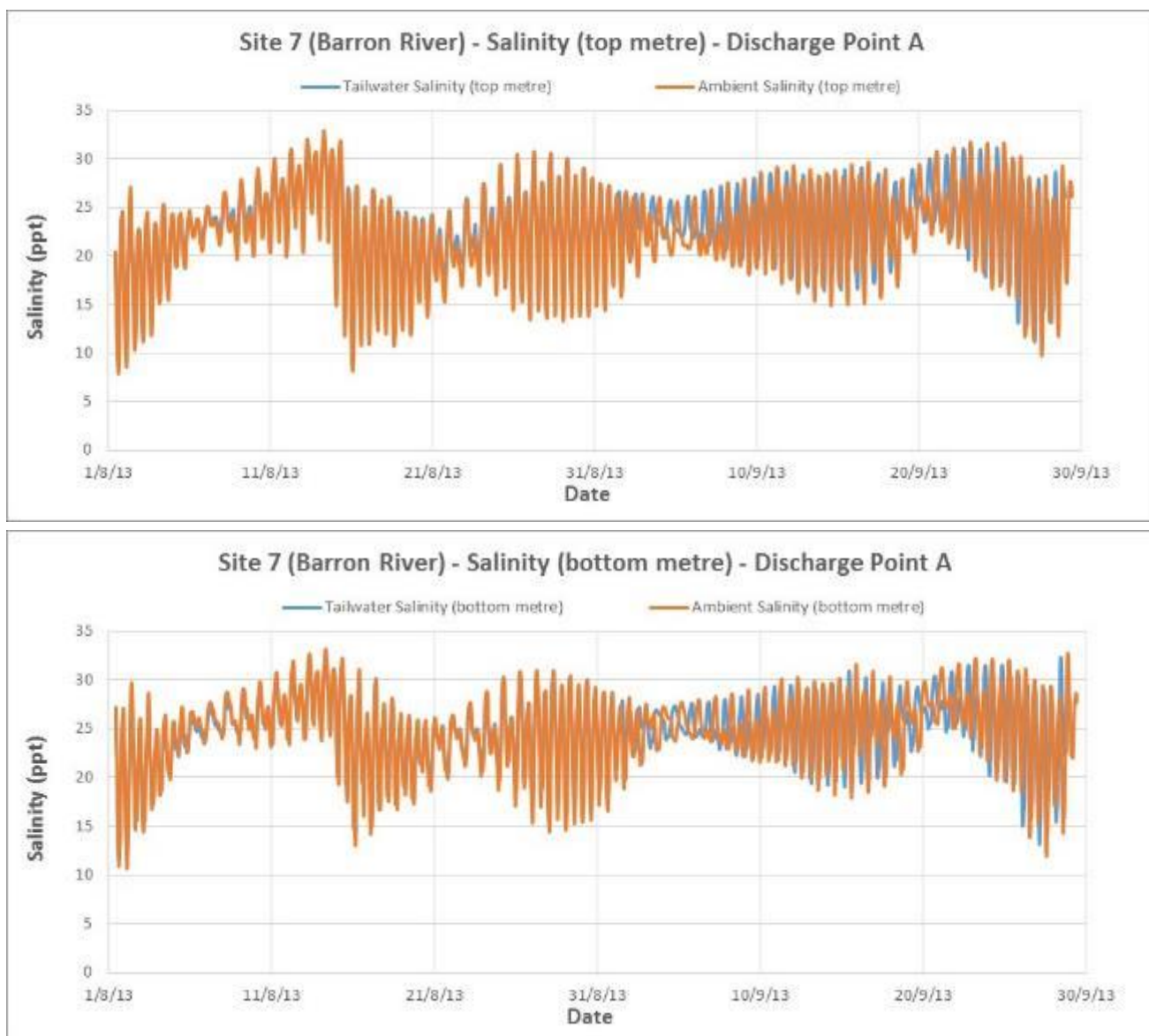


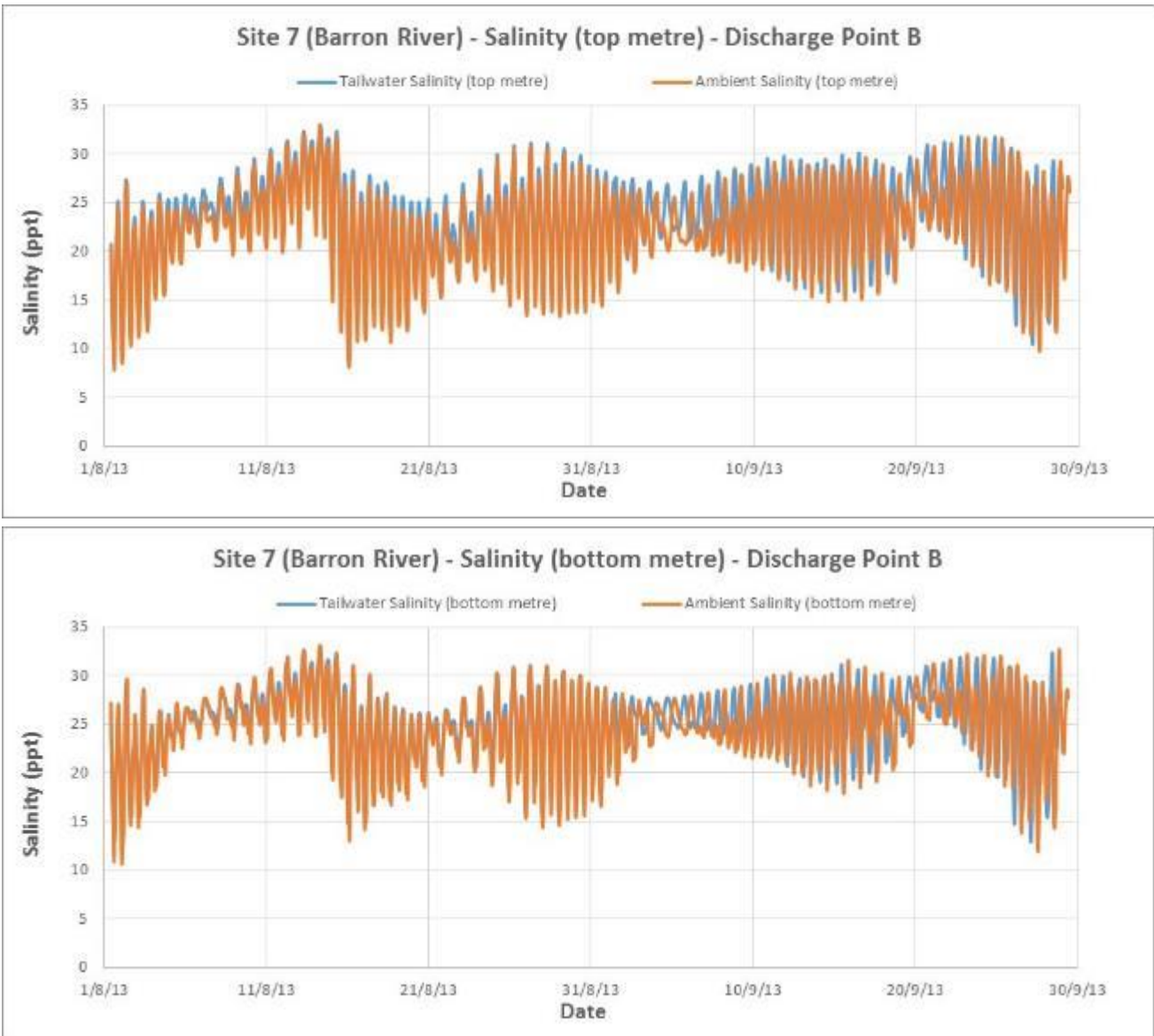


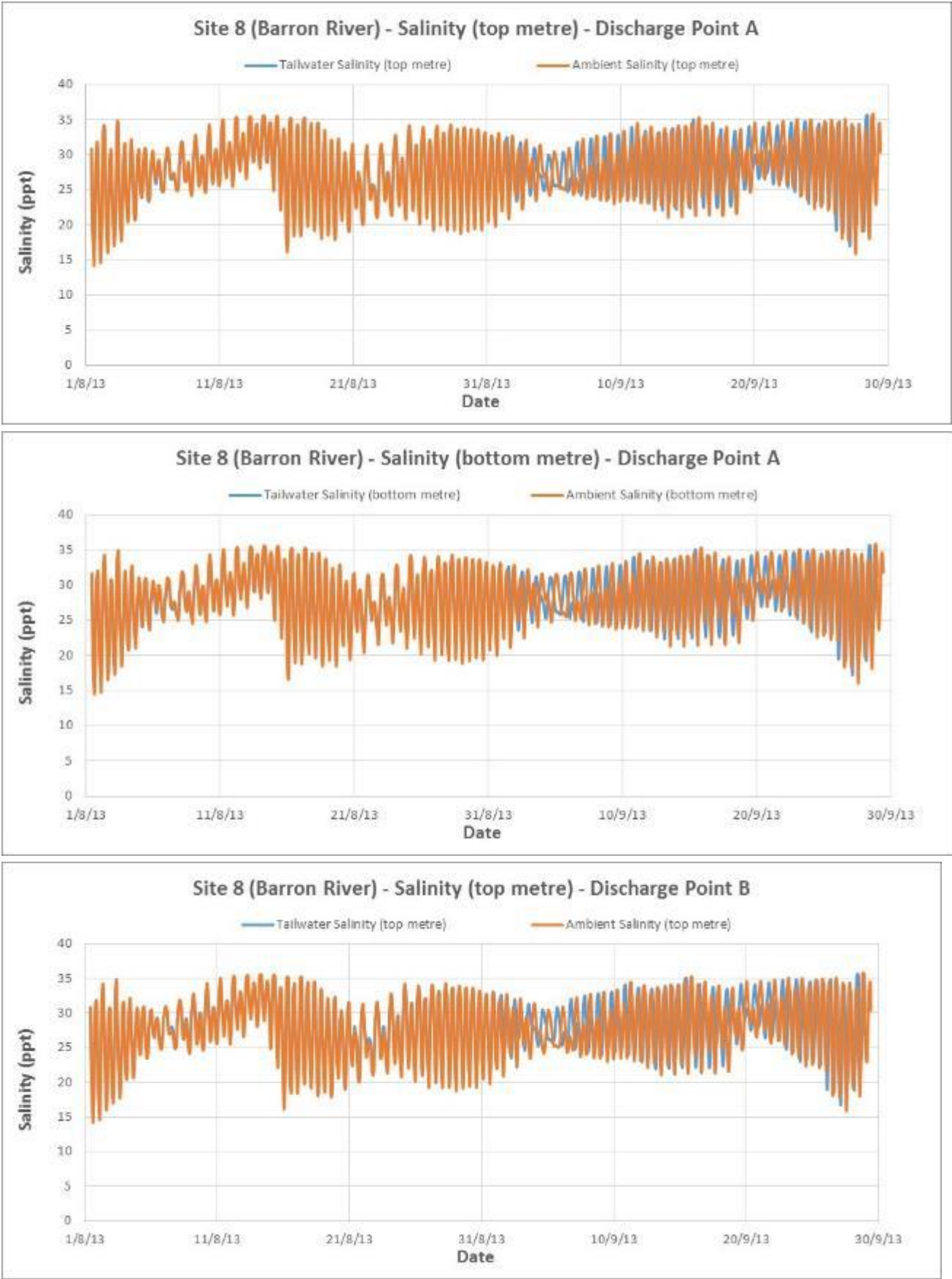


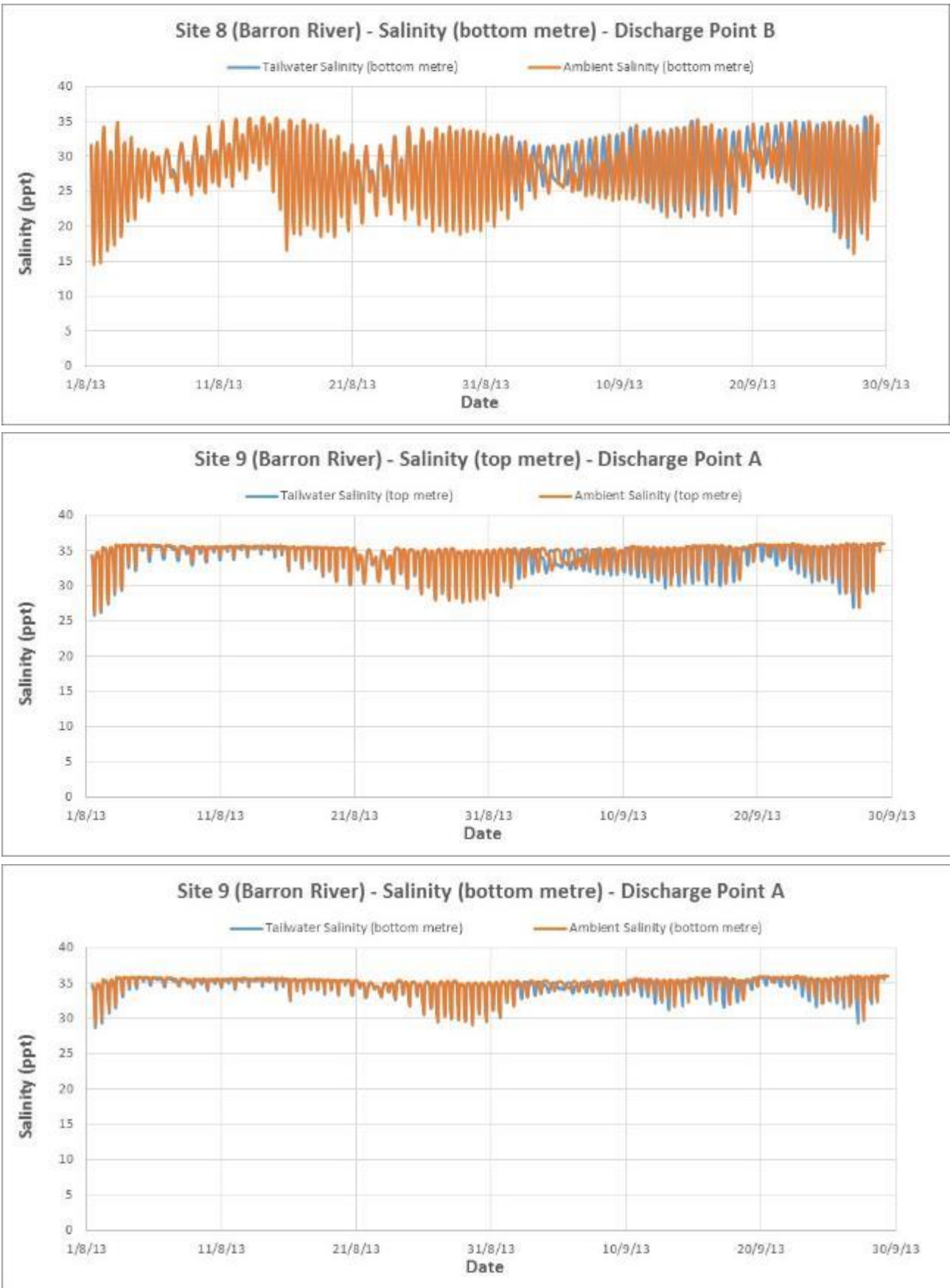


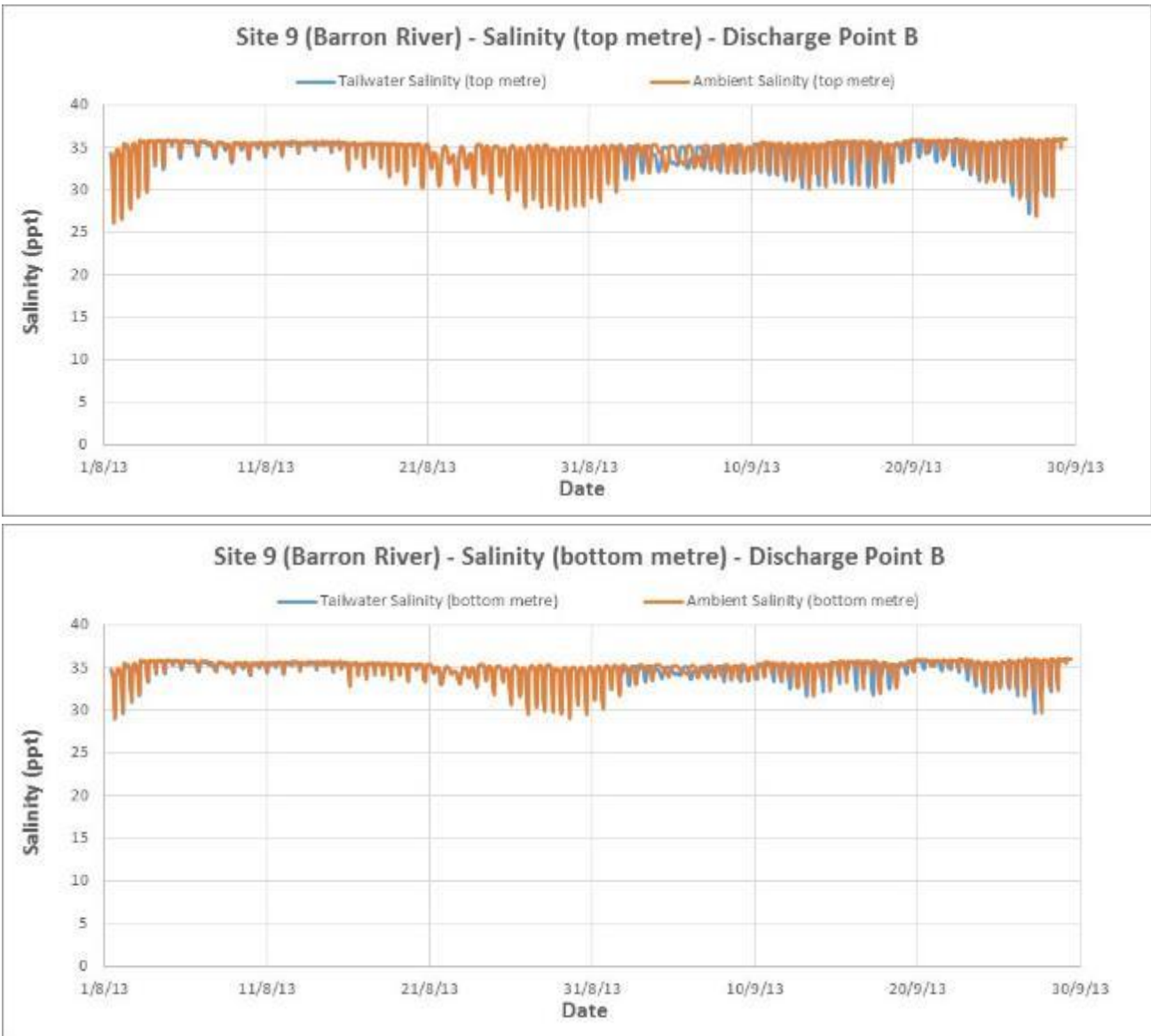


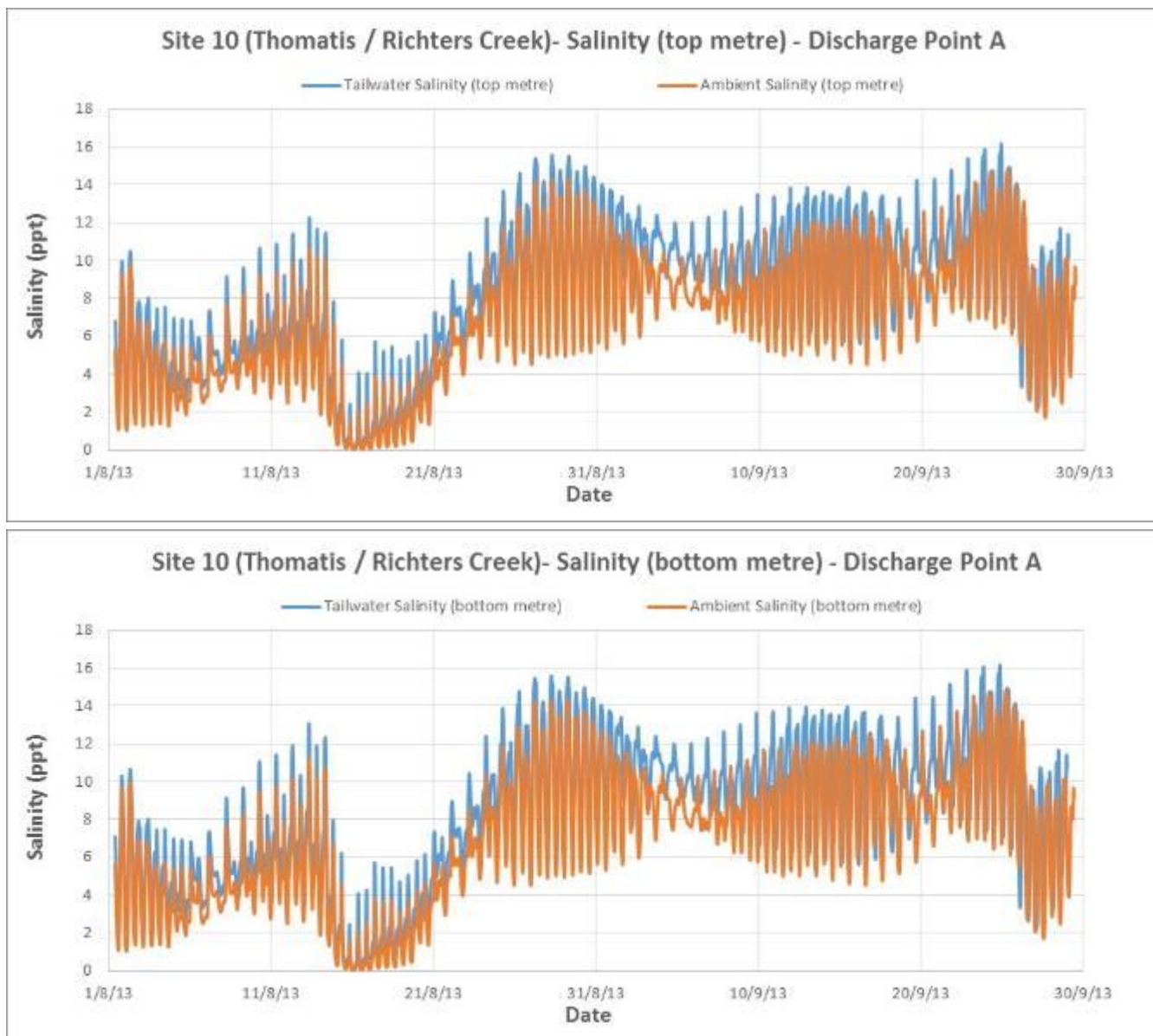


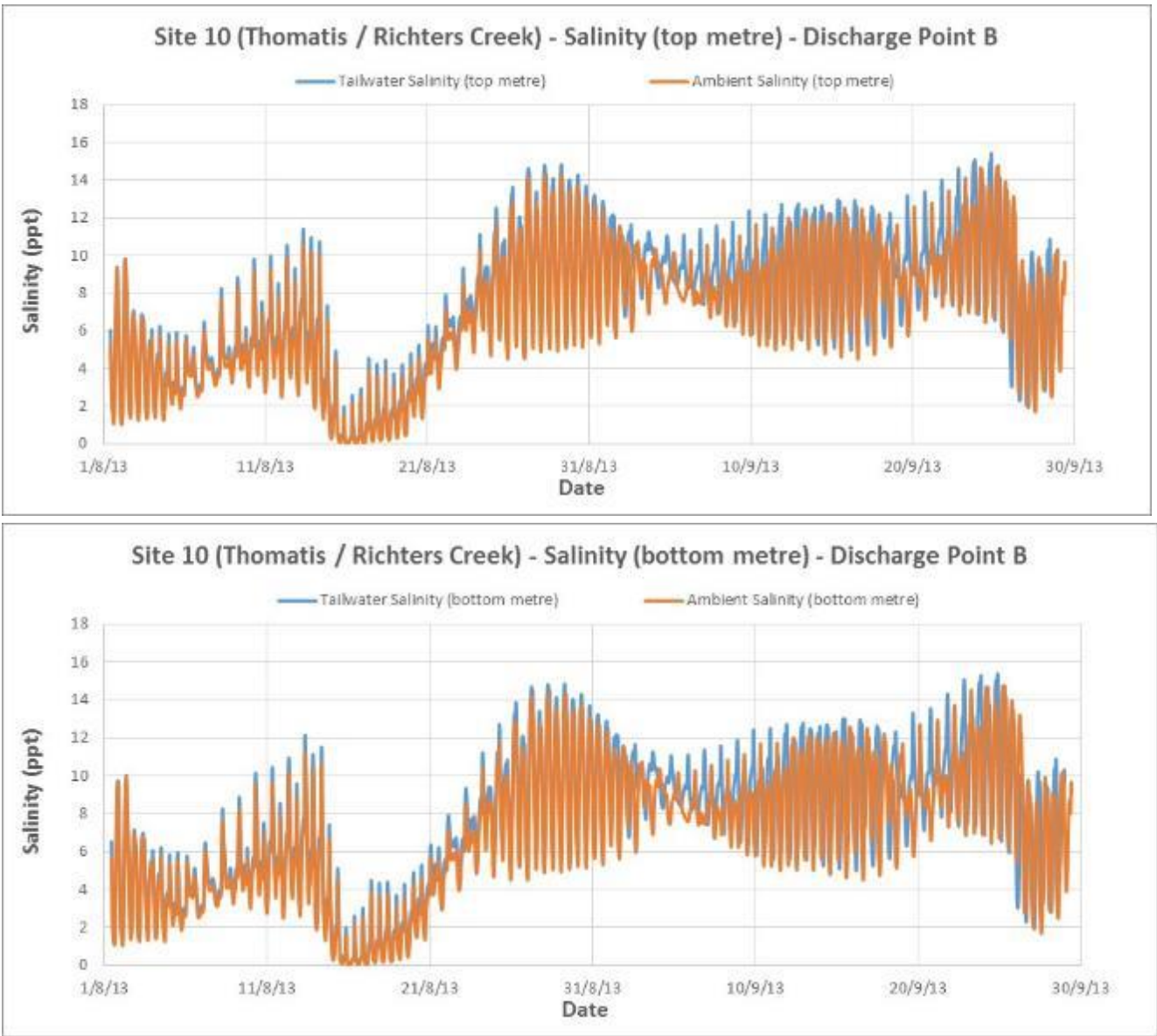


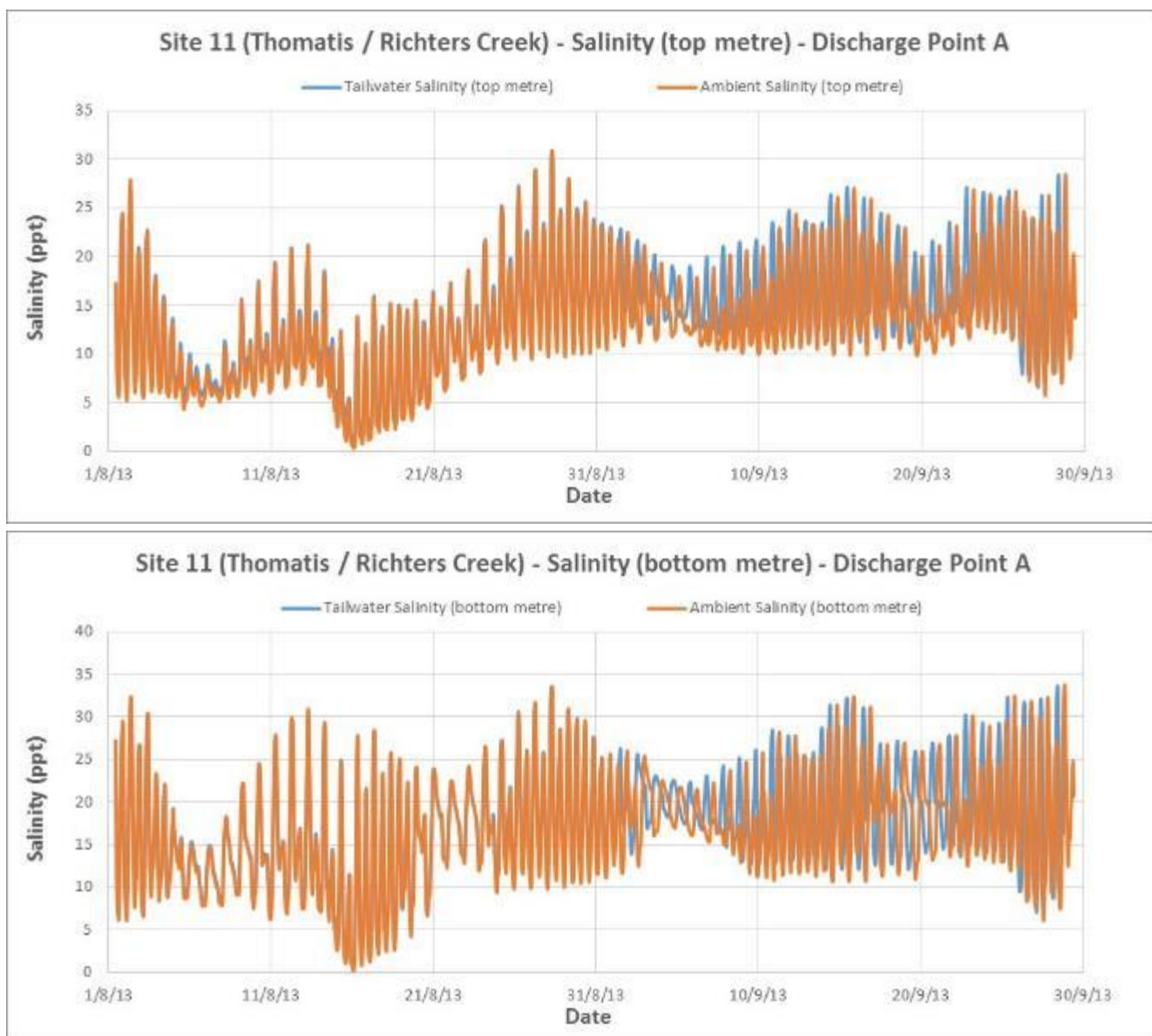


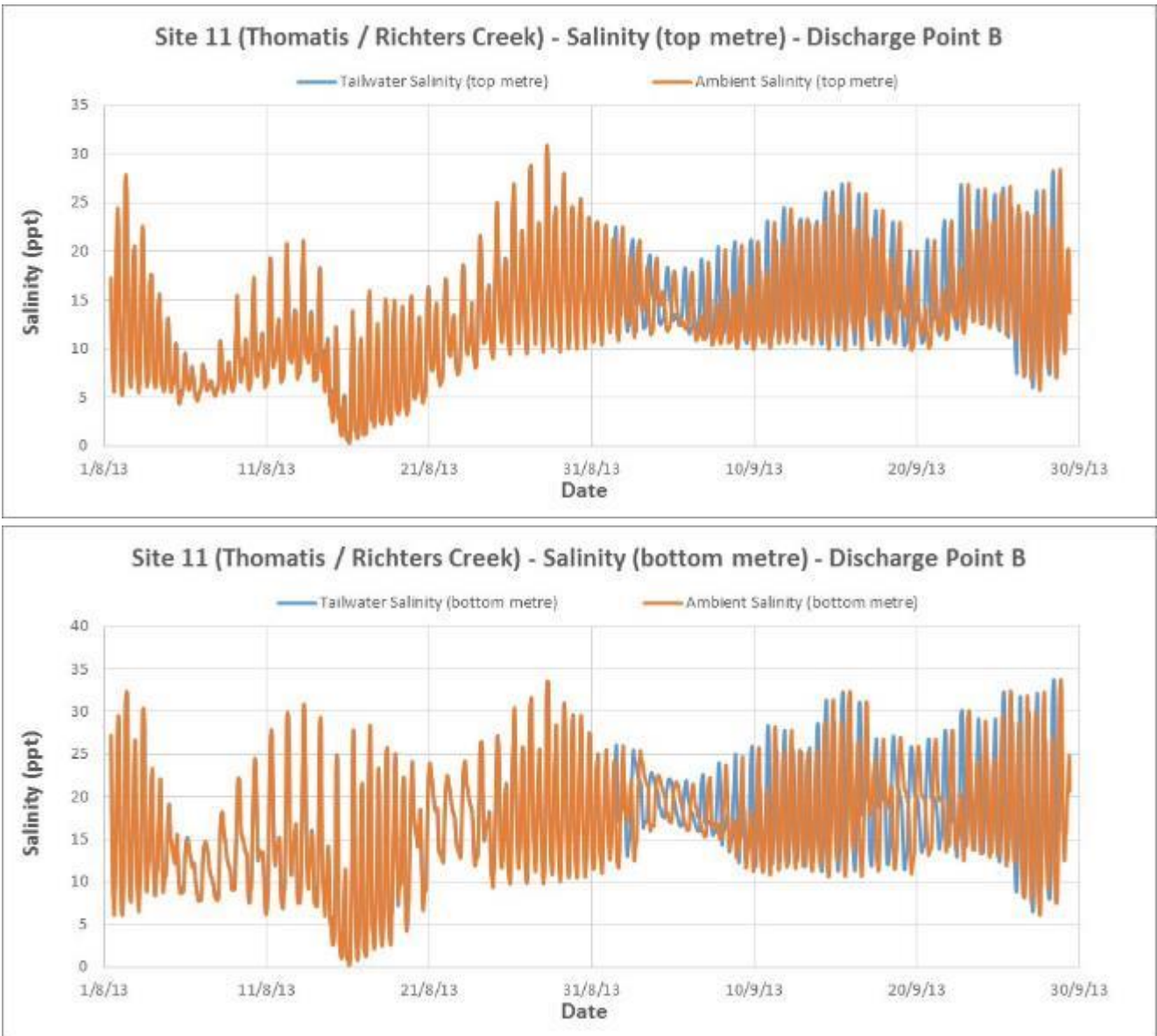














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