CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

APPENDIX M: Coastal Processes Baseline Report 2016

BMT WBM

Cairns Shipping Development EIS – Coastal Processes Baseline Report

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Confidential

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Synopsis: **A baseline report on coastal processes for the revised CSD Project, focussing on land based disposal options. A preliminary assessment of multiple tailwater discharge location options was undertaken to inform concept design shortlisting.**

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Destination	Revision										
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Key Findings and Implications

This section outlines key findings from the coastal process baseline and preliminary tailwater discharge modelling study to assist with the assessing the suitability of land placement sites for dredge material associated with the revised CSD project.

Existing Values/Resources

The existing hydrodynamic processes in the vicinity of the land placement sites can be characterised as follows:

East Trinity

- East Trinity is a relatively well flushed tidal estuary, with a small fluvial influence.

Barron River

- The Barron River adjacent to the Northern Sands site is a relatively poorly flushed salt-wedge estuary.

Threats

Potential threats to existing values if land placement sites are used include:

East Trinity

- Tailwater discharge within bunds or creeks is likely to have a significant influence on water quality (salinity and turbidity) within these confined waterways.
- Despite Trinity Inlet being relatively close to marine conditions, there is still a potential for saline water to advect upstream within this estuarine system.

Barron River

- Tailwater discharge within the Barron River has the potential to change the salinity and turbidity regime due to tailwater discharge rates being comparable to base fluvial flows and around a factor ten less than peak tidal flows.

Mitigation Opportunities

Recommended mitigation measures to reduce impacts include:

East Trinity

- From a hydrodynamic and water quality perspective, discharge of tailwater directly into Trinity Inlet would allow improved mixing compared to discharge into the smaller Firewood Creek and/or Hills Creek. This is confirmed by preliminary tailwater discharge modelling.

Barron River

- Tailwater should be discharged as far downstream towards the river mouth as practicable – this will decrease the risk of saline waters being mobilised upstream.

Constraints

- As outlined above, Firewood Creek and Hills Creek have limited flushing compared to Trinity Inlet and discharge of tailwater into these systems is less preferable than direct discharge to Trinity Inlet.
- Discharge at the placement site at Northern Sands increases the risk of saline waters advecting upstream into brackish waterways. Discharge as far as practicable downstream from the site is preferred to maximise mixing.
- Constraints related to extreme coastal processes, such as generated by Tropical Cyclones have not been assessed at this stage.

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1 Introduction

This report presents the findings of the coastal process baseline and preliminary tailwater modelling study for the recalibrated Cairns Shipping Development (CSD) Environmental Impact Statement (EIS).

The recalibrated CSD EIS now includes the following two land placement options:

- Northern Sands;
- East Trinity (of which there are three sub-options being evaluated).

These options contribute a potential new source of environmental risk related to reclamation tailwater discharge impacts on the receiving environment. The numerical model/s from the draft EIS describing physical and water quality processes have been updated to ensure a robust assessment of the potential tailwater impacts.

1.1 Previous Data Collection

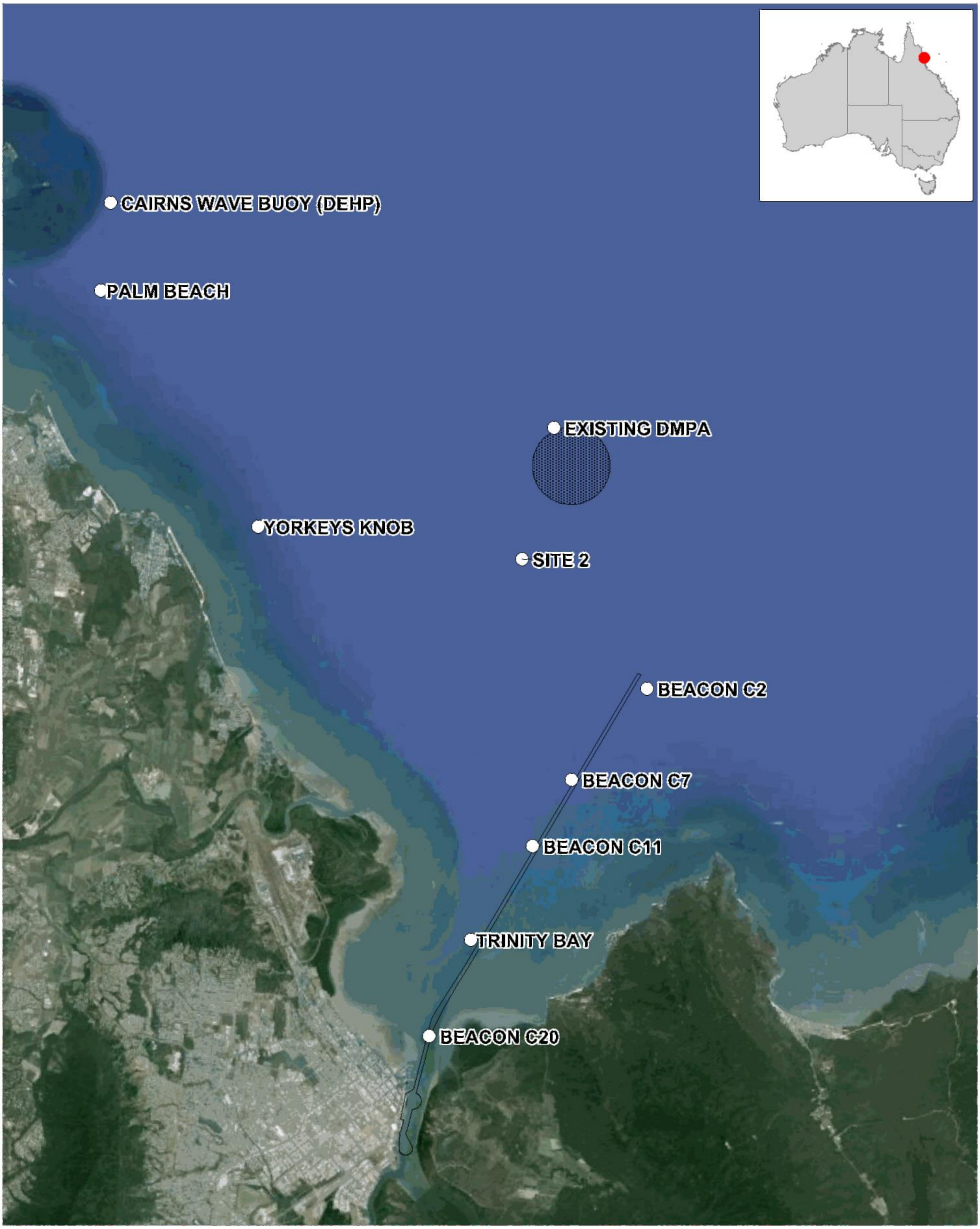
Metocean data collection was undertaken as part of the original CSD EIS and was focussed on measurements in the vicinity of the channel dredging footprint and offshore DMPA/s as indicated in Table 1-1 and Table 1-2 below. Measurements of water levels, currents and water quality parameters were also undertaken as part of the AQUIS EIS for a study area focussed on Richters Creek. These measurements have been made available to the recalibrated CSD EIS.

Table 1-1 Fixed Data Collection Sites and Instruments

Location	Coordinate	Deployment Period/s	Tide Recorder	ADCP Currents	Waves	Neph-elometer	CTD
DMPA	145.8104, 16.7804	15/2/2013-15/4/2014	Yes	600 kHz AWAC	Directional.	Near bed.	Near bed.
Alternative DMPA	145.8040, -16.8089	15/2/2013-22/08/2013	Yes	600 kHz AWAC	Directional.	Near bed.	Near bed.
Outer Channel Beacon C2	145.8326, -16.8361	20/2/2013-22/8/2013	Yes		Non-Directional (from CTD)		Near bed.
Outer Channel Beacon C7	145.8162, -16.8561	20/2/2013-15/4/2014	Yes	600 kHz AWAC.	Directional.		Near-bed. Near-surface.
Outer Channel Beacon C11	145.8078, -16.8706	20/2/2013-24/8/2013	Yes	1200 kHz RDI Workhorse	Directional.	Near bed.	Near-bed. Near-surface.

Table 1-2 Transect Locations and Timings

Location	Timing	Data Campaign
Port Area Navy swing basin between berth 10 - 11	2 occasions (May and June) spring tides – along channel and cross channel	ADCP transect with TSS and CTD profiles - TSS samples at profiler locations
Inner Channel Beacon C20 to Beacon C15	2 occasions (May and June) spring tides – along channel and cross channel	ADCP transect with TSS and CTD profiles - TSS samples at profiler locations
Outer Channel Beacon C15 to Beacon C5	2 occasions (May and June) spring tides – along channel and cross channel	ADCP transect with TSS and CTD profiles - TSS samples at profiler locations



Title:

Data Recording Locations

Figure: **1-1**

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Approx. Scale

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1.2 Study Aim and Objectives

The broad aim of this study is to update the CSD EIS coastal process baseline and numerical models to be fit for the purpose for assessing impacts related to land based disposal and associated tailwater discharges into the receiving environment. The update comprises:

- Improvement of hydrodynamic and receiving water quality model resolution in the potential areas affected by tailwater discharge options.
- More detailed representation of estuarine processes in the Barron River and Trinity Inlet in order to robustly resolve tidal exchange, freshwater inflows and salinity structure.
- Modelling of catchment runoff into Trinity Inlet to support the above.
- Data collection to calibrate and validate the updated numerical model in the Barron River and East Trinity/Trinity Inlet, where tailwater discharges are proposed.

Preliminary tailwater modelling has also been undertaken at this stage in order to help inform selection of a single preferred land disposal site for ongoing assessments and to determine the preferred location for discharge (if practicable).

1.3 Terms of Reference/EIS Guidelines

This coastal process baseline and numerical model study addresses the requirements contained in the State Terms of Reference (TOR) and the Commonwealth EIS Guidelines developed for the CSD EIS.

The relevant sections of these documents include:

- Section 5.3.1 (Hydrodynamics and Sedimentation) of the State TOR.
- Section 5.9 (Existing Environment) of the Commonwealth EIS Guidelines.
- Attachment 4 (Guidelines for the use of hydrodynamic numerical modelling for dredging projects in the Great Barrier Reef Marine Park) of the Commonwealth EIS Guidelines.

2 Methodology

2.1 Metocean Data Collection

The coastal process monitoring program comprised the following components:

- ADCP *in-situ* measurements of water level, current speed and direction (Figure 2-1 and Figure 2-2).
- ADCP transect measurements of tidal flows at tailwater locations (Figure 2-1 and Figure 2-2).
- Bathymetry survey in the vicinity of tailwater locations (Figure 2-3 and Figure 2-4).

The coastal process monitoring was undertaken in conjunction with co-located water quality monitoring described in a separate baseline report.

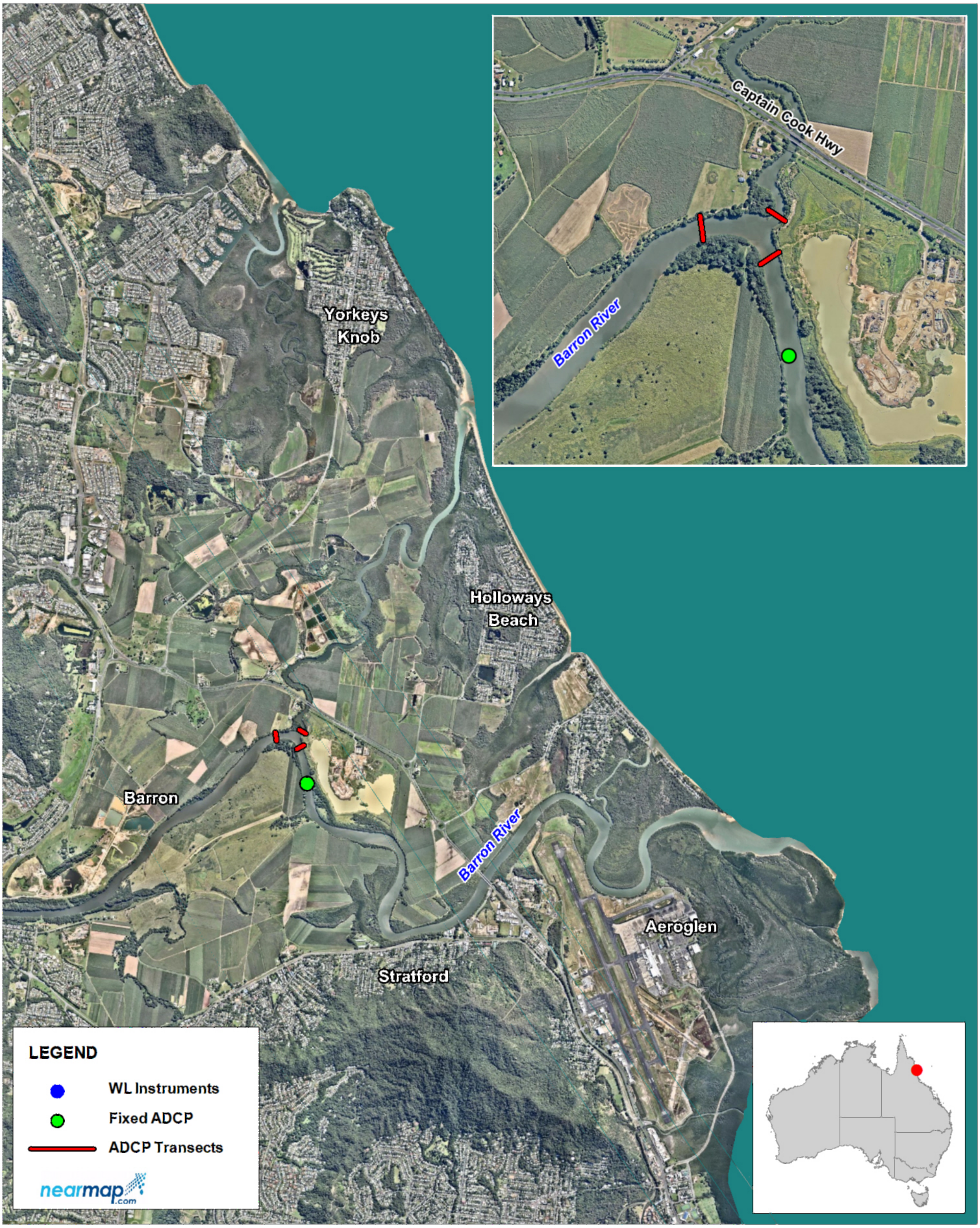
Dry season data collection occurred in July–September 2016 as summarised in Table 2-1 and Table 2-2 below.

Table 2-1 Fixed Data Collection Sites and Instruments

Location	Coordinates	Deployment Period/s	Tide Recorder	ADCP Currents	Nephelometer	CTD
Trinity Inlet	145.787639, -16.946891	26/7/2016- Ongoing	Yes	600 kHz RDI ADCP	Near bed.	Near bed.
Barron R	145.717381, -16.859564	26/7/2016- Ongoing	Yes	1200 kHz RDI ADCP	Near bed.	Near bed.
Firewood Ck D/S Bund	145.789482, -16.943531	26/7/2016- Ongoing	Yes	No	Near bed.	Near bed.
Firewood Ck U/S Bund	145.795171, -16.942263	26/7/2016- Ongoing	Yes	No	Near bed.	Near bed.
Hills Ck D/S Bund	145.792450, -16.921261	26/7/2016- Ongoing	Yes	No	Near bed.	Near bed.
Hills Ck U/S Bund	145.795038, -16.924738	26/7/2016- Ongoing	Yes	No	Near bed.	Near bed.

Table 2-2 Transect Locations and Timings

Location	Timing	Data Campaign
Trinity Inlet Adjacent Firewood Creek	27/7/2016 Neap tides 31/7/2016 Spring tides	ADCP transect with TSS and CTD profiles - TSS samples at profiler locations
Barron River Adjacent Thomatis Creek	28/7/2016 Neap tides 30/7/2016 Spring tides	ADCP transect with TSS and CTD profiles - TSS samples at profiler locations



Title:

Current Metocean Data Collection Sites - Barron River

Figure: **2-1**

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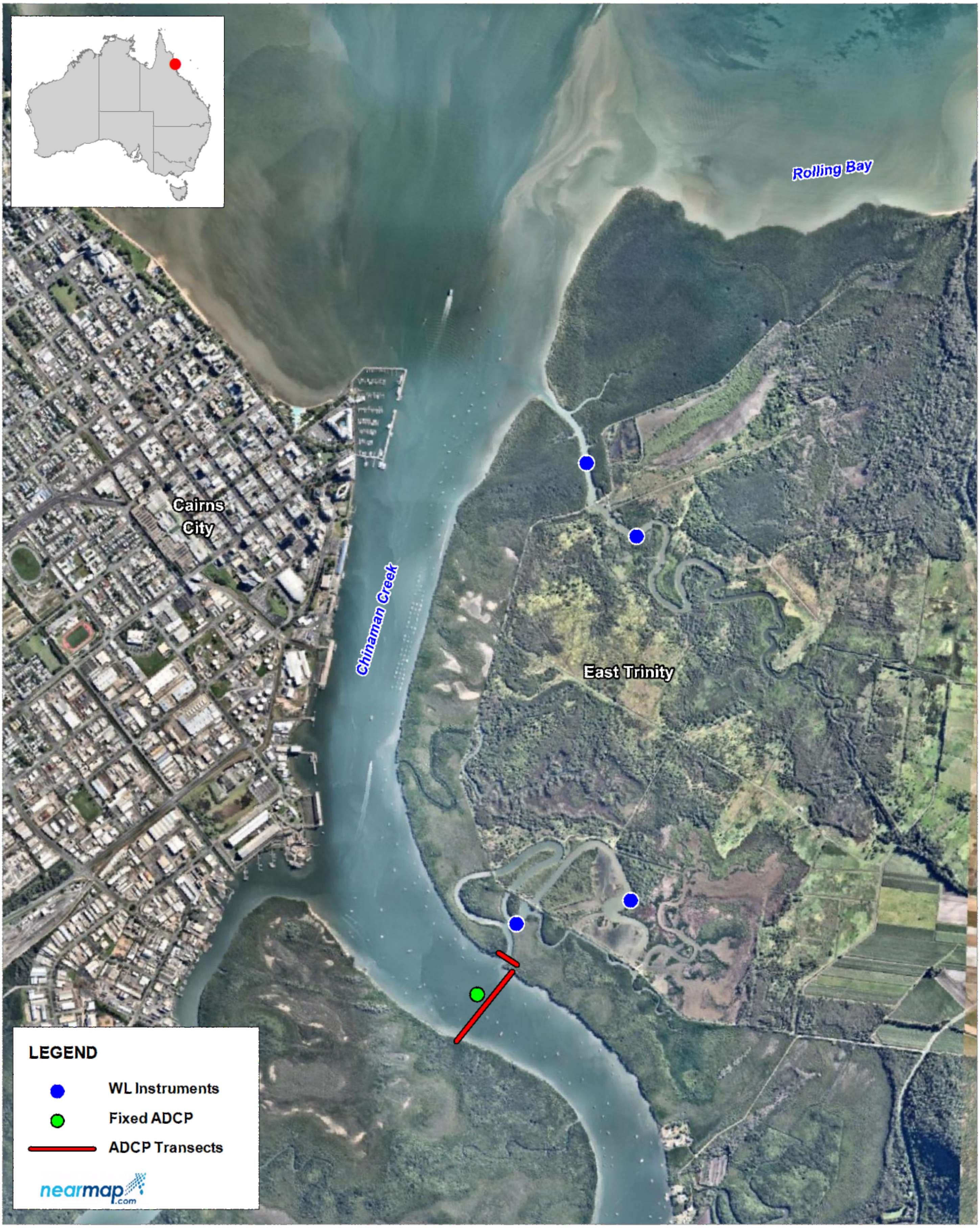

Title:

Current Metocean Data Collection Sites – East Trinity

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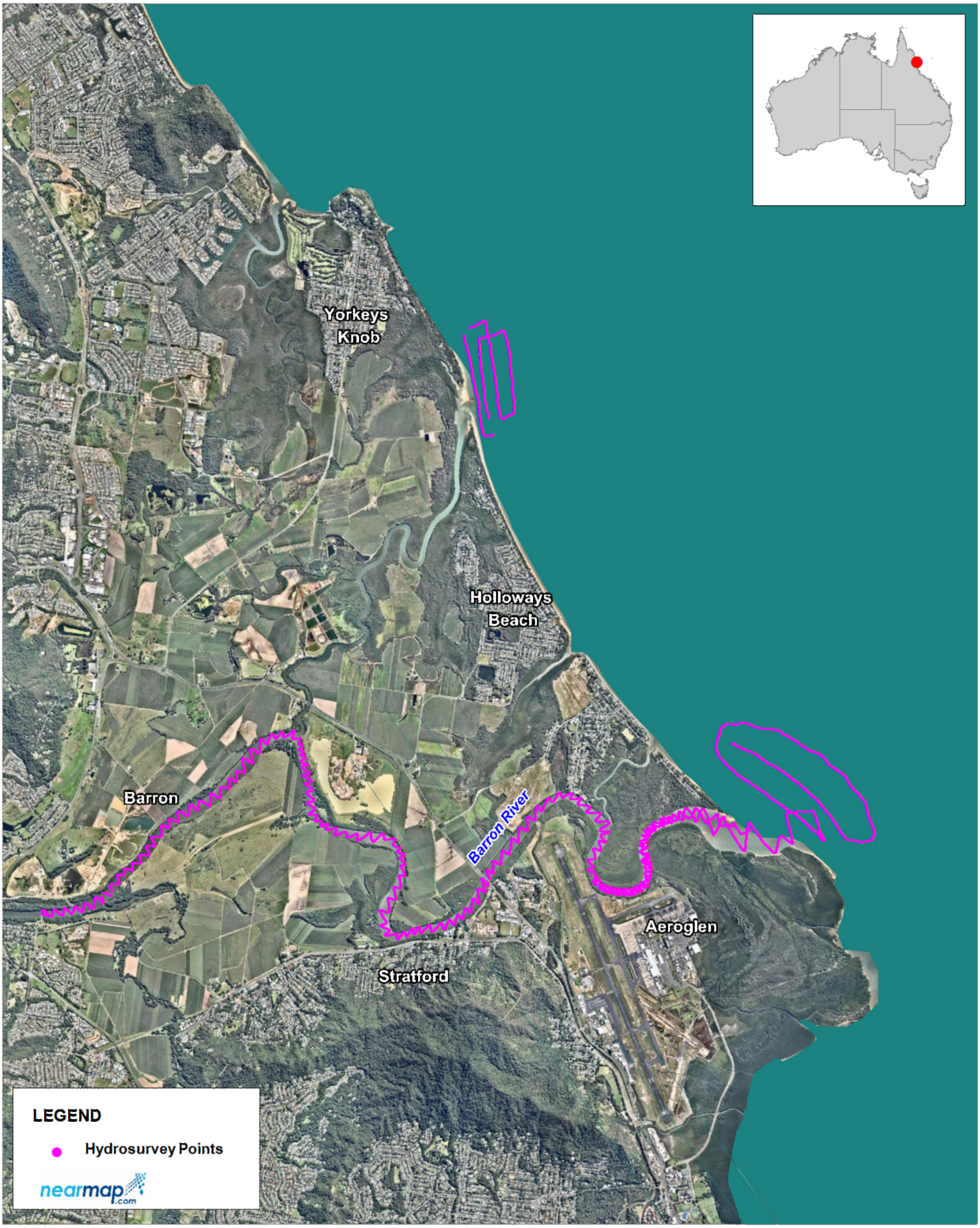

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BMT WBM Hydrosurvey - Barron and Offshore

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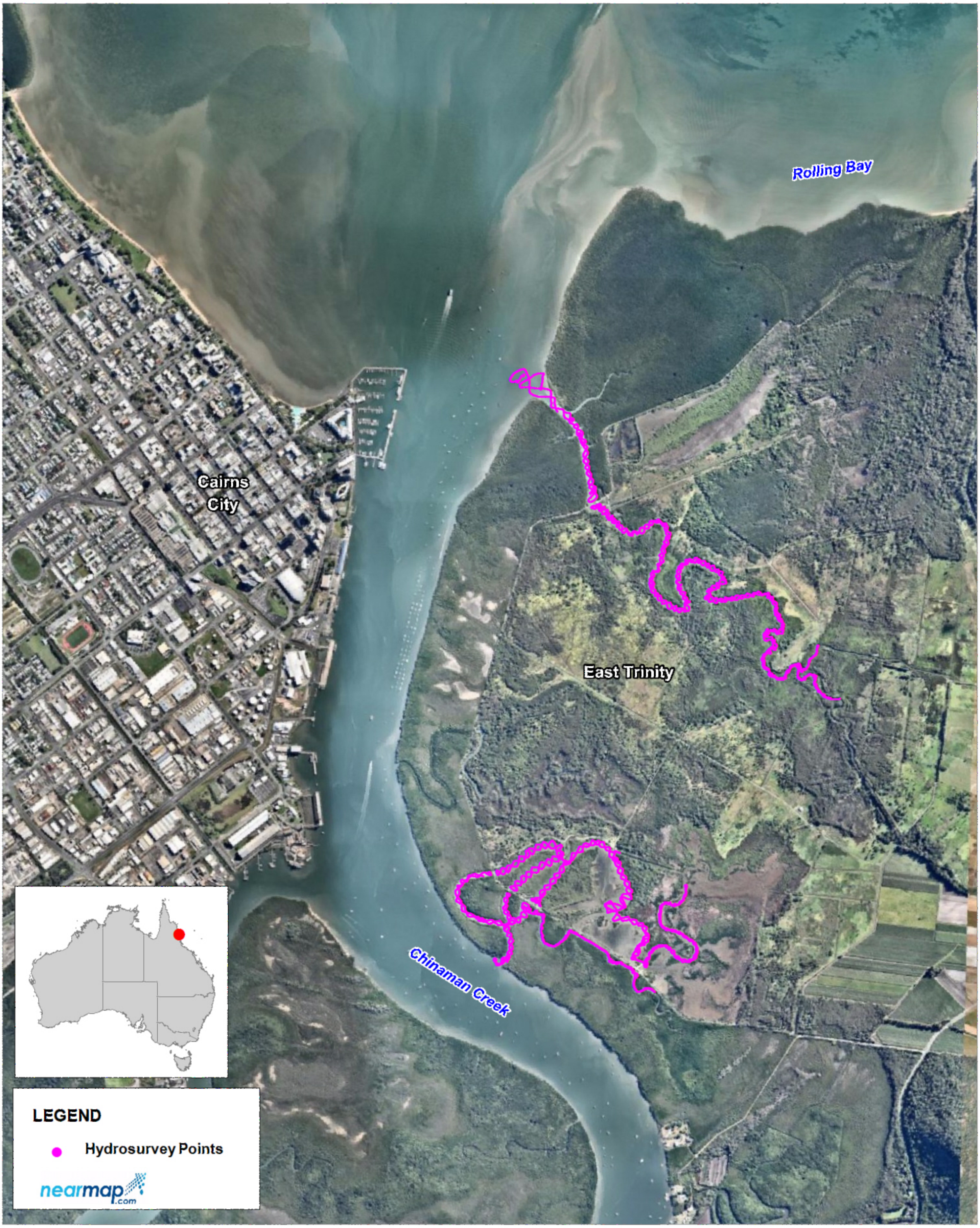

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BMT WBM Hydrosurvey - East Trinity

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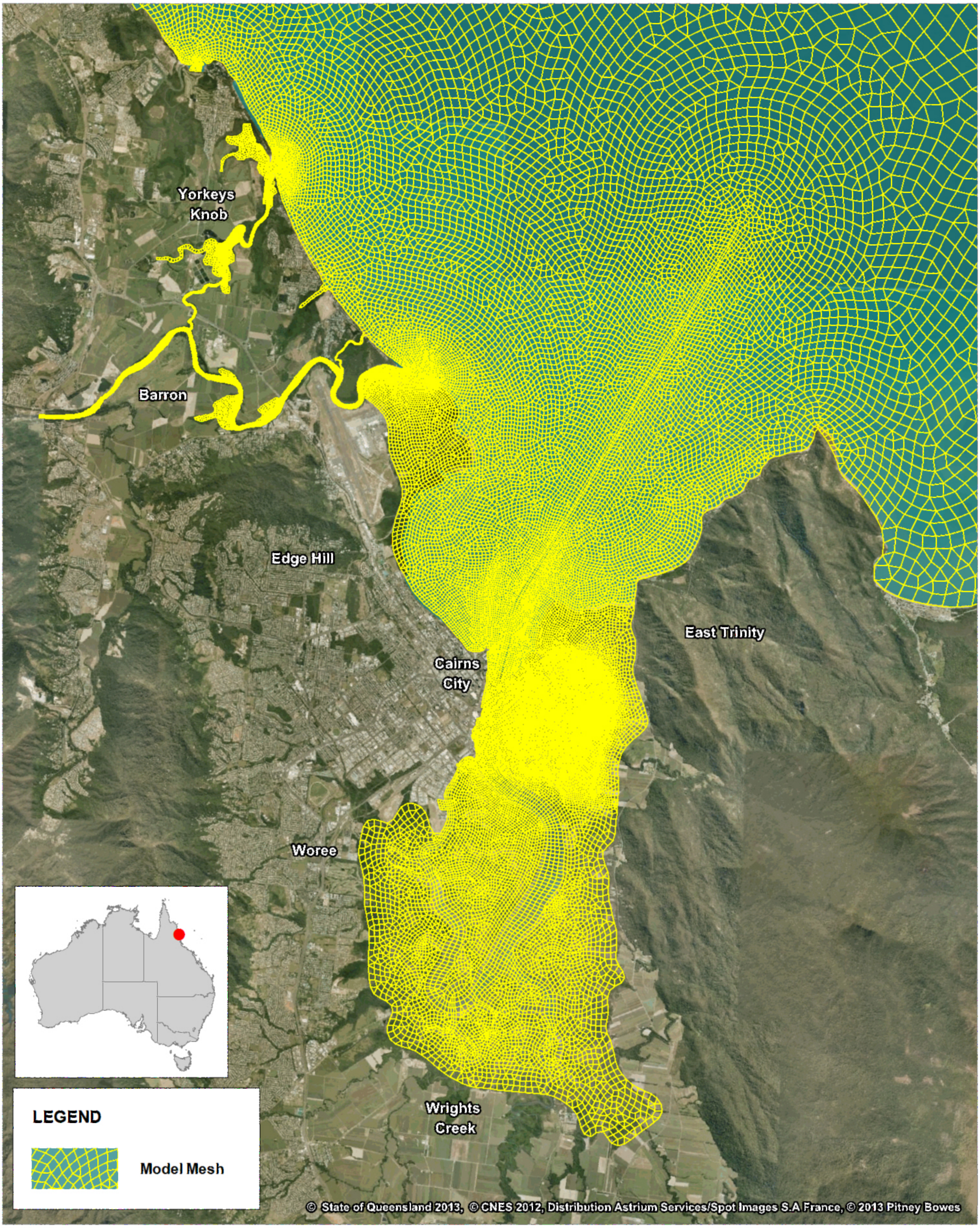
2.2 Model Update

The TUFLOW FV hydrodynamic and receiving water quality model developed for the CSD EIS was substantially upgraded in order to enable it to assess the impact of land based placement tailwater discharges on the receiving environments within Trinity Inlet and the Barron River estuary.

2.2.1 Mesh refinement

The following steps were undertaken in updating the model mesh (Figure 2-5):

- The model mesh was modified to accommodate the recalibrated CSD EIS channel design.
- The mesh and bathymetry were refined in East Trinity precinct, including detailed resolution of Hills Creek, Firewood Creek and the East Trinity bund. Bathymetry was updated using the East Trinity hydrosurvey.
- The TUFLOW FV mesh and bathymetry in the Barron River and Thomatis/Richters Creek were upgraded based on the calibrated hydrodynamic and water quality model developed for the AQUIS EIS.
- Barron River bathymetry was updated between the mouth and the tidal limit using the collected hyrdosurvey data.
- The frequently evolving Richters Creek entrance and Barron River ebb-delta bar were updated using the collected hydrosurvey data.



Title:
TUFLOW FV Mesh - Trinity Inlet

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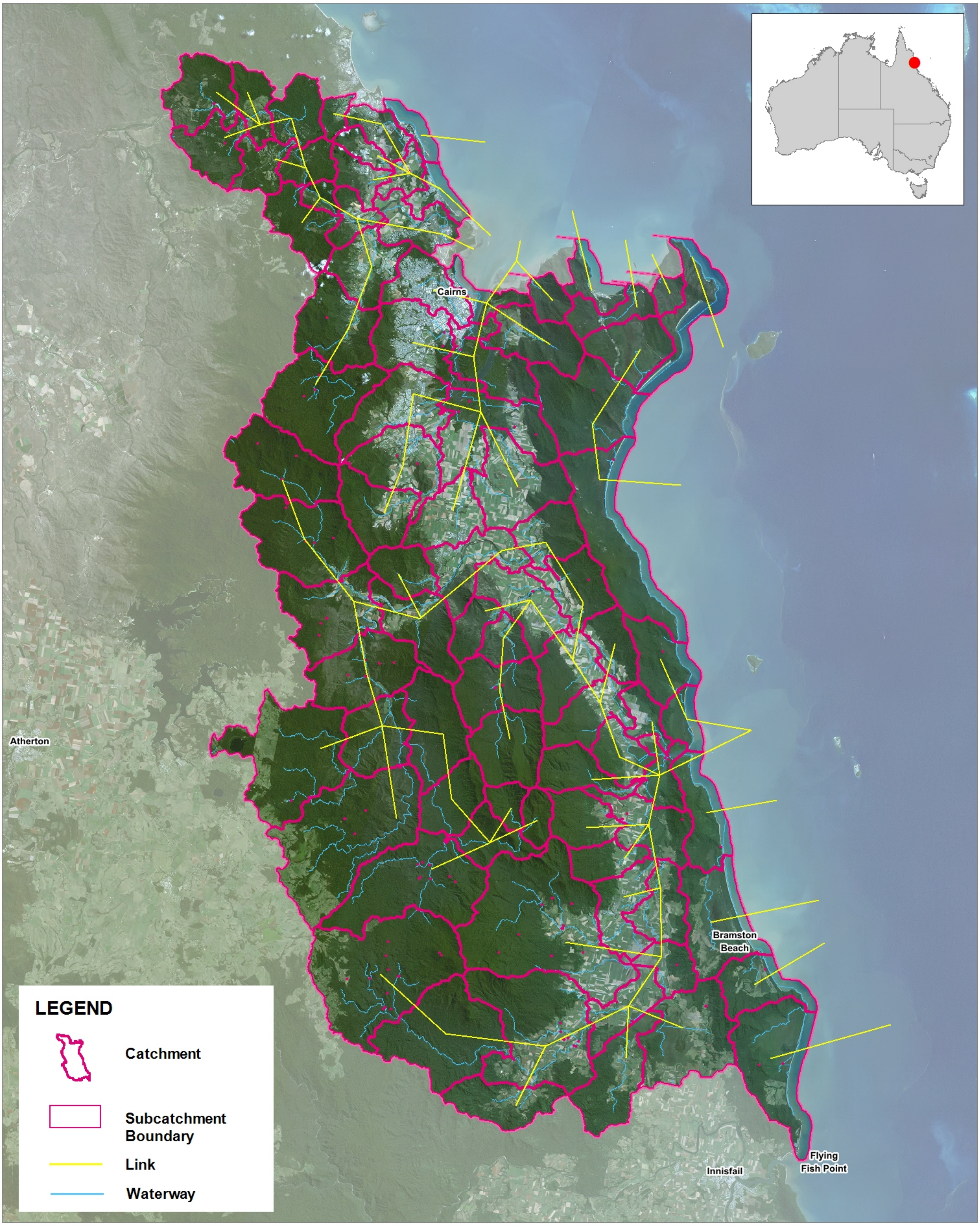
2.2.2 Catchment model

Catchment runoff modelling for Trinity Inlet was performed using the eWater Source modelling framework (Argent et al, 2005; 2008; eWater CRC, 2009). Source simulates rainfall runoff and pollutant export from catchments using a node-link style modelling system for generating and transporting water and constituents within the streams of a catchment. Sub-catchment boundaries are determined based on stream and land topography calculated from a Digital Elevation Model (DEM). Sub-catchments are connected via links, representing riverine reaches, and nodes, representing confluences. Using a daily time step, the model simulates the movement of runoff and optionally pollutant loads through the catchment.

The Source model was developed for the entire catchment flowing into Trinity Inlet as well as the Mulgrave River and Russel River catchments (Figure 2-6) in order to provide sufficient coverage of streamflow gauge sites to enable model calibration. The simulation period was from 1990 to 2016. Flow timeseries computed at the Source model nodes, were applied to the TUFLOW FV hydrodynamic model as point freshwater inflow sources.



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Source Model Delineation

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2.2.3 Calibration

An updated TUFLOW FV model calibration simulation was undertaken for the period of the dry season metocean data collection from July–September 2016.

2.2.3.1 ADCP Discharge

Model predictions of tidal flows were compared with ADCP flow gauging measurements at the following ADCP transect locations:

- Trinity Inlet (adjacent to Firewood Creek)
- Firewood Creek downstream bund
- Barron River downstream Thomatis Creek
- Barron River upstream Thomatis Creek
- Thomatis Creek at Barron River confluence.

The comparisons (shown in Appendix A) demonstrate that the refined model is capable of good quality predictions of tidal flow rates.

2.2.3.2 Water Level Recorders

Model predictions of tidal amplitude and phasing were compared with deployed water level recording instruments at the following locations:

- Trinity Inlet (adjacent to Firewood Creek)
- Barron River (downstream Thomatis Creek)

The comparison shown in Appendix C demonstrate that the refined model provides a fair representation of the tidal water levels.

2.2.3.3 ADCP in-situ measurements

Data not yet available.

2.2.3.4 Salinity/Temperature Profiles

Data not yet available.

2.2.3.5 TSS/Turbidity

Data not yet available.

2.3 Preliminary Tailwater Modelling

2.3.1 Modelling Assumptions

Based on the preliminary advice from BMT JFA the following assumptions were made for the preliminary tailwater modelling:

- Tailwater discharge = 1.0 m^3/s (revised advice received 29/8/2016 – used in assessments of Trinity Inlet and Barron River discharge locations).
- Tailwater TSS = 100 mg/L
- Tailwater sediment settling velocity, w_s = 1e^{-5} m/s
- Tailwater salinity = 35 PSU (i.e. more saline than receiving environment)
- Passive tracer of 100 units concentration also simulated
- 30 day dry season simulation (plus warmup)
- Preliminary tailwater modelling locations as shown in Figure 2-10:
  (1) Firewood Creek Inside Bund
  (2) Firewood Creek Downstream Bund
  (3) Trinity Inlet Adjacent East Trinity Shipyards
  (4) Hills Creek Inside Bund
  (5) Barron River Upstream
  (6) Barron River Middle
  (7) Barron River Adjacent Highway Bridge

Location 7 was added to the preliminary tailwater assessment following the review of results for the other Barron River discharge locations. Both constant and ebb-tide only discharges were assessed for this location. The ebb-tide discharge rate was set to 2.0 m^3/s in order to account for the reduced discharge time.

The preliminary tailwater modelling simulation was performed for 30 day period corresponding to July 2016 as this overlapped with the ADCP transect data collection period. A warmup period was also simulated covering June 2016.

Flow boundary conditions for the simulations were prescribed from:

- Barron River gauge at Myola, Figure 2-7;
- Barron River catchments downstream of Myola (Source model from 2015), Figure 2-8;
- Trinity Inlet catchments (Source model from 2015), Figure 2-9;

The Source model results were extracted from the corresponding period in 2015, as at the time of the preliminary assessment Source boundary condition data did not extend to August 2016. Barron River baseflow during July 2016 was around 4m^3/s and there was limited influence from local catchment runoff.

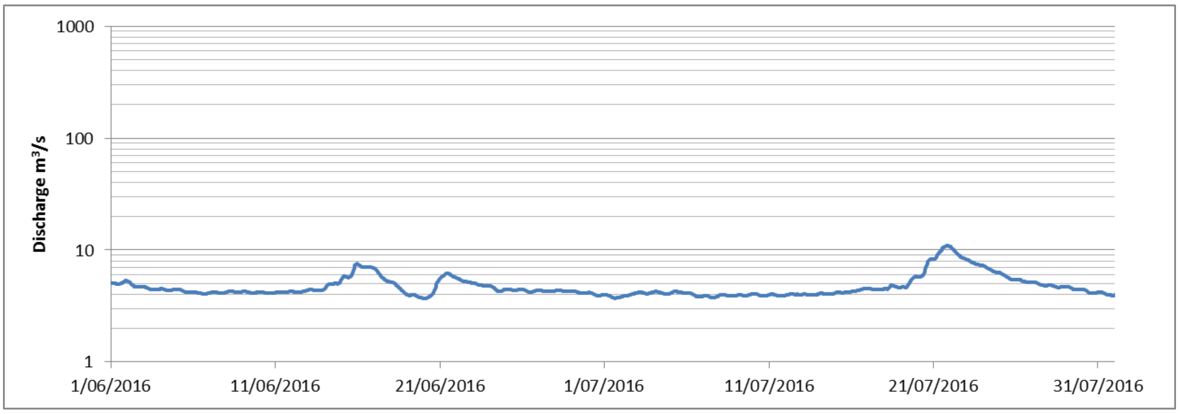

Figure 2-7 Barron River at Myola (Gauge data)

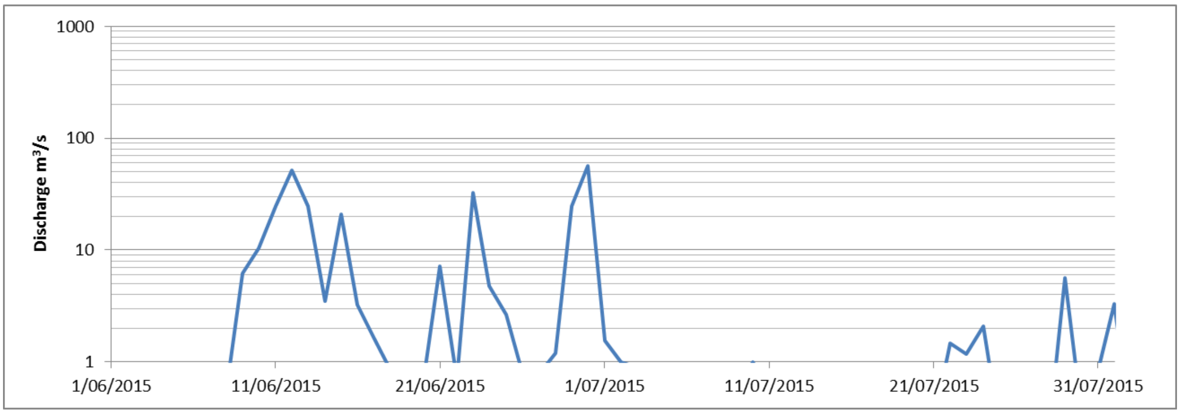

Figure 2-8 Barron River Catchments Downstream of Myola (Source)

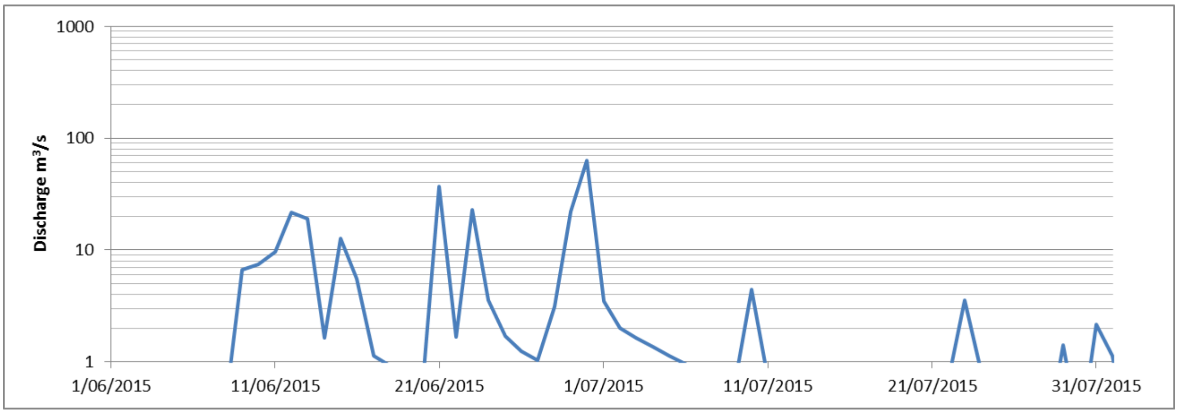

Figure 2-9 Trinity Inlet Catchments (Source)

2.3.2 Model Results

Preliminary tailwater modelling results are presented in Appendix B as follows:

- 50%ile and 95%ile Salinity impact (above background) maps for each discharge location.

    - Salinity impact derived by calculating difference from base case simulation.
- 50%ile and 95%ile passive tracer concentration maps for each discharge location.
    - Passive tracer result represents percentage of water column that is comprised of tailwater discharge.
- 50%ile and 95%ile turbidity (above background) maps for each discharge location.
    - Turbidity calculated from modelled TSS using **Turbidity = TSS / 1.7**.
- All model results have been depth-averaged.
- 50%ile results represent the chronic/persistent impacts associated with the tailwater discharge.
- 95%ile results represent acute impacts (exceeded for only 36 hours) during the 30 day simulation period.

Title:
Tailwater Locations - Barron and Offshore

Figure: **2-10**

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Title:

Tailwater Locations - East Trinity

Figure:

2-11

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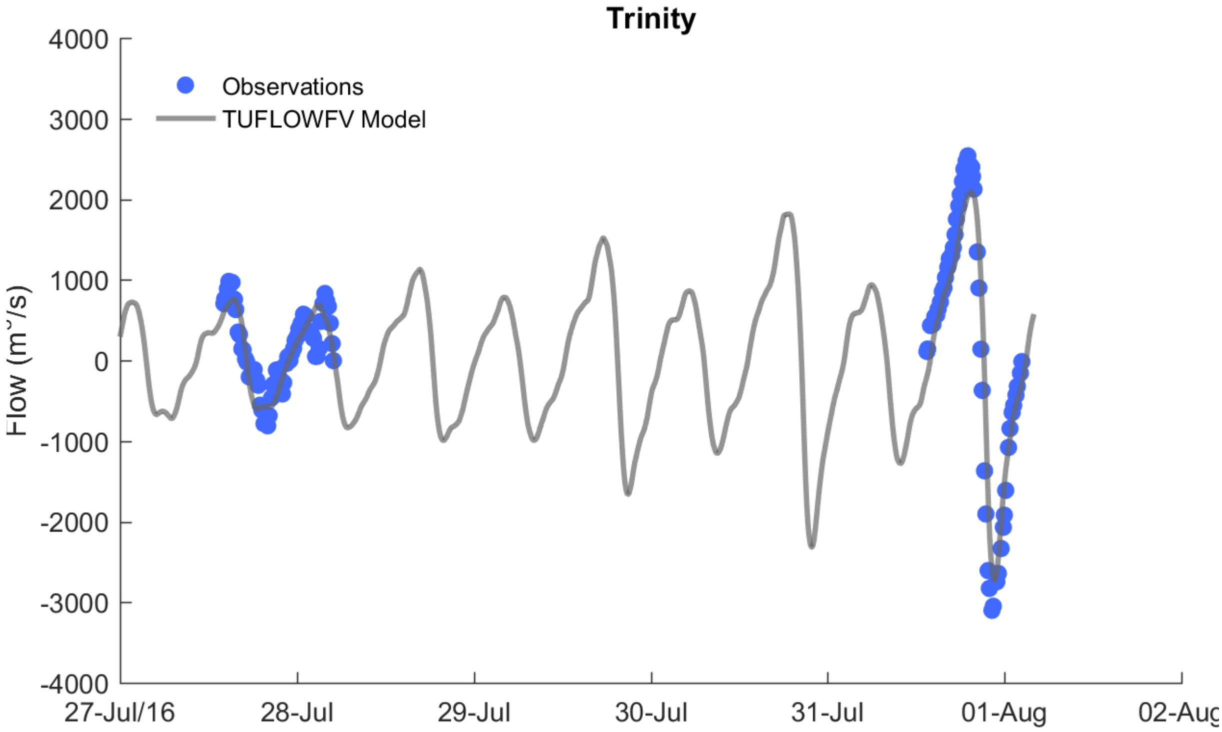
3 Findings

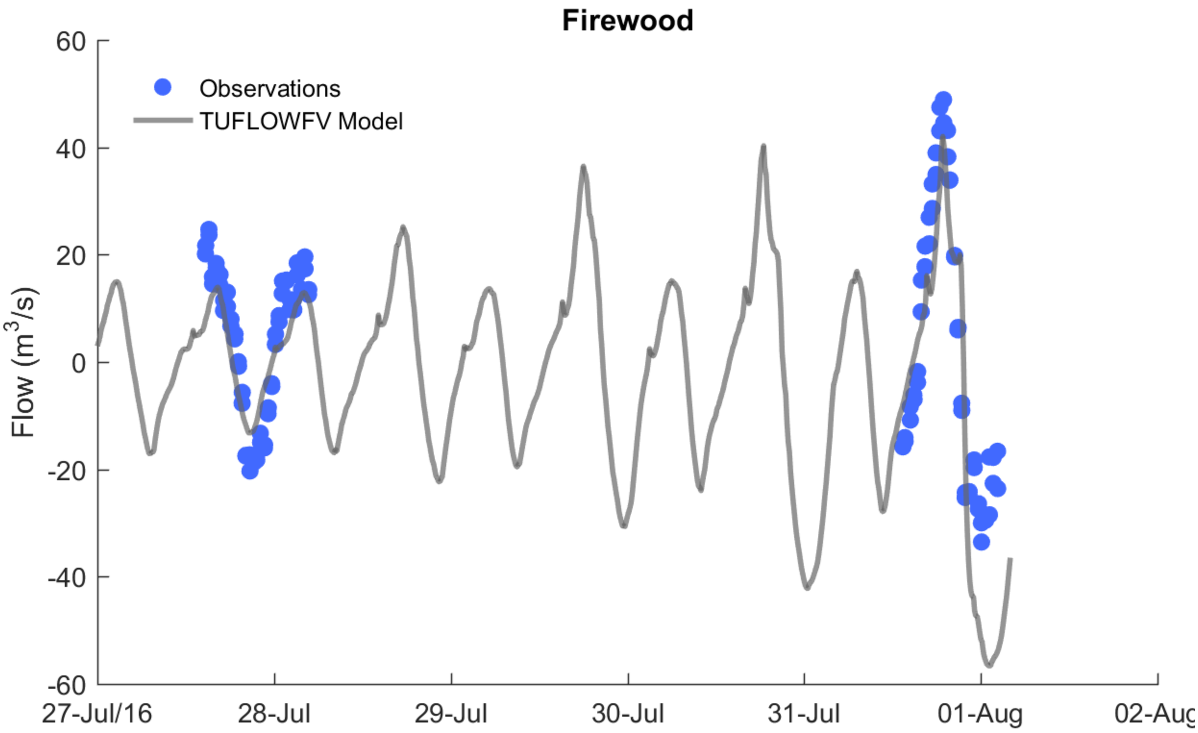
Key findings from the tailwater modelling assessment (refer Appendix B) are as follows:

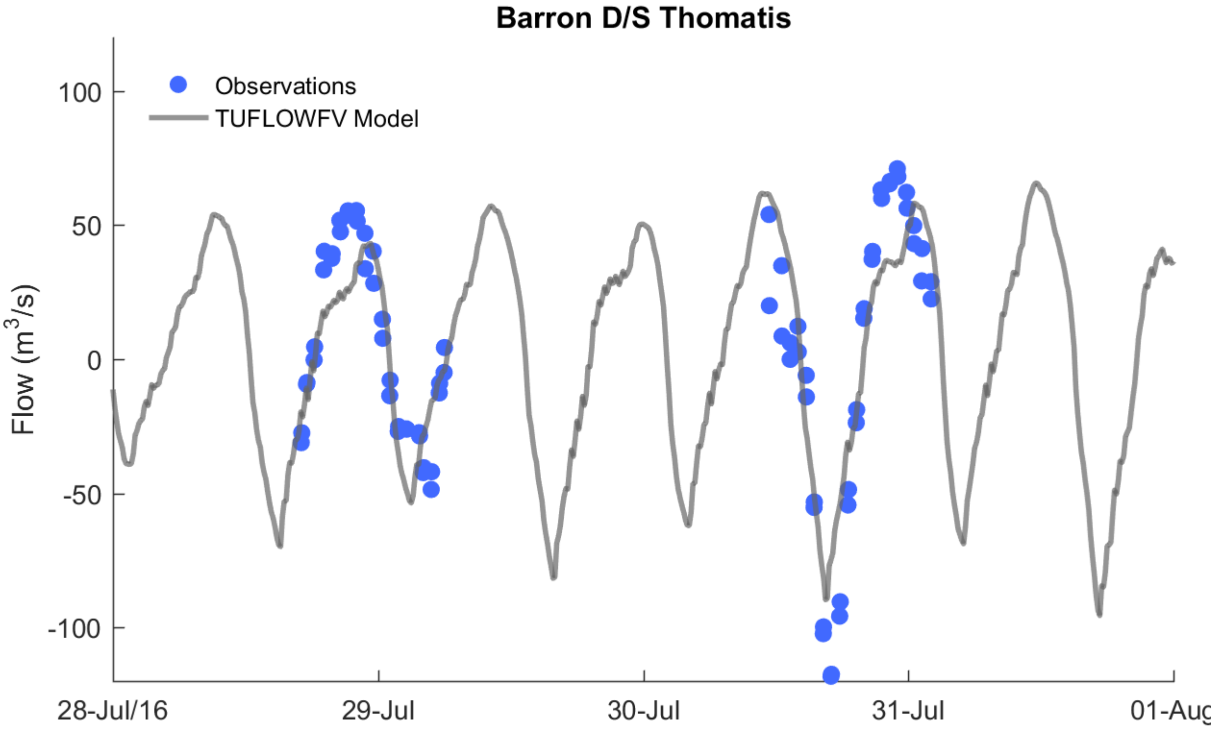
- Both the Trinity Inlet and the Barron River are estuarine environments, characterised by salinities lower than marine. Trinity Inlet is the more marine environment of the two.
- Dense tailwater plumes with marine salinity will have a tendency to advect upstream in these environments.
- Trinity Inlet is much better flushed by tidal exchange than the Barron River (by a factor 30 or more). Refer Appendix A for measured and modelled tidal discharge timeseries.
- Dry season fluvial baseflows in the Barron River are typically around 4 m^3/s (Figure 2-7).
- Fluvial inflow into Trinity Inlet is characterised by episodic catchment runoff without any significant baseflow.
- Tailwater discharge into Firewood Creek upstream of the bund (Location 1) results in a median tailwater concentration inside the bund of approximately 30%. Associated salinity increases are relatively modest (~1 PSU) due to the ambient salinity being close to marine levels. Median turbidity increases are predicted to exceed 20 NTU above background within the bund.
- Tailwater discharge into Firewood Creek downstream of the bund (Location 2) results in a median tailwater concentration within the restricted creek waterway of approximately 25%. Associated salinity increases are relatively modest (<1 PSU) due to the ambient salinity being close to marine levels. Median turbidity increases are predicted to exceed 8 NTU above background within the creek.
- Tailwater discharge into Hills Creek upstream of the bund (Location 4) results in a median tailwater concentration within the restricted creek waterway exceeding 80%. Associated median salinity increases exceed 5 PSU. Median turbidity increases are predicted to exceed 30 NTU above background within the creek.
- All of the Trinity Inlet discharge locations, including the direct discharge (Location 3) benefit from the good tidal flushing once mixing occurs within the main estuary channel. Median tailwater concentrations are less than 3% within the main estuary. Associated median salinities are only marginally increased and median turbidity increases are predicted to be less than 1.5 NTU above background.
- Tailwater discharge into the upstream Barron River site (Location 5) results in a median tailwater concentration within the river of approximately 12%. Associated median salinity increases exceed 2.5 PSU. Median turbidity increases are predicted to exceed 6 NTU above background within the Barron River.
- Tailwater discharge into the middle Barron River site (Location 6) results in a median tailwater concentration within the river of approximately 12%. Associated median salinity increases exceed 2 PSU. Median turbidity increases are predicted to exceed 5 NTU above background within the River.

- Tailwater discharge (of 1.0 m^3/s) into the Barron River site at the highway bridge (Location 7) results in a median tailwater concentration within the river of approximately 8%. Associated median salinity increases are approximately 1 PSU. Median turbidity increases are predicted to exceed 5 NTU above background within the River.
- Tailwater discharge (of 2.0 m^3/s) on the ebbing tide (~50% of the time) in to the Barron River site at the highway bridge (Location 7) results in a median tailwater concentration within the river of approximately 10%. Associated median salinity increases are approximately 1 PSU. Median turbidity increases are predicted to exceed 4 NTU above background within the River.
- The downstream Barron River site is preferred compared with the upstream site near the confluence with Thomatis Creek.
- Significant mitigation of impacts to salinity and turbidity was predicted by moving the tailwater discharge location further downstream within the Barron River.
- Significantly improved flushing of tailwater from the Barron River was achieved with the 1.0 m^3/s rate at the bridge location. This might be in part due to less reinforcing of the baroclinically driven salt wedge intrusion for the lower flow rate (i.e. it is quite possible that the flushing behaviour is non-linear with flow rate).

Appendix A ADCP Discharge Model Validation






Barron D/S Thomatis
Observations
TUFLOWFV Model
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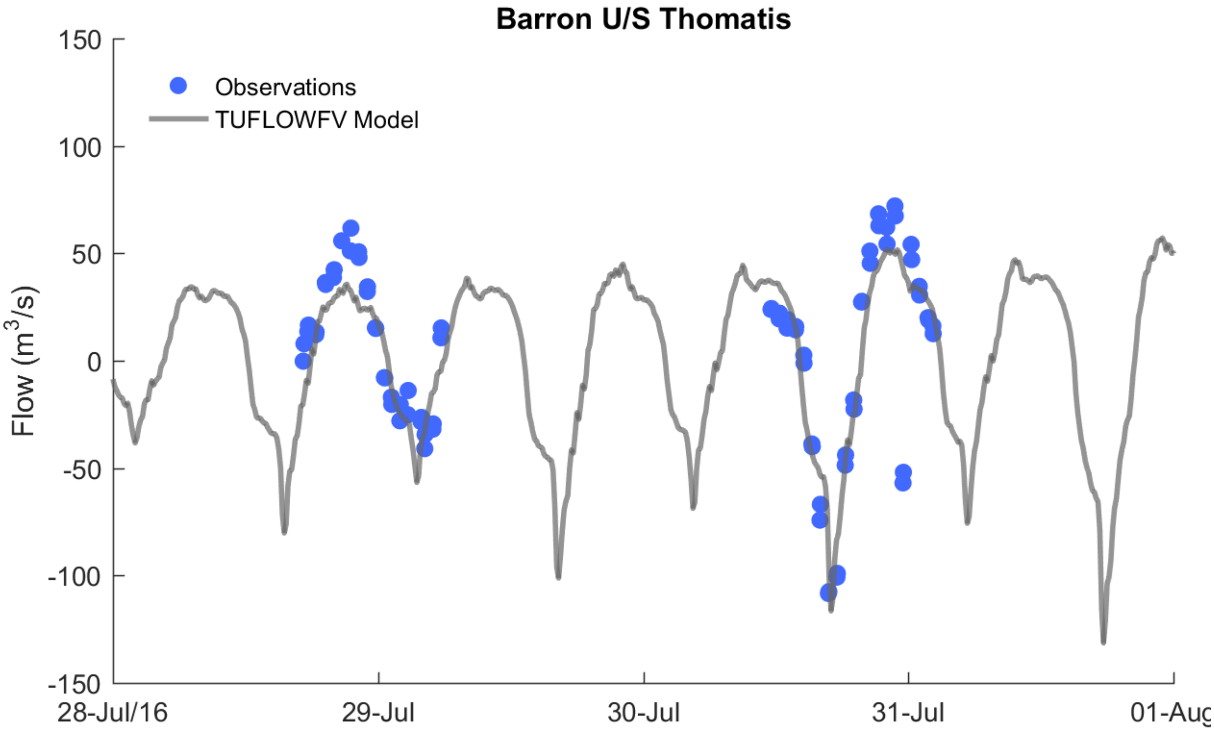
50
0
-50
-100
28-Jul/16
29-Jul
30-Jul
31-Jul
01-Aug


Barron U/S Thomatis
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TUFLOWFV Model
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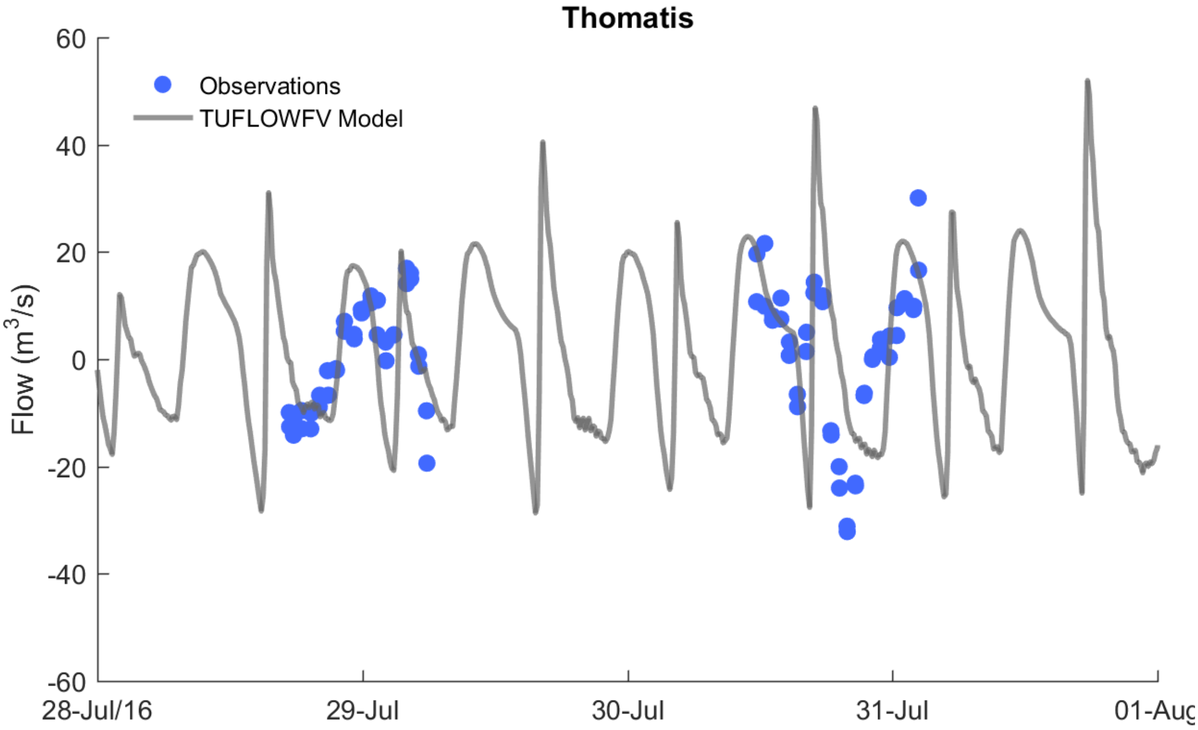
Thomatis
Observations
TUFLOWFV Model
Flow (m3/s)
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-40
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28-Jul/16
29-Jul
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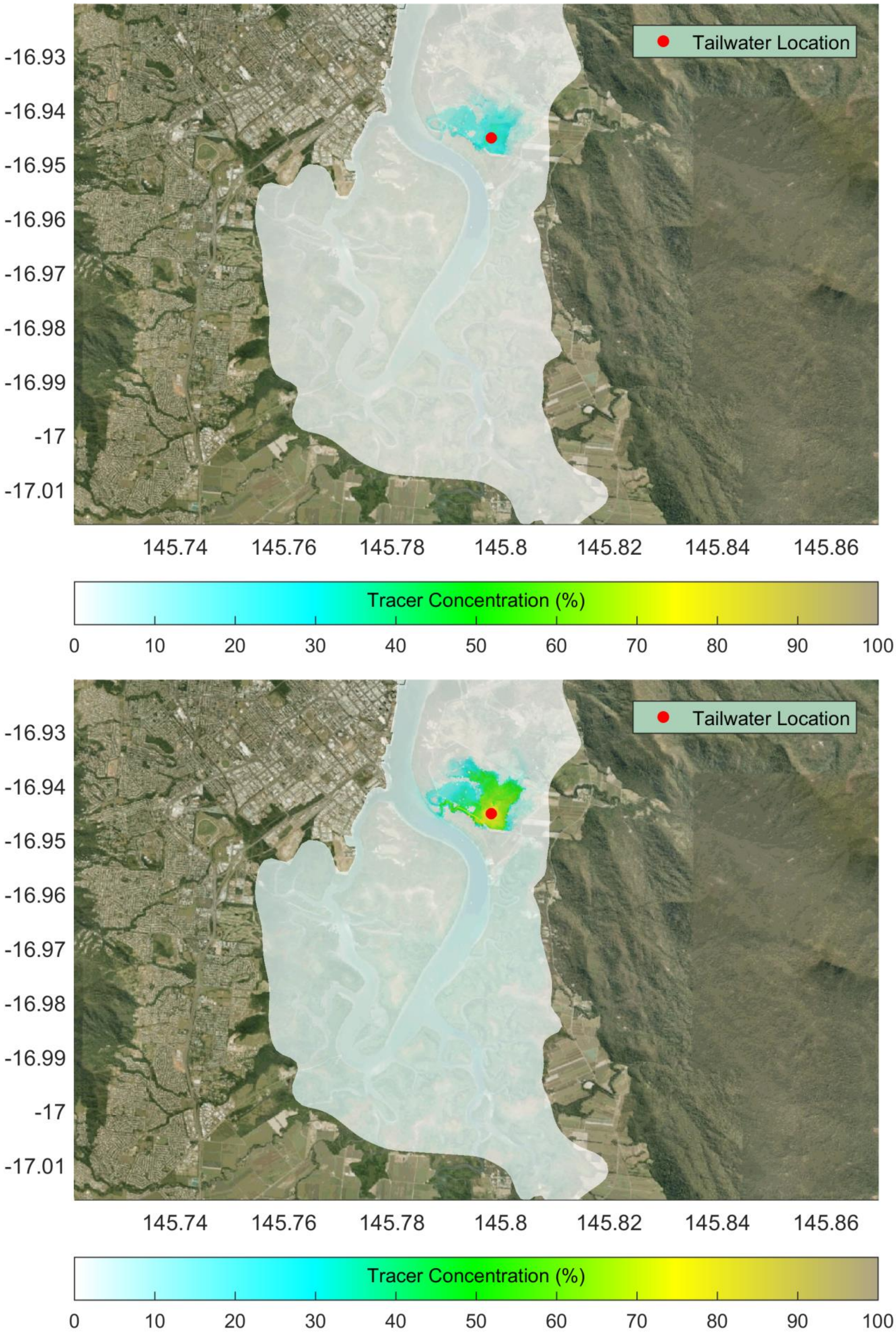
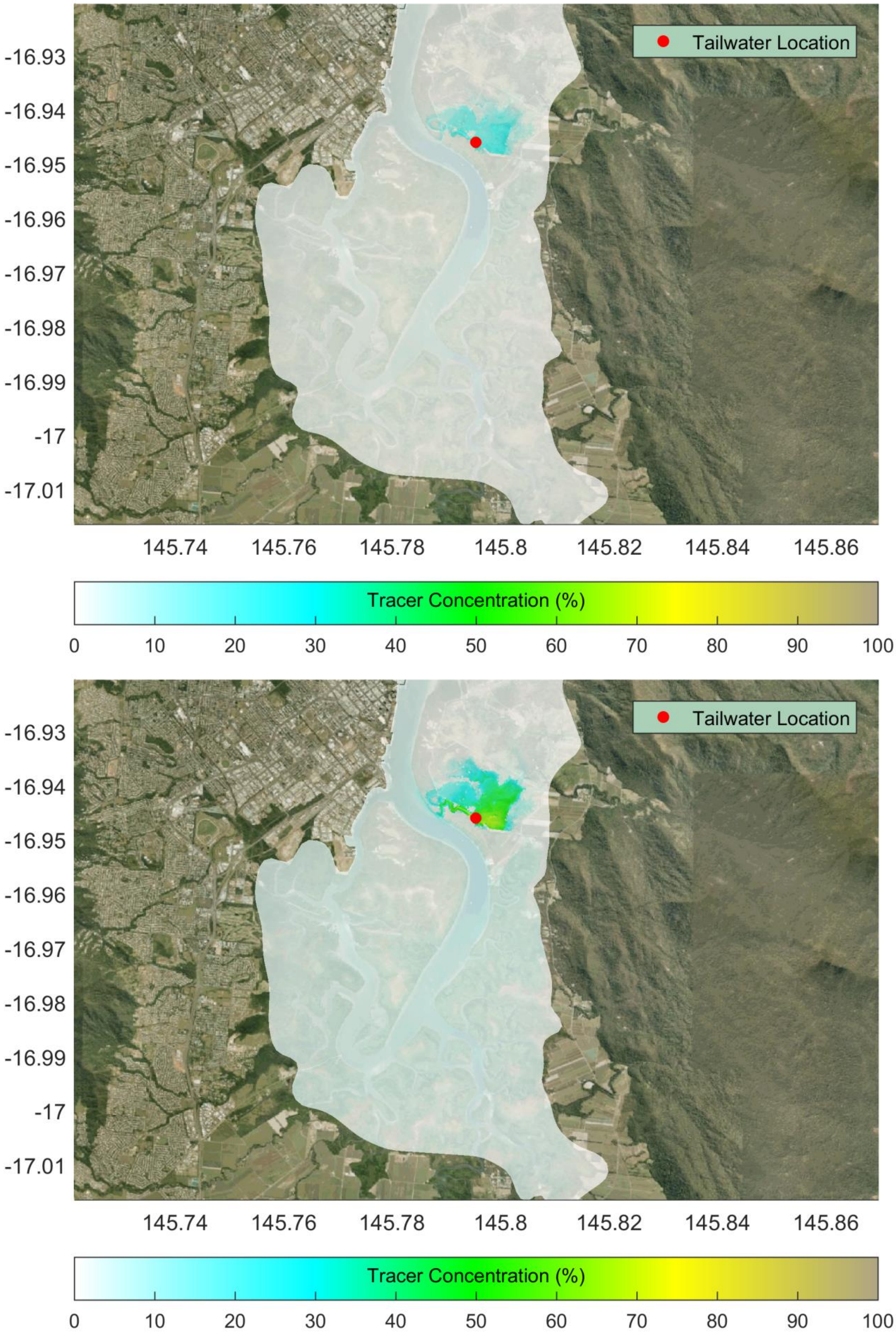
Appendix B Preliminary Tailwater Simulation Results



Location 1. Passive Tracer 50%ile (top) and 95%ile (bottom).



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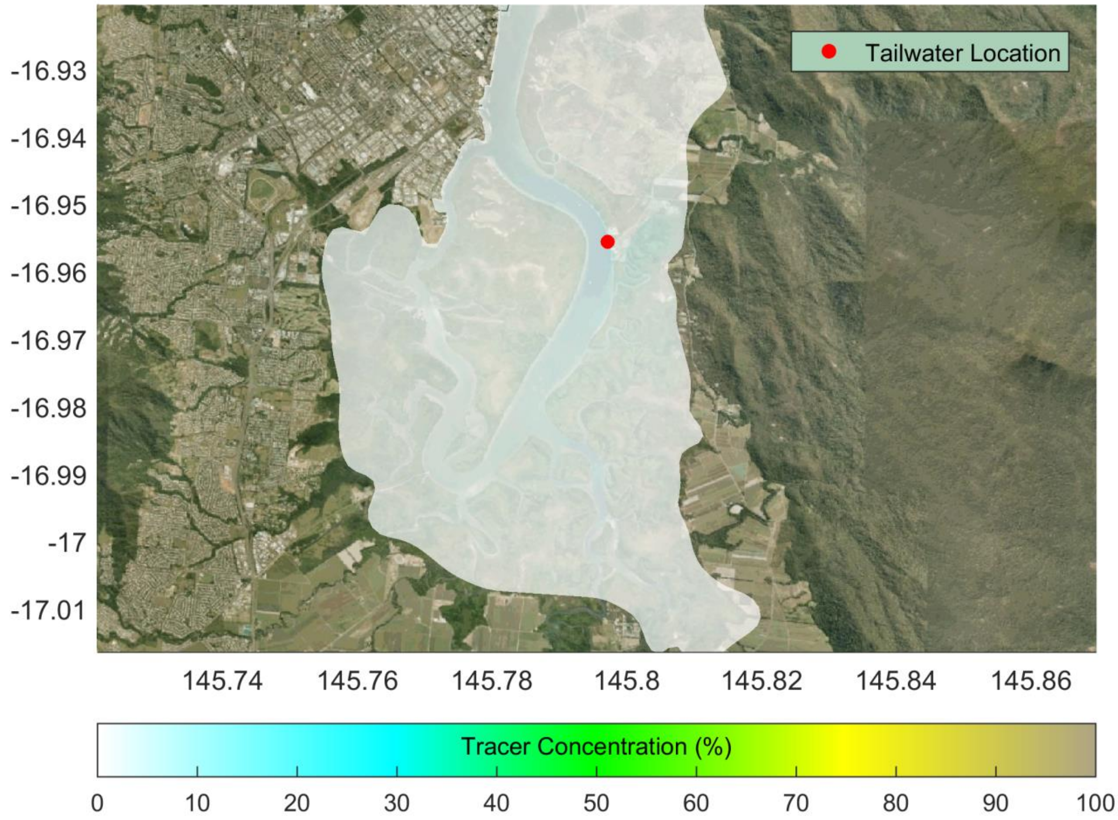

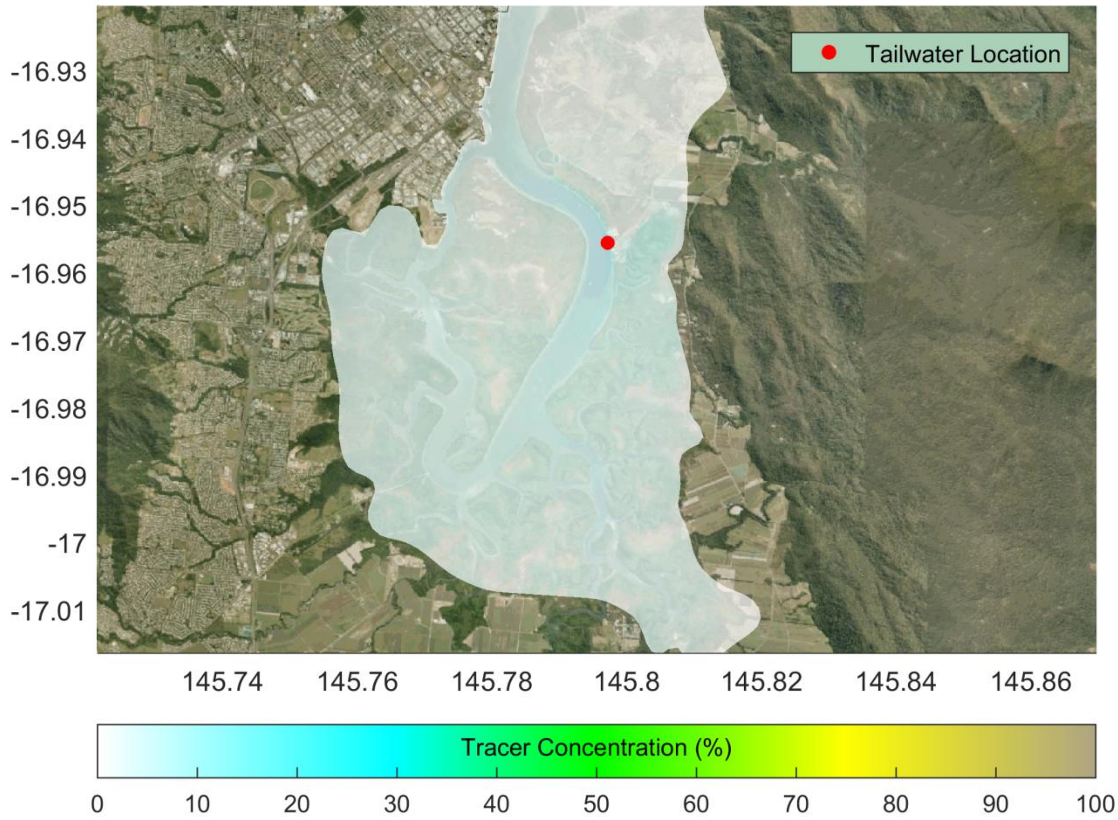

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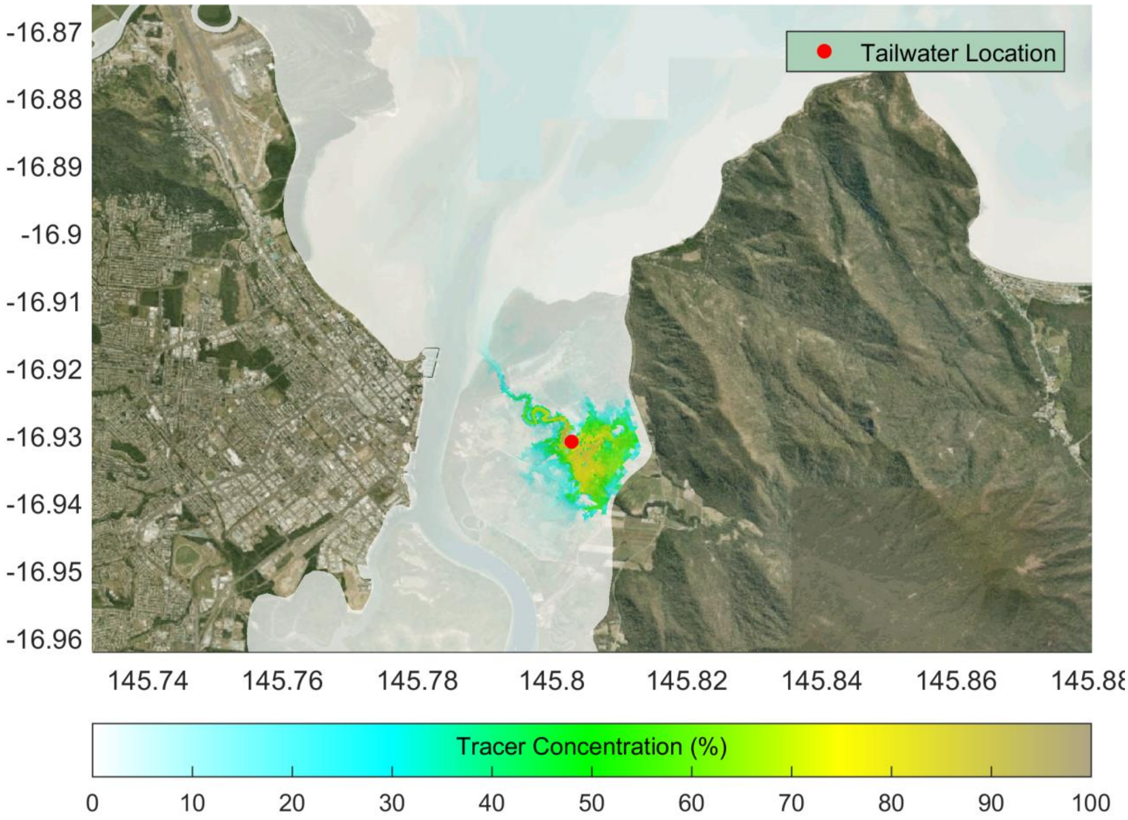

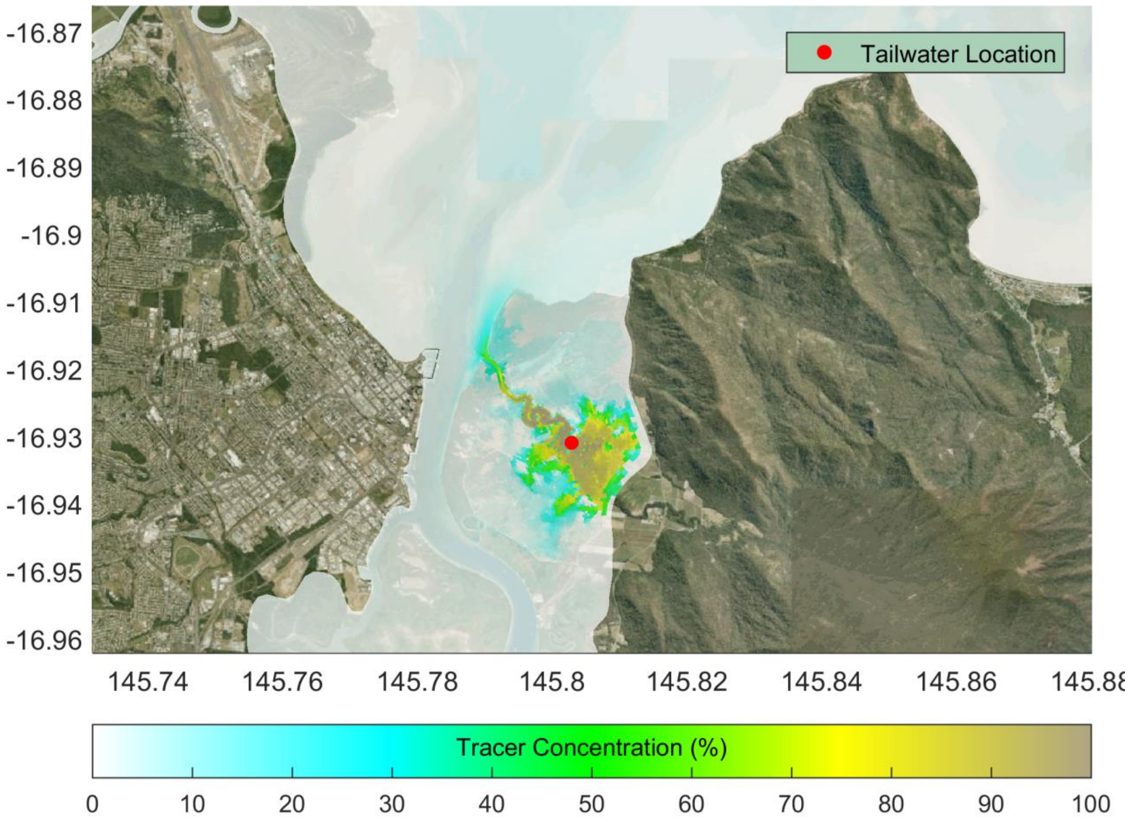

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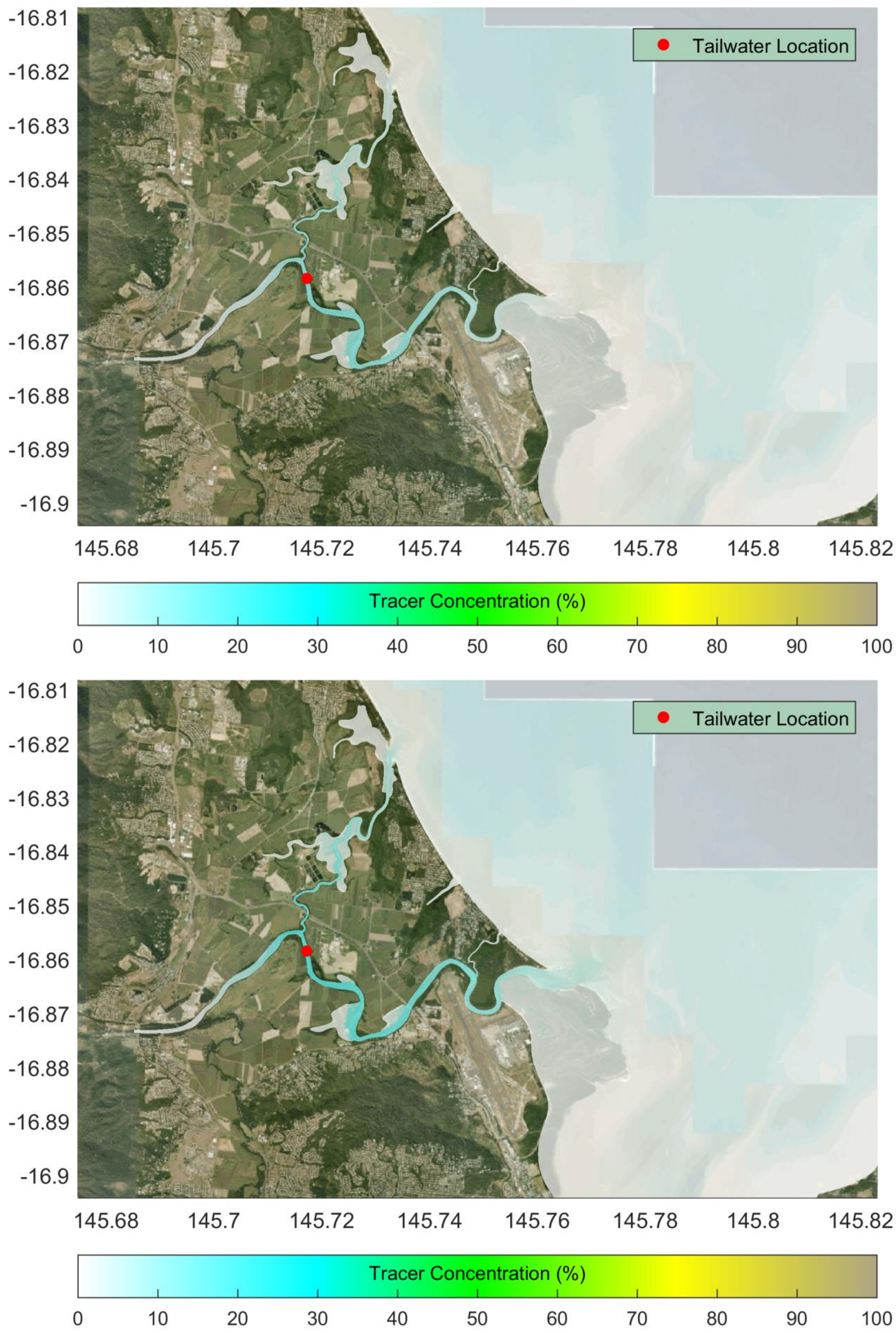

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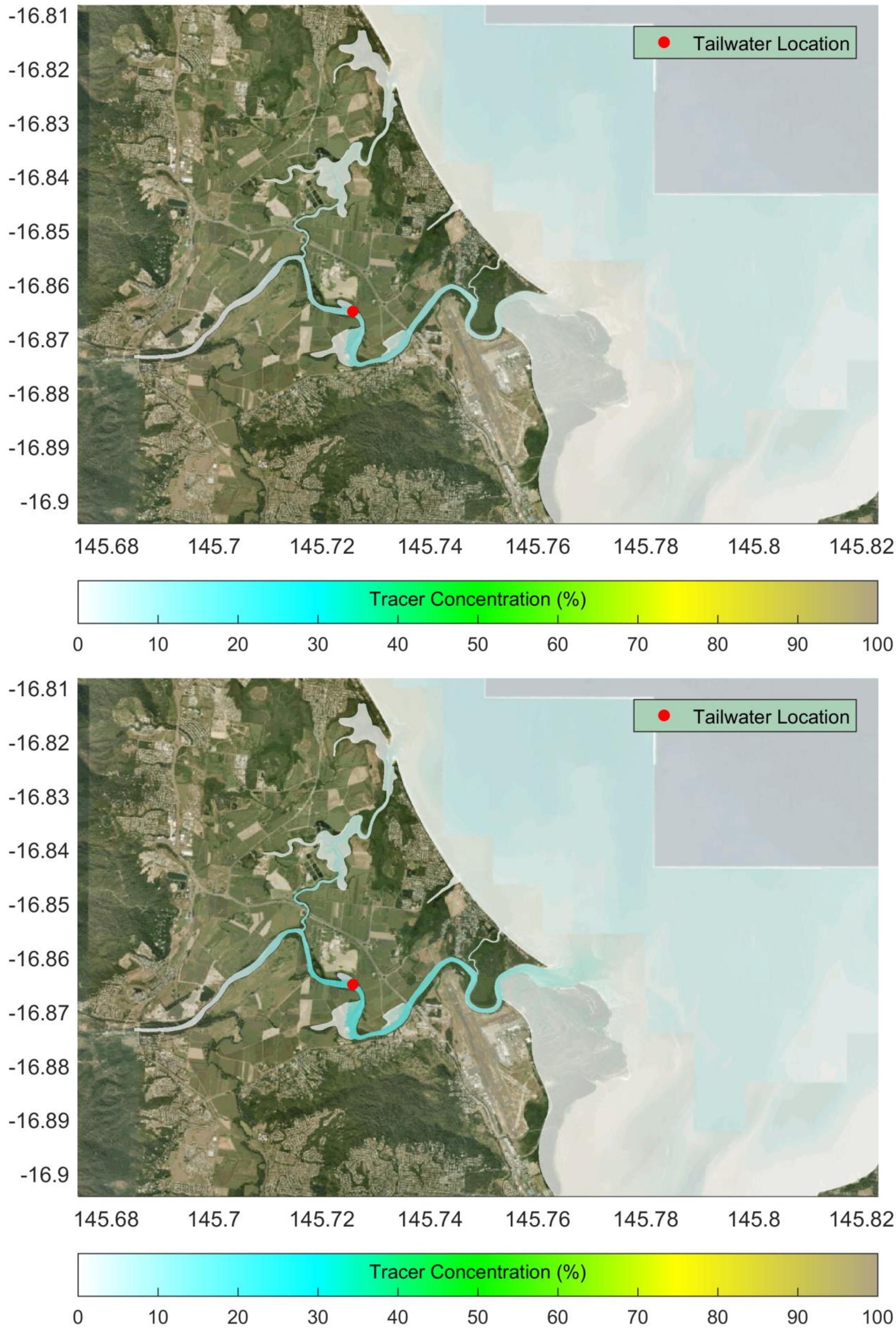
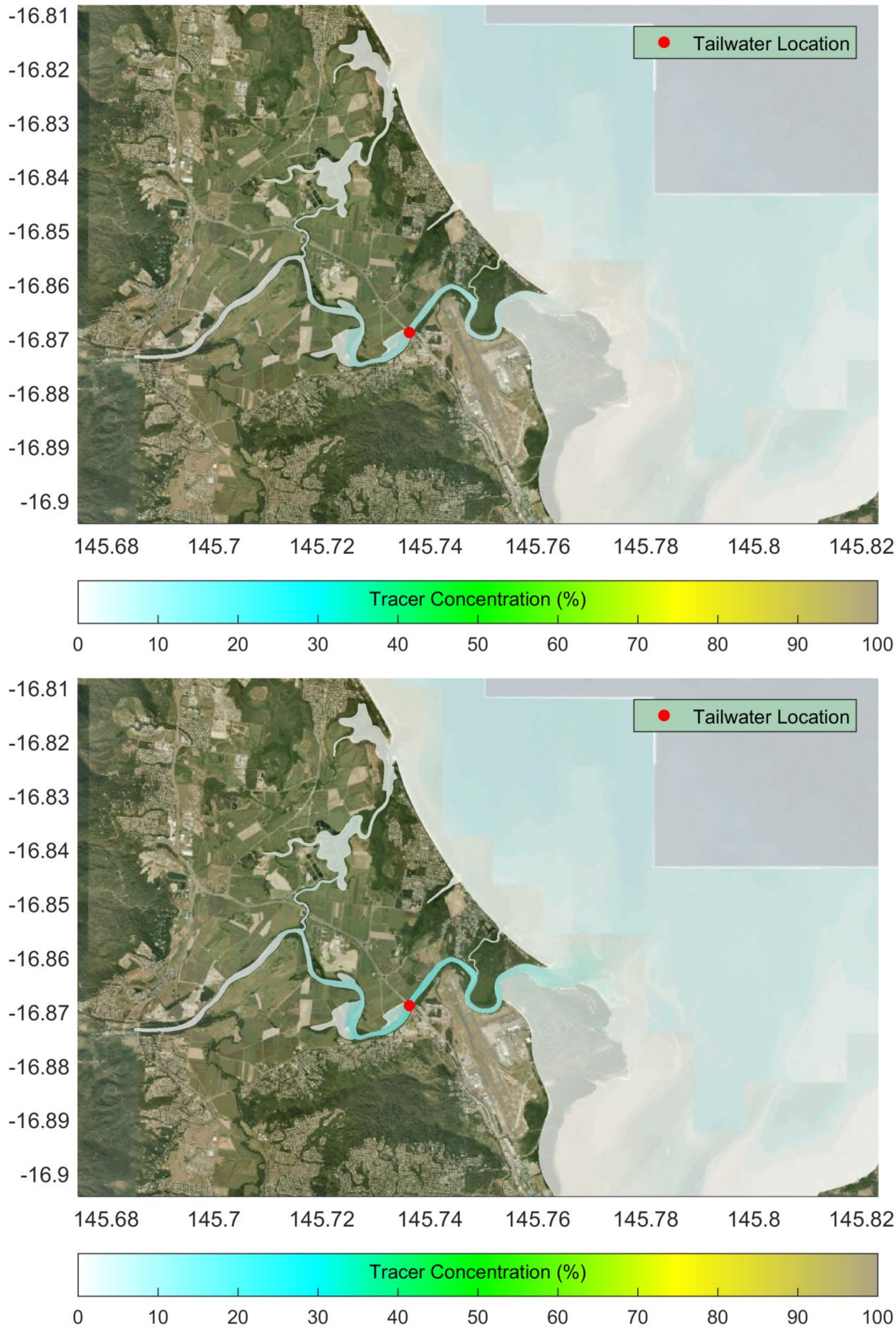
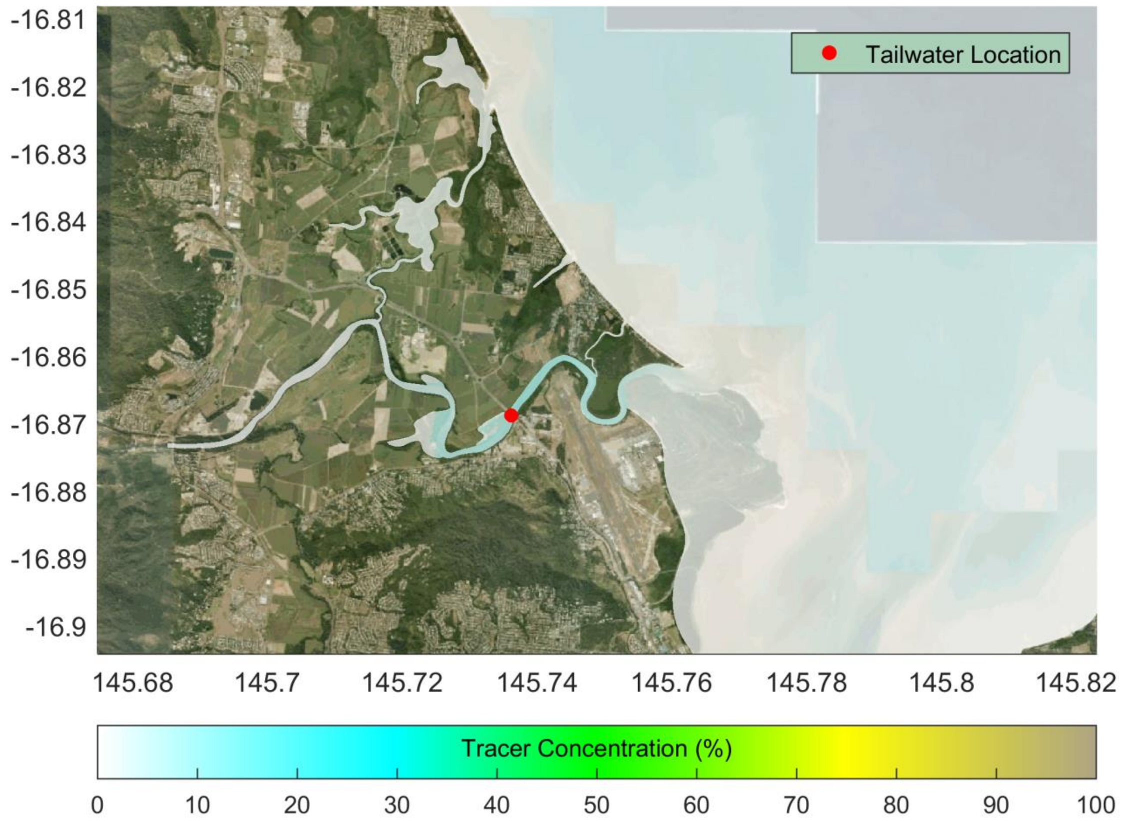
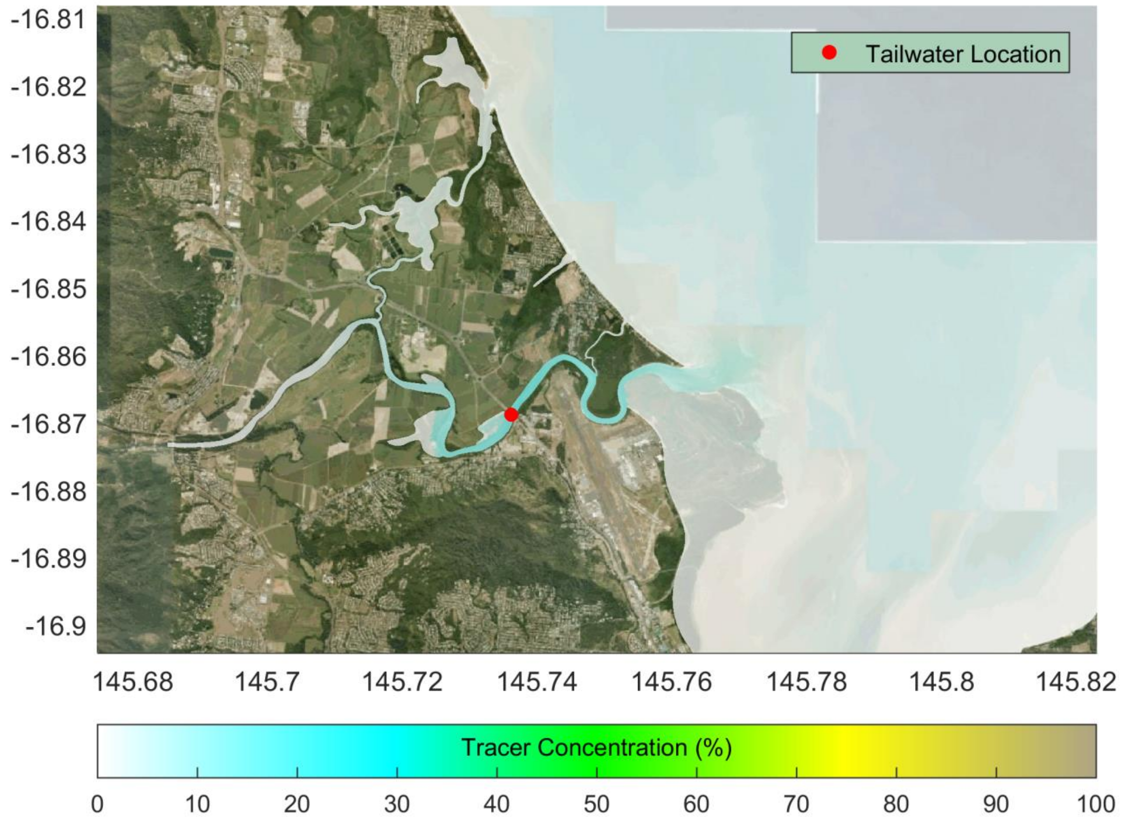


Location 6. Passive Tracer 50%ile (top) and 95%ile (bottom).

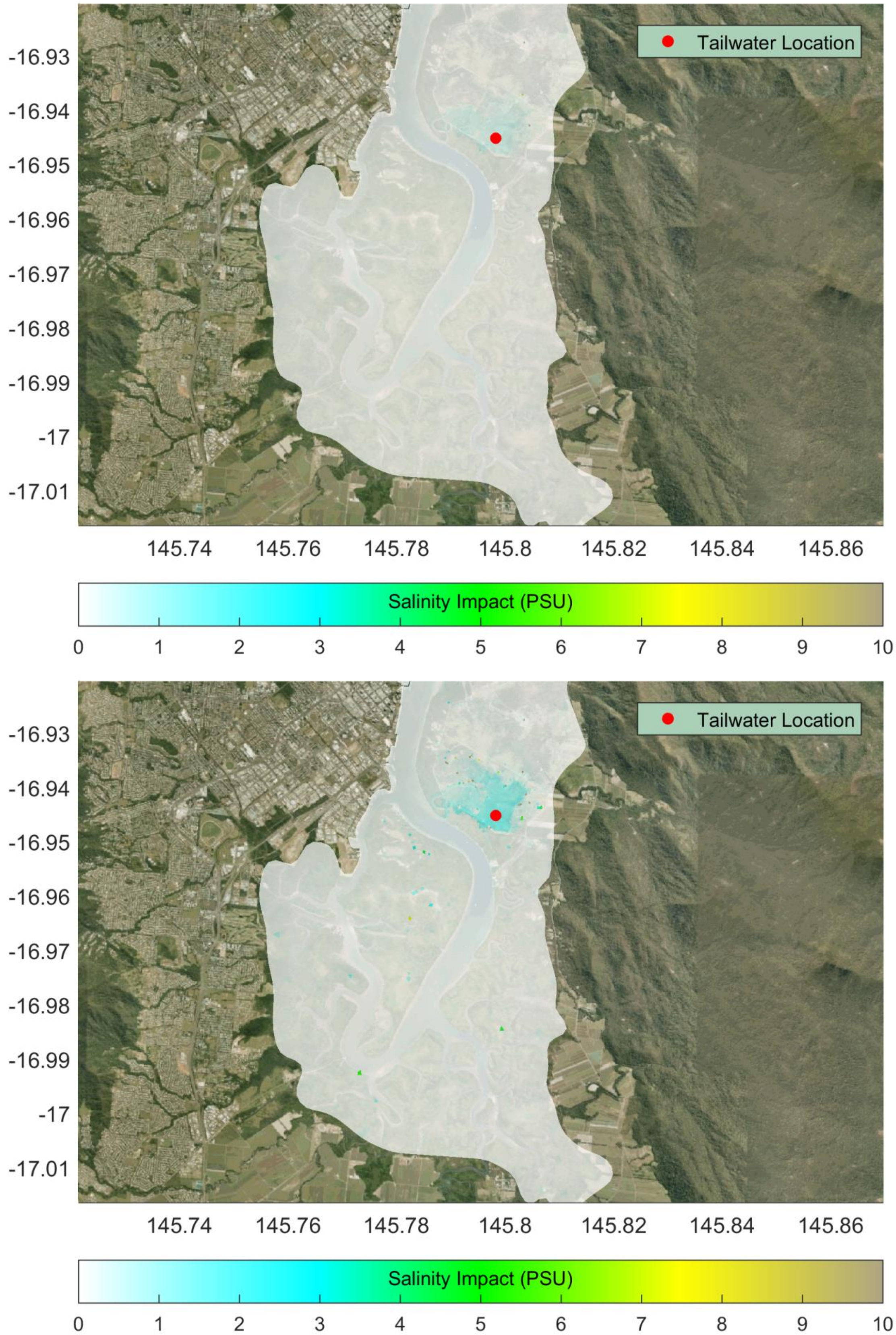


Location 7. Passive Tracer 50%ile (top) and 95%ile (bottom).

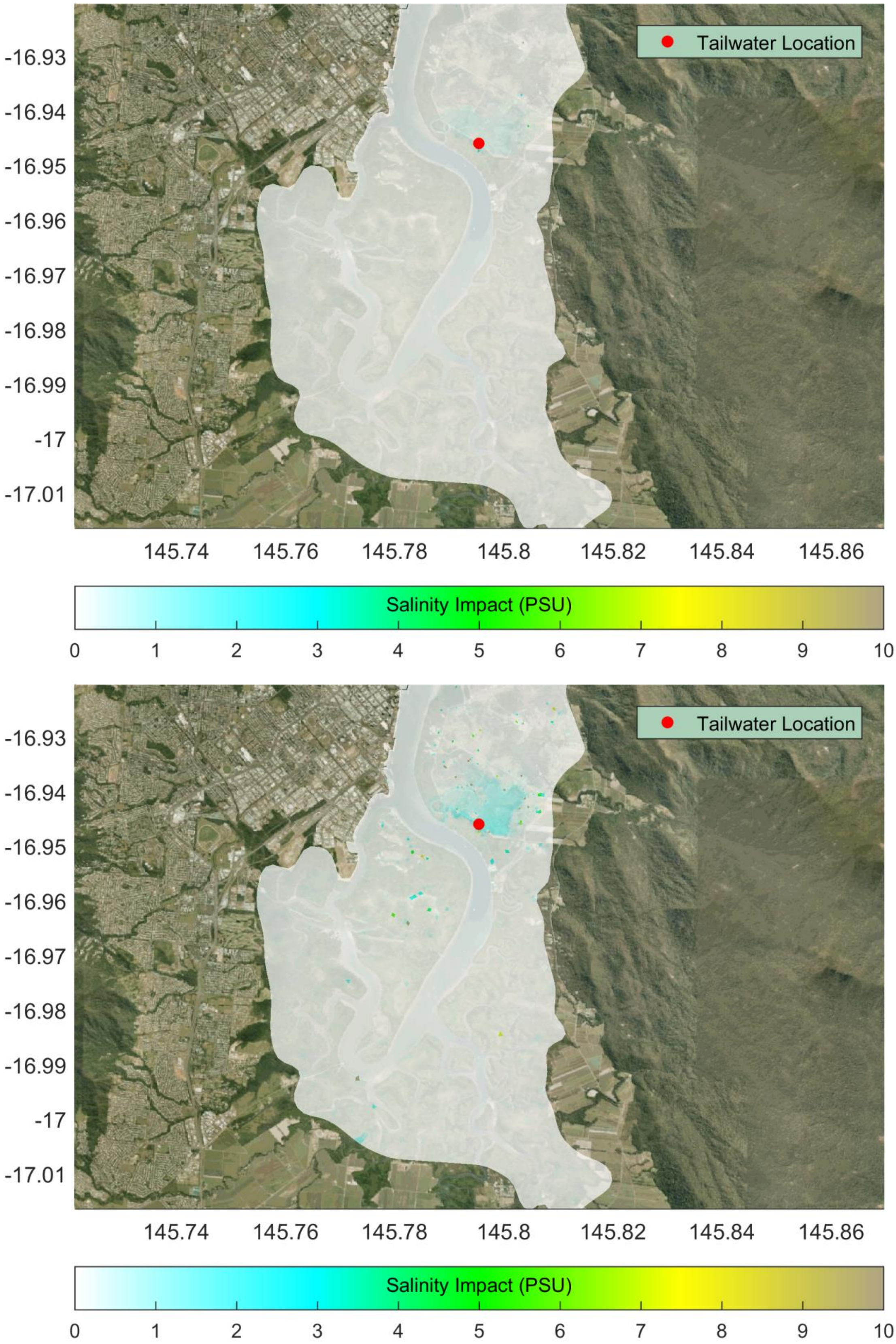




Location 7 Ebb. Passive Tracer 50%ile (top) and 95%ile (bottom).



Location 1. Salinity Impacts 50%ile (top) and 95%ile (bottom).



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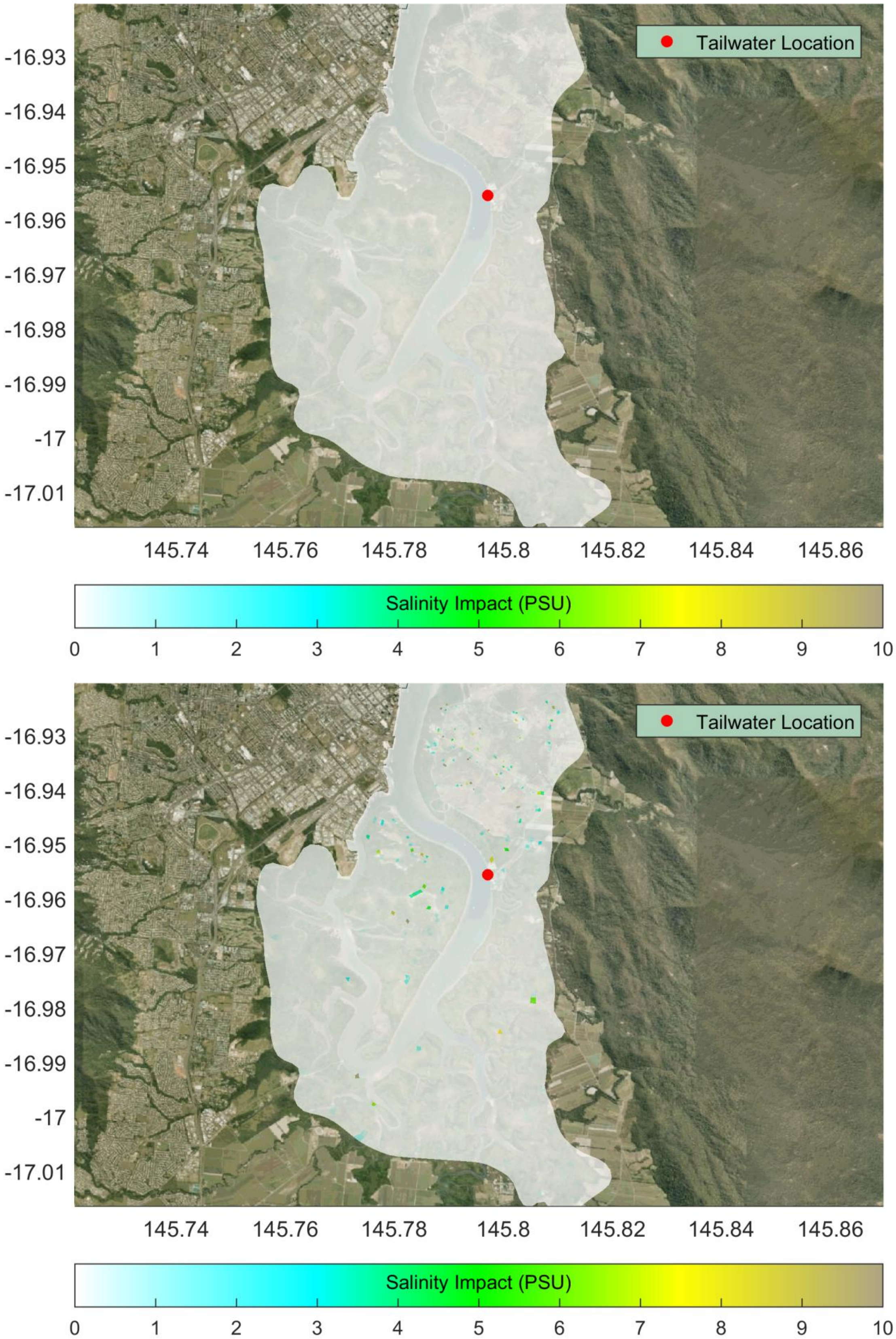
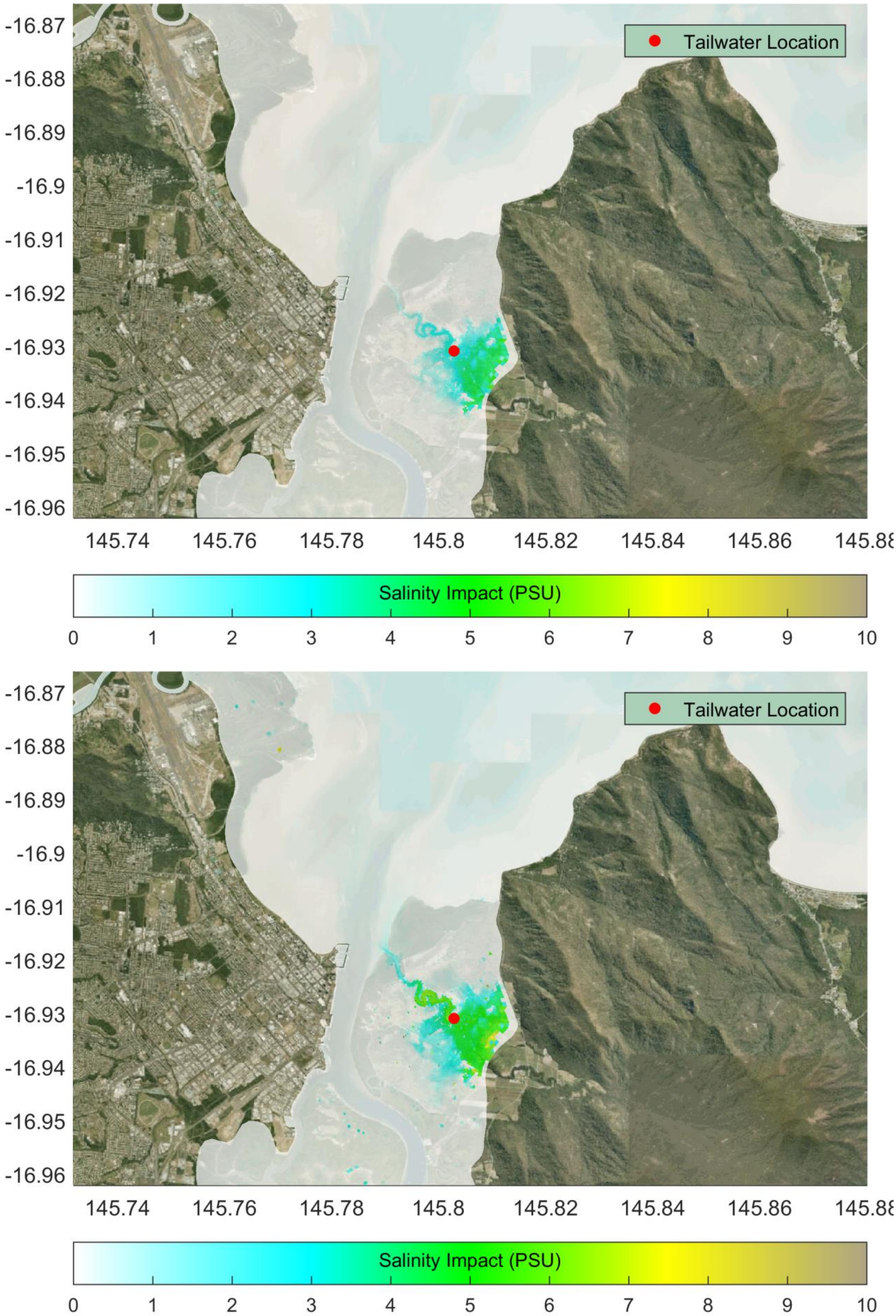
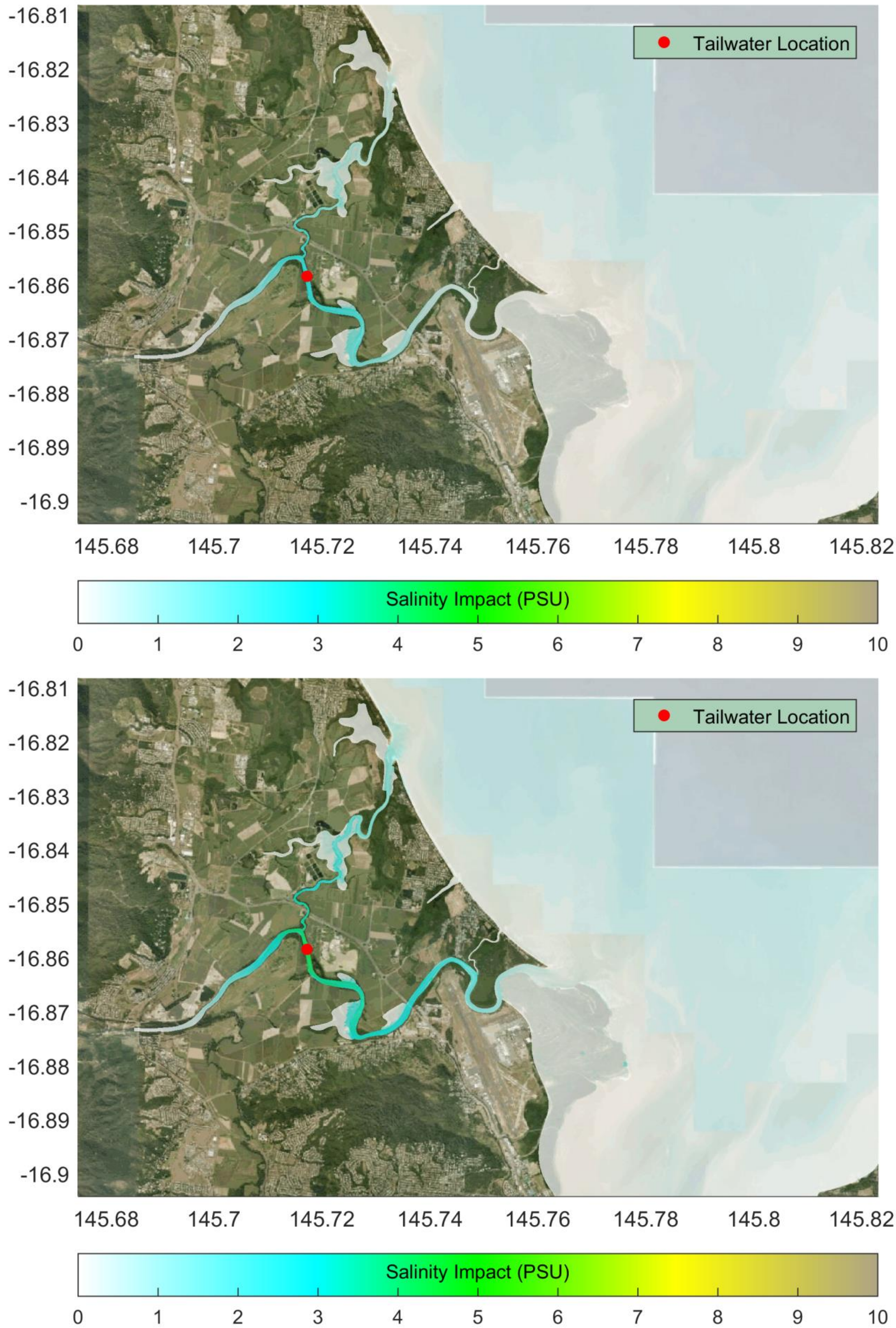


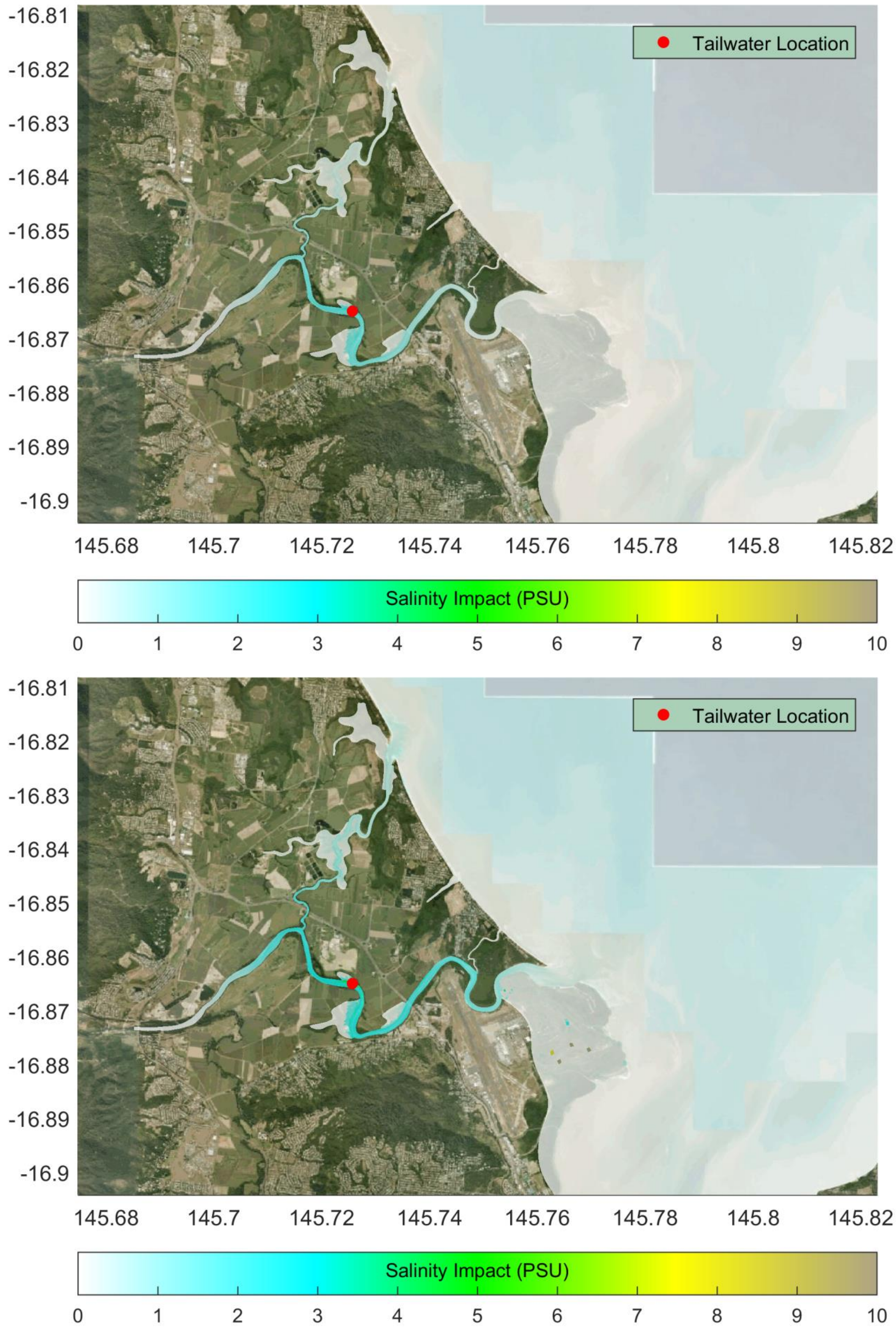
Location 3. Salinity Impacts 50%ile (top) and 95%ile (bottom).



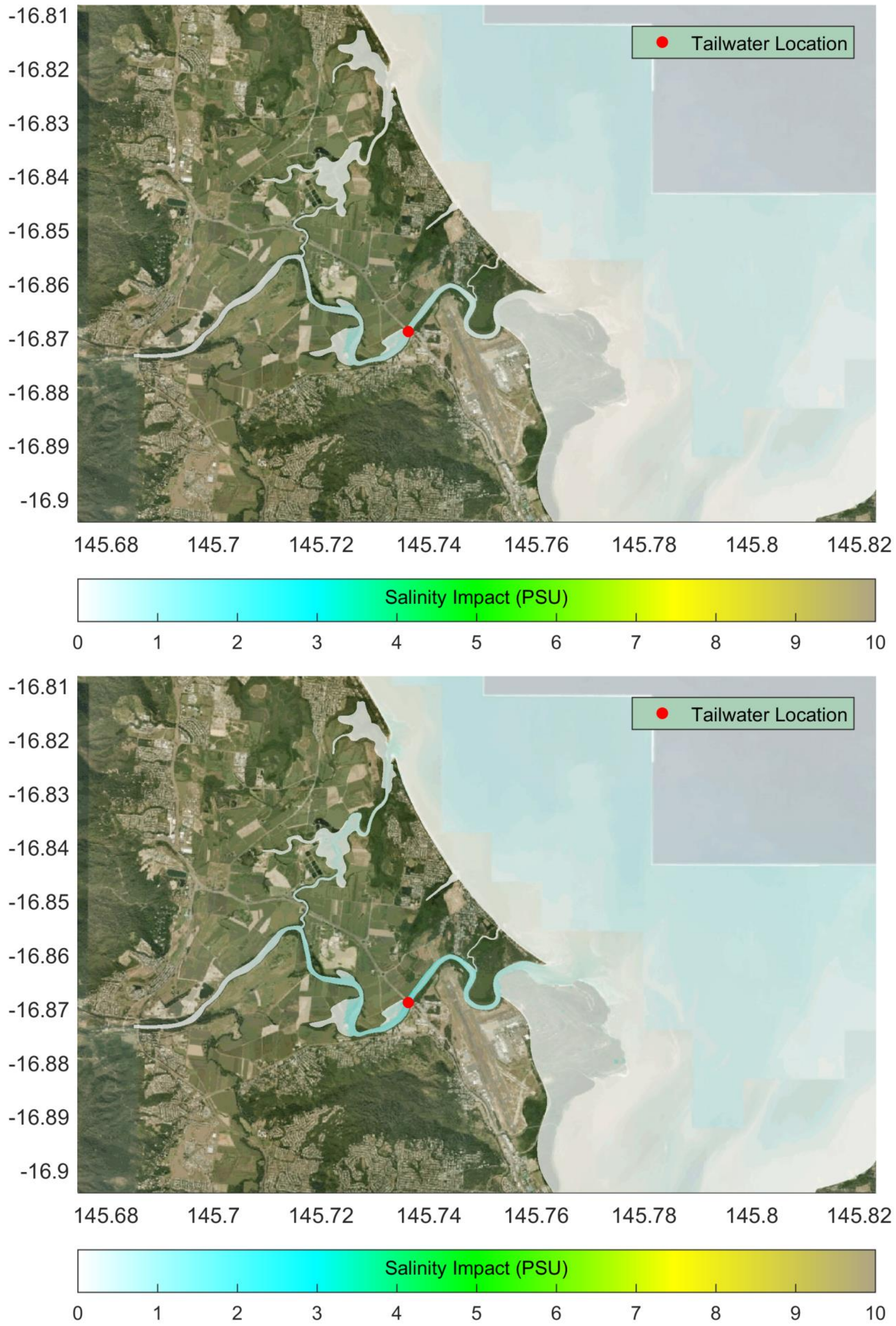
Location 4. Salinity Impacts 50%ile (top) and 95%ile (bottom).



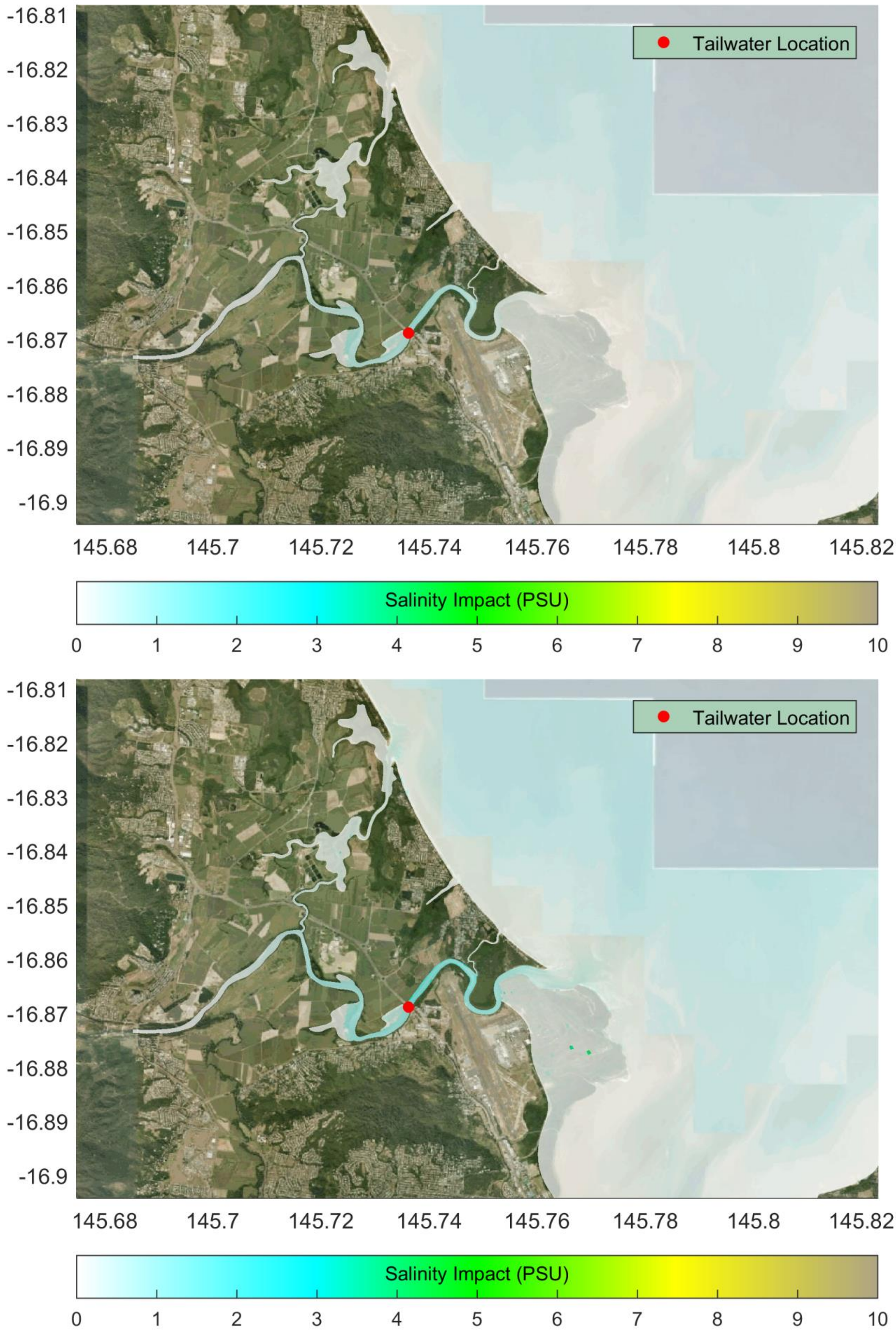
Location 5. Salinity Impacts 50%ile (top) and 95%ile (bottom).



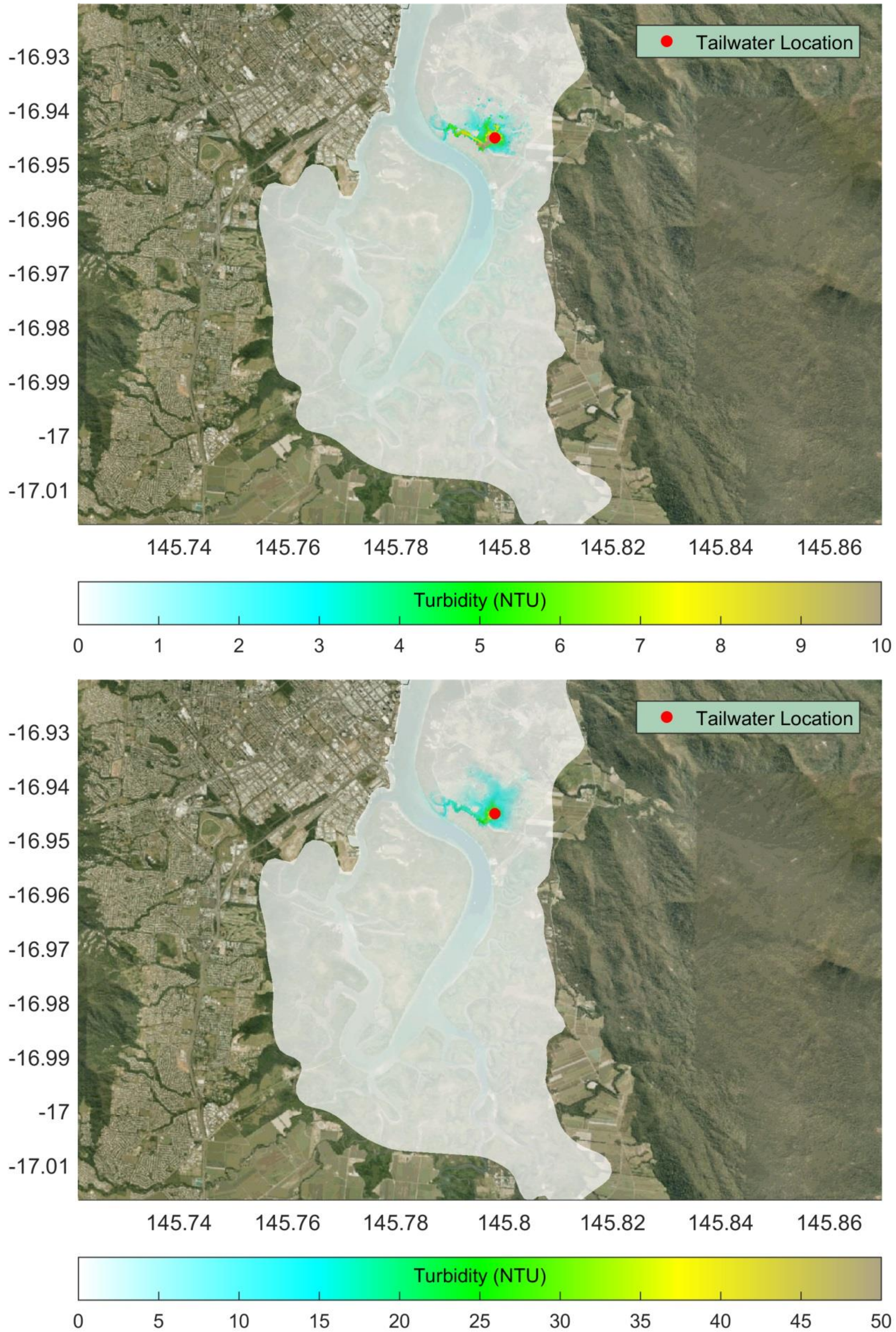
Location 6. Salinity Impacts 50%ile (top) and 95%ile (bottom).



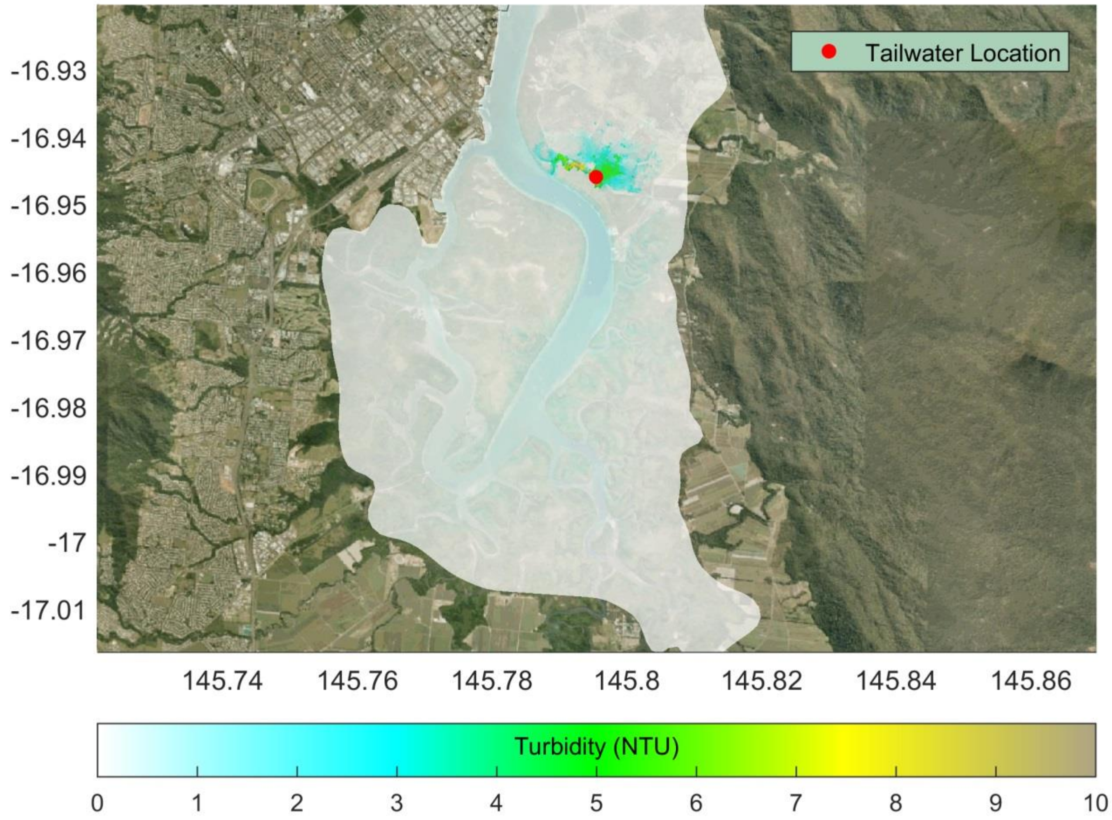
Location 7. Salinity Impacts 50%ile (top) and 95%ile (bottom).

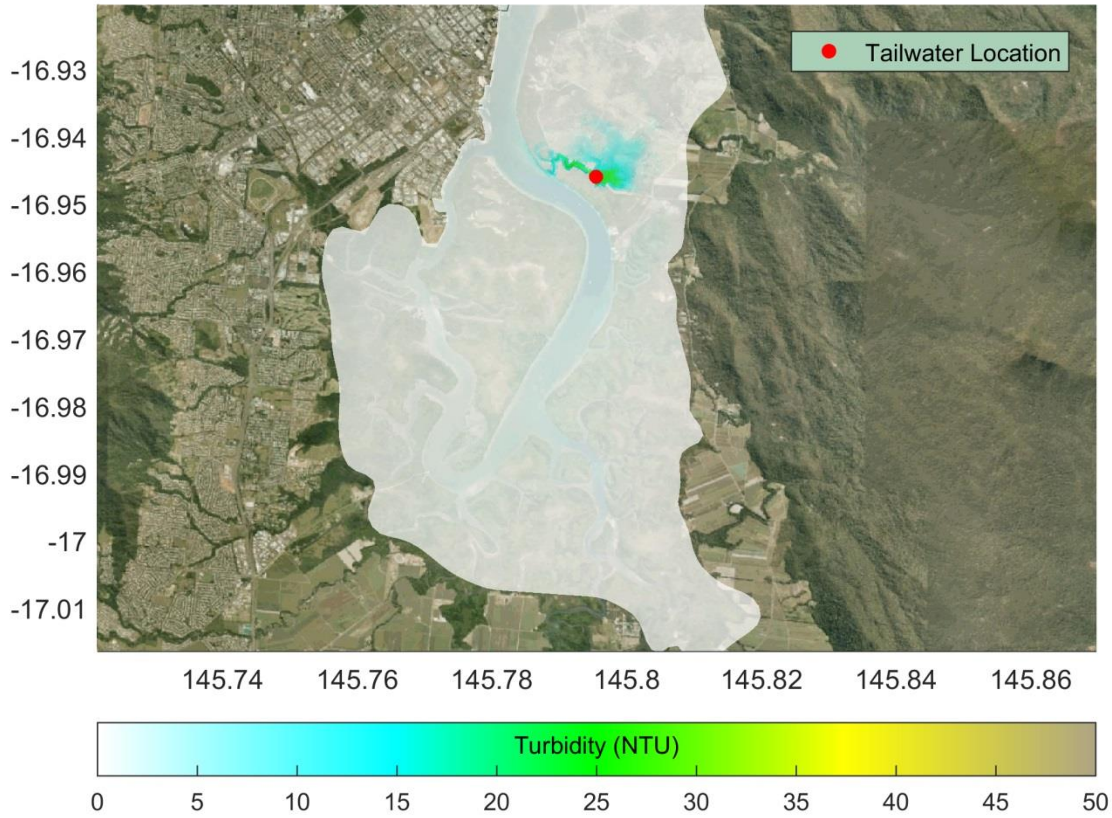


Location 7 Ebb. Salinity Impacts 50%ile (top) and 95%ile (bottom).

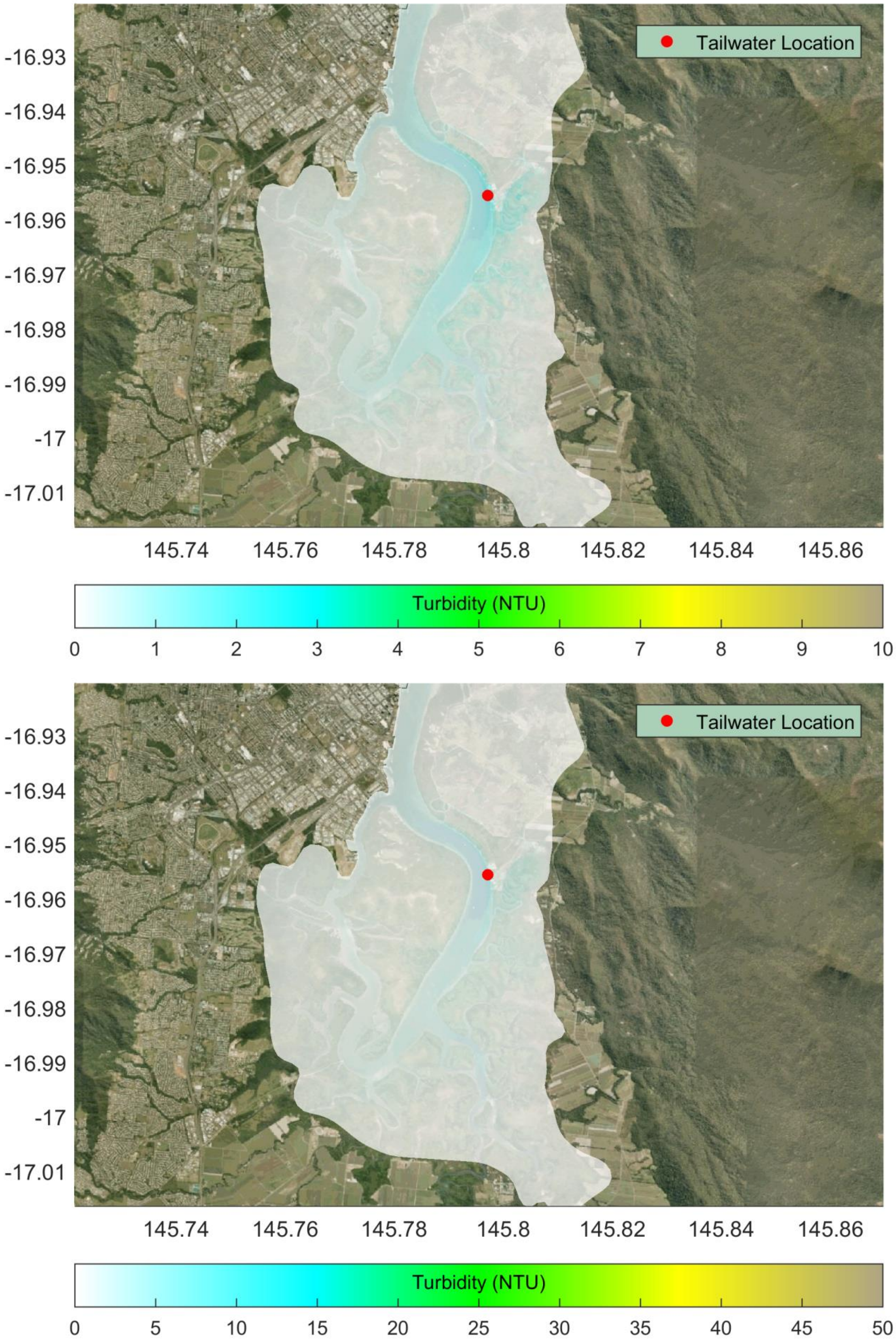


Location 1. Turbidity 50%ile (top) and 95%ile (bottom).

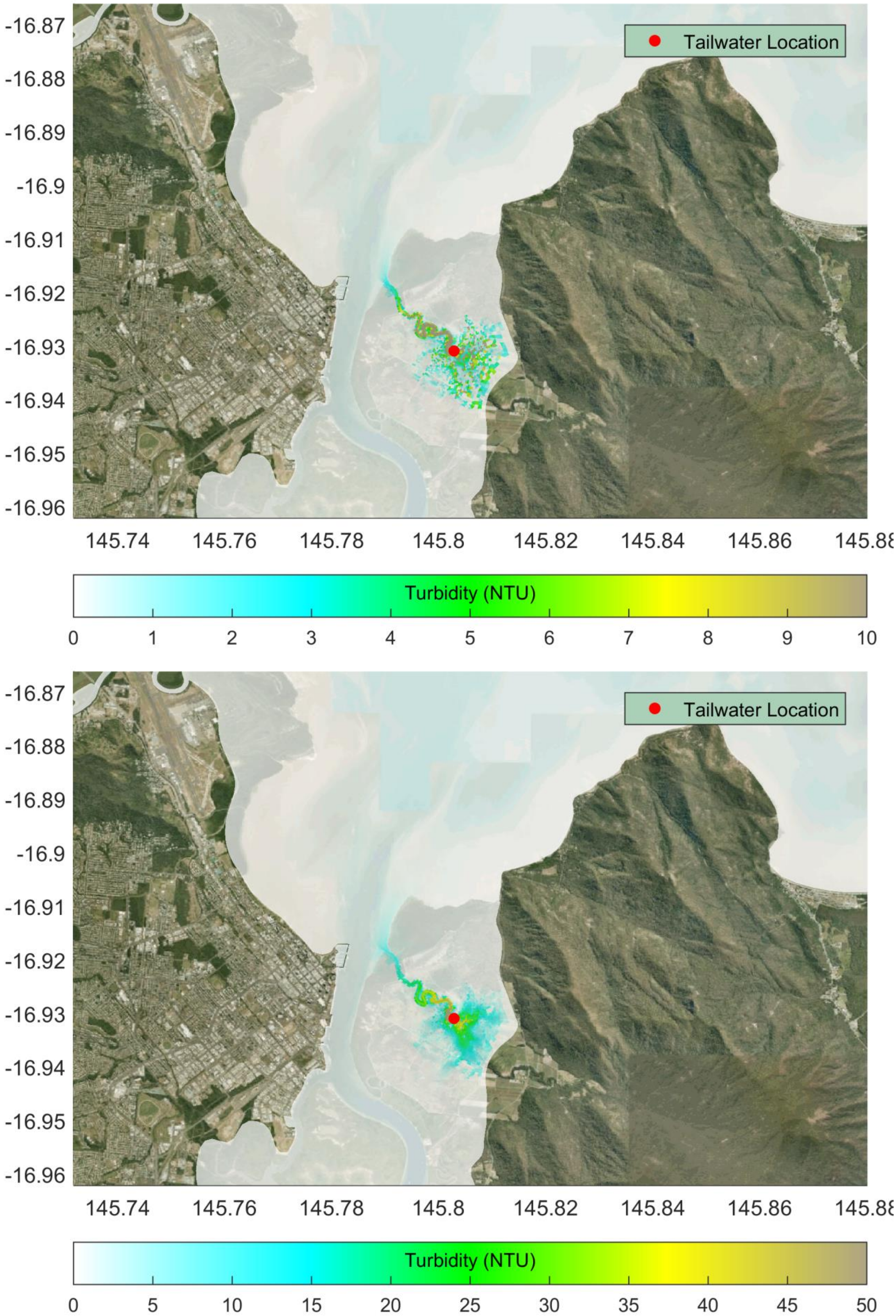




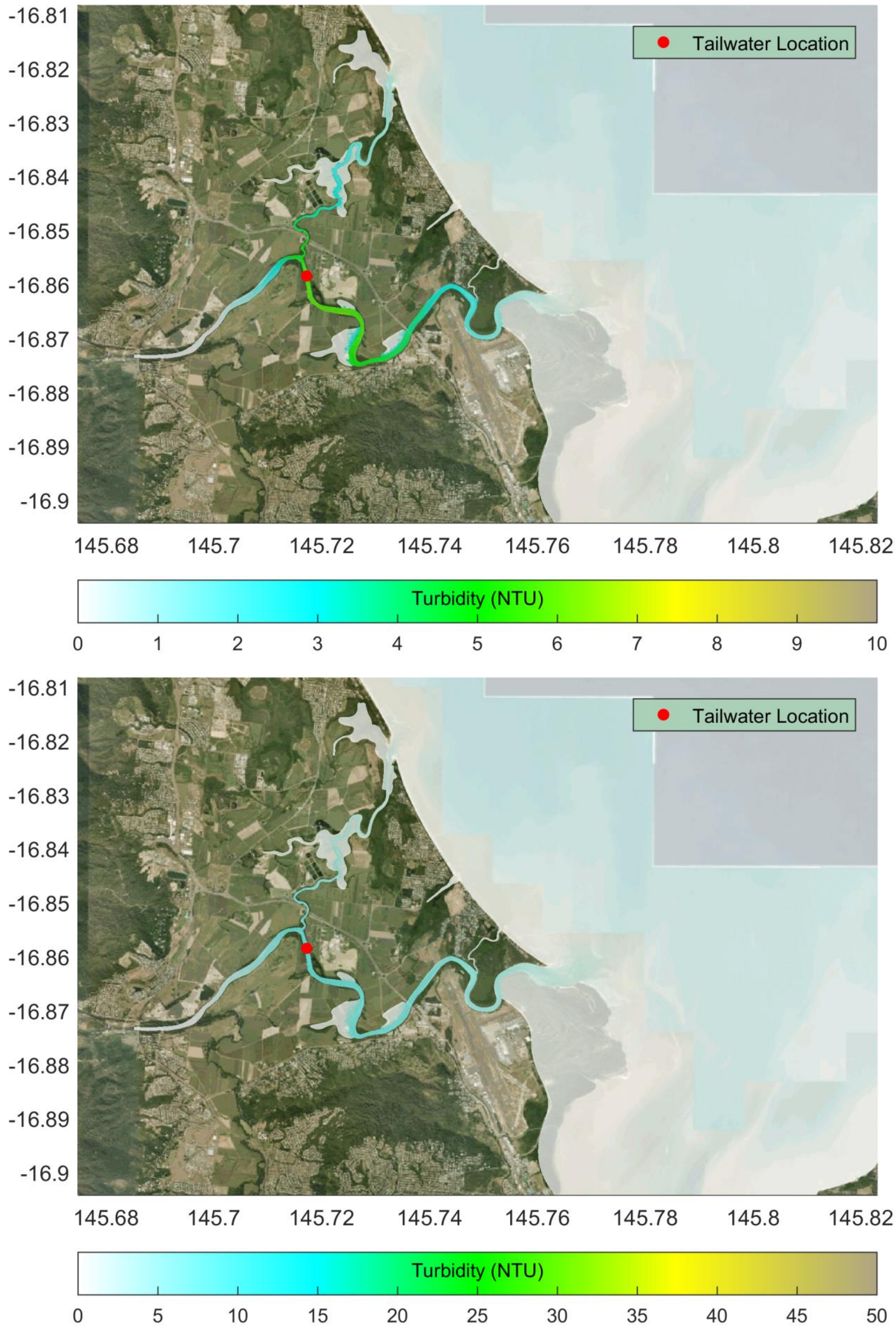
Location 2. Turbidity 50%ile (top) and 95%ile (bottom).



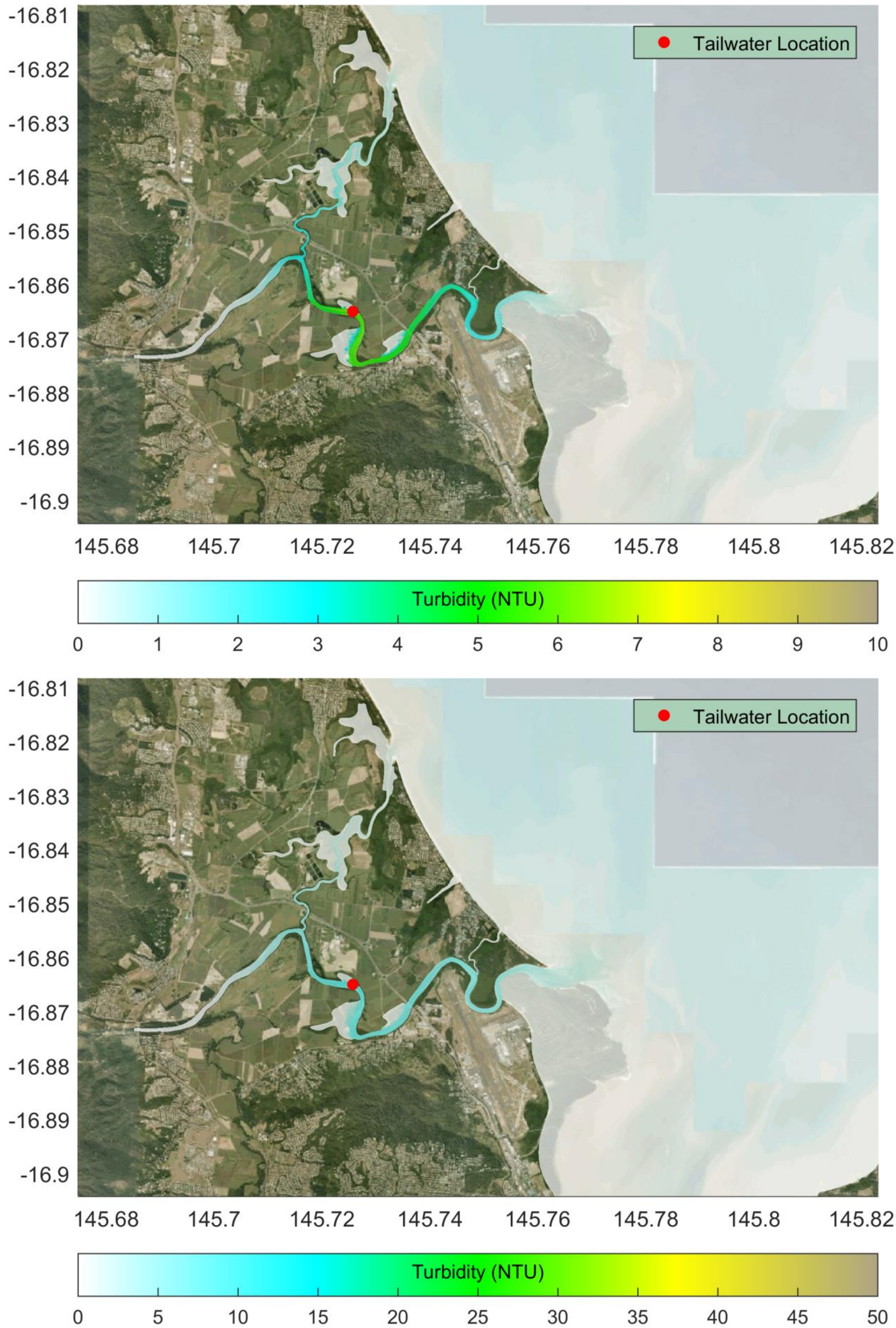
Location 3. Turbidity 50%ile (top) and 95%ile (bottom).



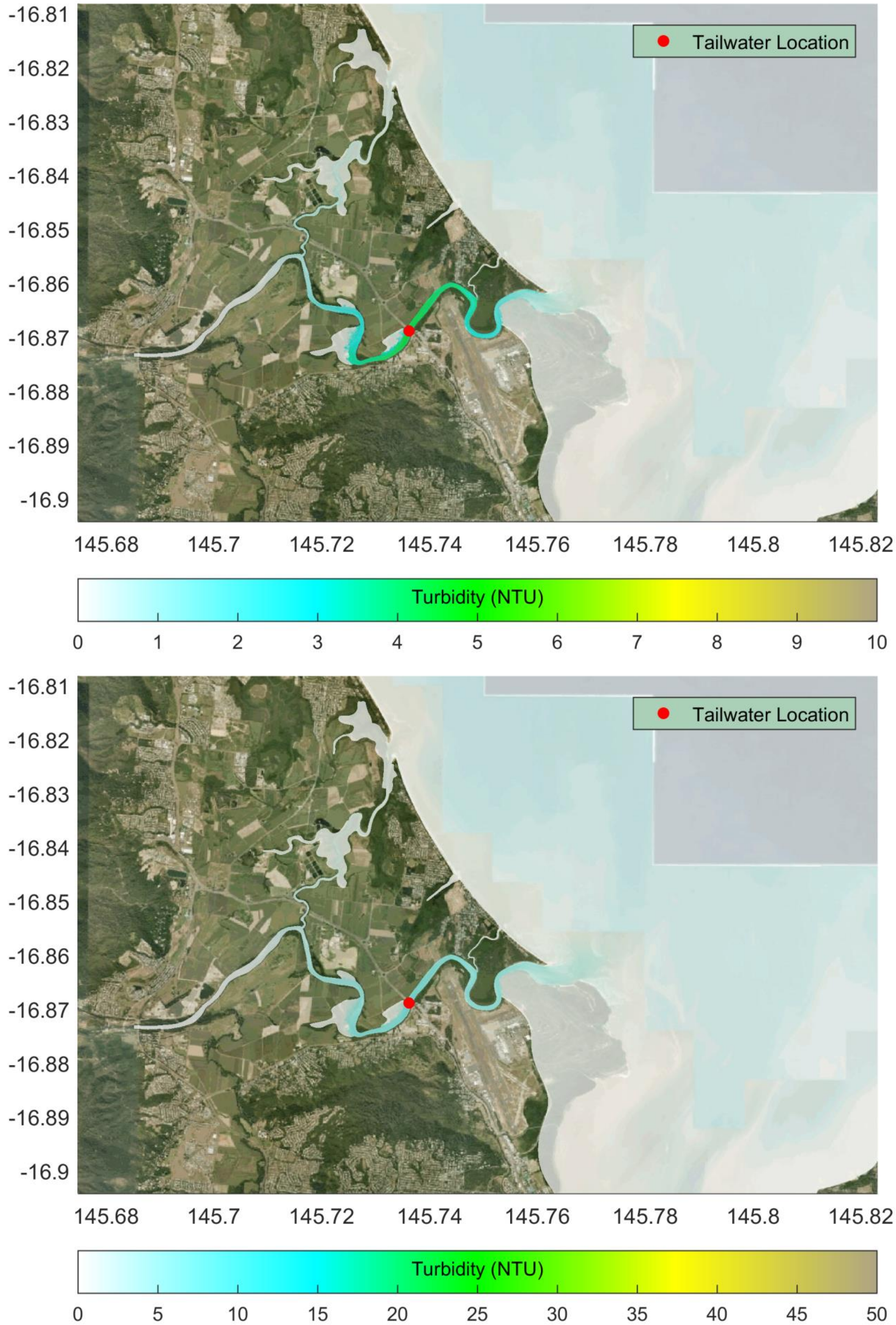
Location 4. Turbidity 50%ile (top) and 95%ile (bottom).



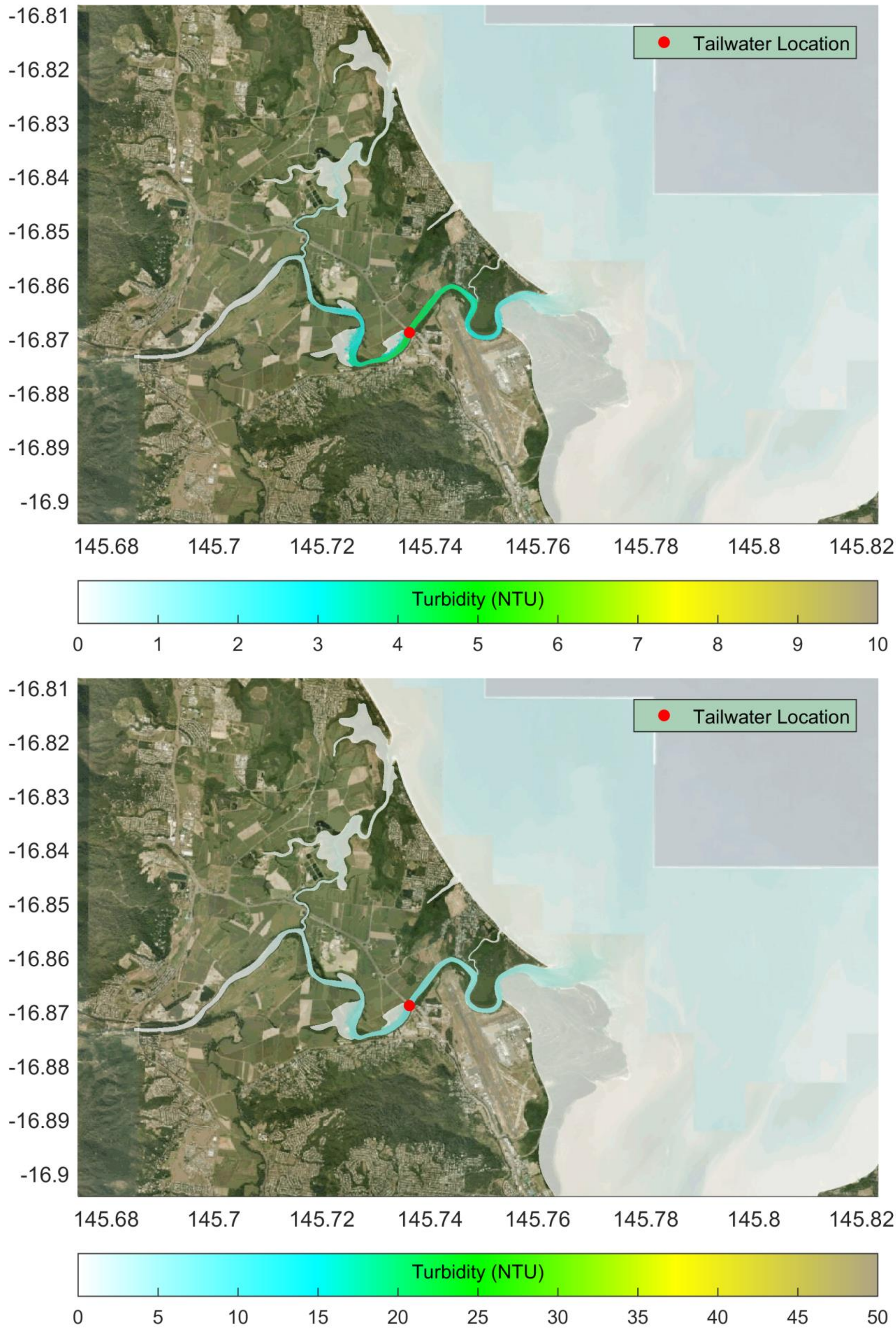
Location 5. Turbidity 50%ile (top) and 95%ile (bottom).



Location 6. Turbidity 50%ile (top) and 95%ile (bottom).

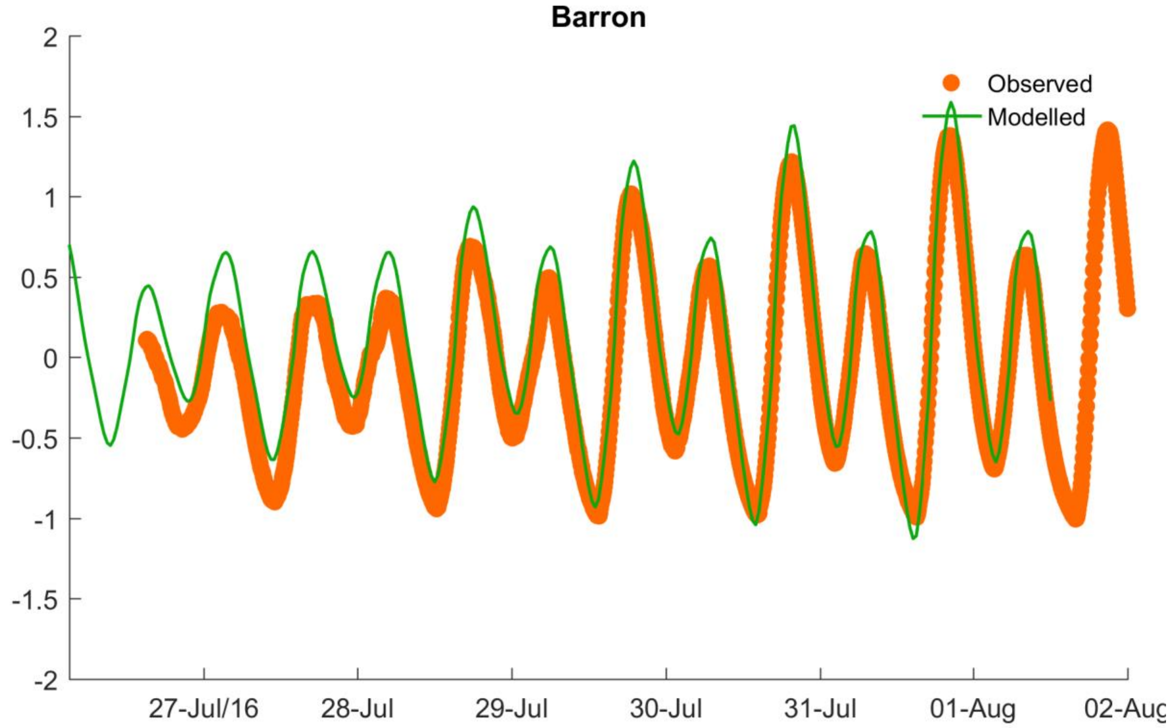


Location 7. Turbidity 50%ile (top) and 95%ile (bottom).

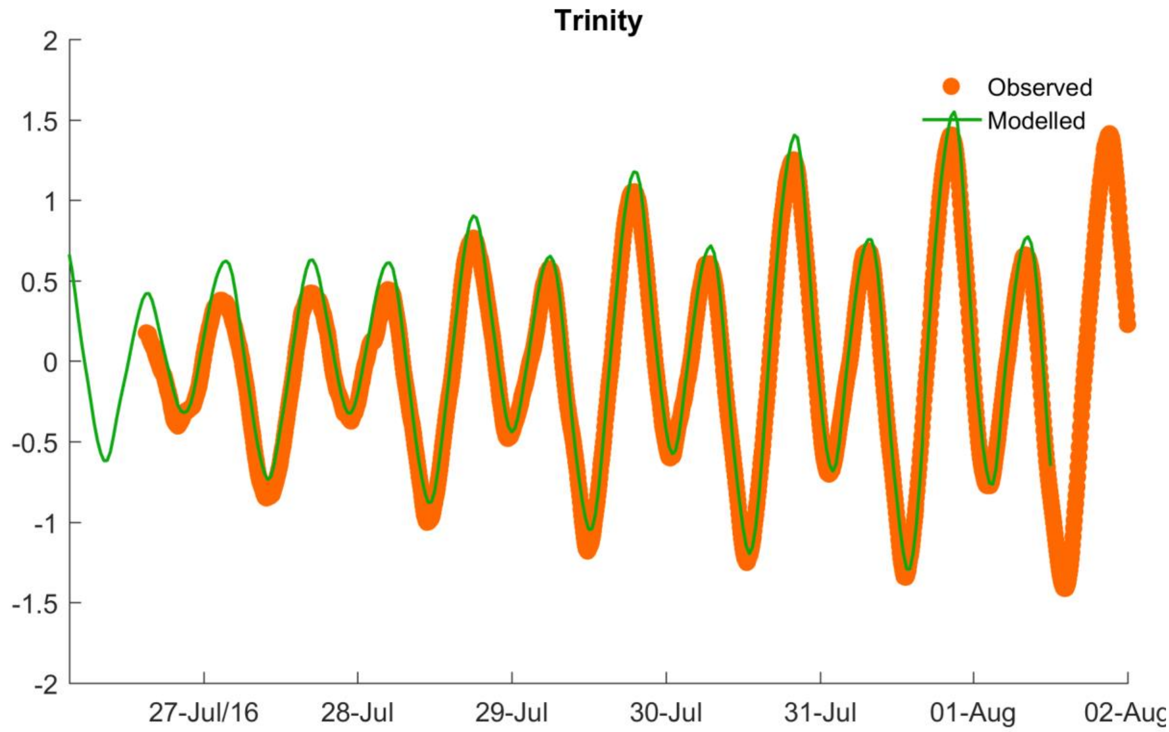


Location 7 Ebb. Turbidity 50%ile (top) and 95%ile (bottom).

Appendix C Water Level Calibration



Barron River Water Level Comparison



Trinity Inlet Water Level Comparison

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