

# 5 Interim Entrance Management Procedure

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## 5.1 Procedure context and objective

Under the NSW Flood Prone Land Policy and Floodplain Development Manual (2005), the management of flood liable land remains the responsibility of local government. The Tuggerah Lakes Floodplain Risk Management Study and Plan (FRMSP) (WMAwater, 2014) provides management recommendations to reduce risk to life, public and private infrastructure associated with flooding. The FRMSP recommended a number of high priority actions to reduce flood risk including adaption planning for foreshore suburbs, flood emergency management planning, public education and awareness, adoption of development controls and formalising an entrance management strategy.

This procedure seeks to provide an evidence-based Interim Entrance Management Procedure for Tuggerah Lakes in accordance with the objectives of the FRMSP and supporting Council's transition to a Coastal Management Program (CMP) under the Coastal Management Act 2016 to see thriving and resilient coastal communities living and working on a healthy coast, now and into the future. The procedure is an interim entrance management procedure until an Entrance Management Strategy is formalised through the CMP process.

The main purpose of an interim entrance management strategy should be to account for critical environmental issues and facilitate an approved opening at short notice under formulated, documented and agreed procedures and criteria (DPI, 2013). The Tuggerah Lakes Interim Entrance Management Procedure provides a rational decision-making framework for Central Coast Council to undertake entrance management works to the entrance throat channel and berm at the Tuggerah Lakes entrance. The procedure is supported by decision support tools that utilising real-time quantitative data to facilitate a rational, proactive and informed approach to management actions.

The primary objective of the interim procedure is to reduce risk to life, public and private infrastructure associated with flooding in accordance with the FRMSP (WMAwater, 2014). Flood level reductions associated with the procedure have been modelled in the development of the procedure and are expected to be small (typically less than 0.2 m, varying depending on antecedent entrance conditions and flood severity), however, are considered beneficial in assisting to reduce flood damages.

It is important to note that flooding in Tuggerah Lakes cannot be eliminated. The impacts of flooding will continue to be experienced even under the implementation of the proposed interim management procedure and will likely worsen with sea level rise. It is important that the community in the Tuggerah Lakes Floodplain understand their level of flood risk as well as adapt and prepare to live with the impacts of flooding. The interim procedure is to be implemented alongside other floodplain risk management controls identified in the FRMSP (WMAwater, 2014) to further reduce flood risk.

The interim procedure does not seek to maintain a permanently open entrance. The entrance channel will naturally constrict with sand particularly during dryer periods with low rainfall while scour to a wider entrance during wetter periods with increased rainfall. The interim procedure recognises this dynamic variability of Tuggerah Lakes entrance and has been developed to provide tailored works for different entrance conditions. These works are to be undertaken

immediately prior to flooding to assist in providing minor flood risk reduction. Outside of flood events the interim procedure seeks to minimise disturbances to the natural hydraulic characteristics of the Tuggerah Lakes entrance.

The interim procedure has been developed based on the review of previous studies, analysis of historical data, modelling assessment and stakeholder consultation undertaken in the present Tuggerah Lakes Entrance Management Study.

## 5.2 Description of procedure

### 5.2.1 Characteristic conditions of Tuggerah Lakes entrance

The condition of the Tuggerah Lakes entrance channel and shoals is dynamic and continuously shaped by catchment and coastal processes including rainfall, ocean waves, and tides. By analysing tidal signals (M2 constituent) in the Lake water levels and investigating historical satellite imagery and surveys, the Tuggerah Lakes Entrance Management Study (MHL, 2022) classified the condition of the Tuggerah Lakes entrance into characteristic states shown in **Table 5.1** and **Figure 5.1**:

- **Wide open entrance:** relatively wide open entrance conditions with scoured shoals and channel typically greater than 90 m wide (at 0 m AHD) with high tidal penetration. These conditions were observed to occur occasionally following heavy rainfall and an elevated lake level typically greater than the moderate flood level classification for Tuggerah Lakes of 1.3 m AHD.
- **Moderately open entrance:** moderately open entrance conditions with a throat channel typically 50 - 90 m in width (at 0 m AHD), associated with moderate tidal penetration and only minor flood tide shoals in the entrance region. This was observed to be a common state of the entrance.
- **Moderately constricted entrance:** moderately constricted entrance conditions with a throat channel typically 20 - 50 m in width (at 0 m AHD), associated with moderately low tidal penetration and developing flood tide shoals. This was observed to be a common state of the entrance.
- **Heavily constricted entrance:** heavily constricted entrance conditions with a throat channel less than 20 m in width (at 0 m AHD), associated with low tidal penetration and dominant flood tide shoals filling the entrance channel. These conditions were observed to occur only occasionally, particularly with prolonged periods of low catchment rainfall.





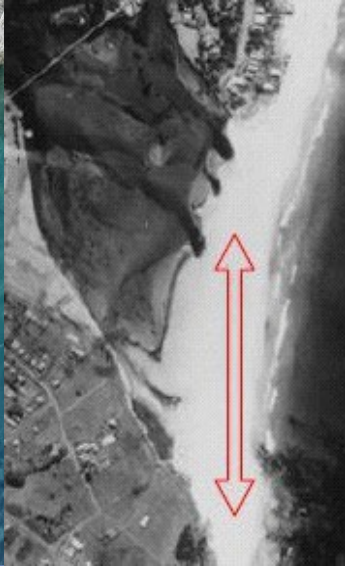
A heavily constricted entrance may remain open to the ocean (with low entrance flows) or, with extended low rainfall, can historically enter a fifth state where the entrance channel fully closes to the ocean described below:

- **Fully closed:** Entrance channel completely closes to the ocean due to the progressive sediment infilling and entrance berm growth by wave activity. No flow exchange occurs between the estuary and the ocean during any tidal stage.

Example satellite images in **Table 5.1** show the entrance in each of the above conditions and historical trends in classification over the last 29 years using tidal harmonic analysis are shown in **Figure 5.1**.

The interim procedure recognises the dynamic variability of the Tuggerah Lakes entrance and has been developed to provide tailored works for each of the different characteristic entrance states described above.

**Table 5.1: Characteristic entrance conditions**

<p>Entrance images from Nearmaps and Umwelt (2011)</p>	 <p>Nov 13 2016</p>	 <p>Apr 29 2017</p>	 <p>Apr 8 2018</p>	 <p>Jul 15 2018</p>	 <p>1941</p>
<p><b>Characteristic Entrance Conditions</b></p>	<p><b>Wide Open Entrance</b></p>	<p><b>Moderately Open Entrance</b></p>	<p><b>Moderately Constricted Entrance</b></p>	<p><b>Heavily Constricted Entrance</b></p>	<p><b>Fully Closed Entrance</b></p>
<p>Frequency of occurrence</p>	<p>Occasional following heavy rainfall</p>	<p>Common state of entrance</p>	<p>Common state of entrance</p>	<p>Occasional with dry periods of low rainfall</p>	<p>Infrequent and associated with extended dry periods of low rainfall</p>
<p>Entrance tidal penetration</p>	<p>High</p>	<p>Moderate</p>	<p>Low</p>	<p>Minimal</p>	<p>No flow exchange between estuary and ocean during any tidal stage</p>
<p>Typical entrance throat channel width at MSL (m)</p>	<p>Greater than 90 m</p>	<p>50-90 m</p>	<p>20-50 m</p>	<p>1-20 m</p>	<p>0 m</p>
<p>Typical M2 at The Entrance Bridge (m)</p>	<p>Greater than 0.03 m</p>	<p>0.015 -0.03 m</p>	<p>0.005 -0.015 m</p>	<p>Less than 0.005 m</p>	<p>Less than 0.005 m</p>

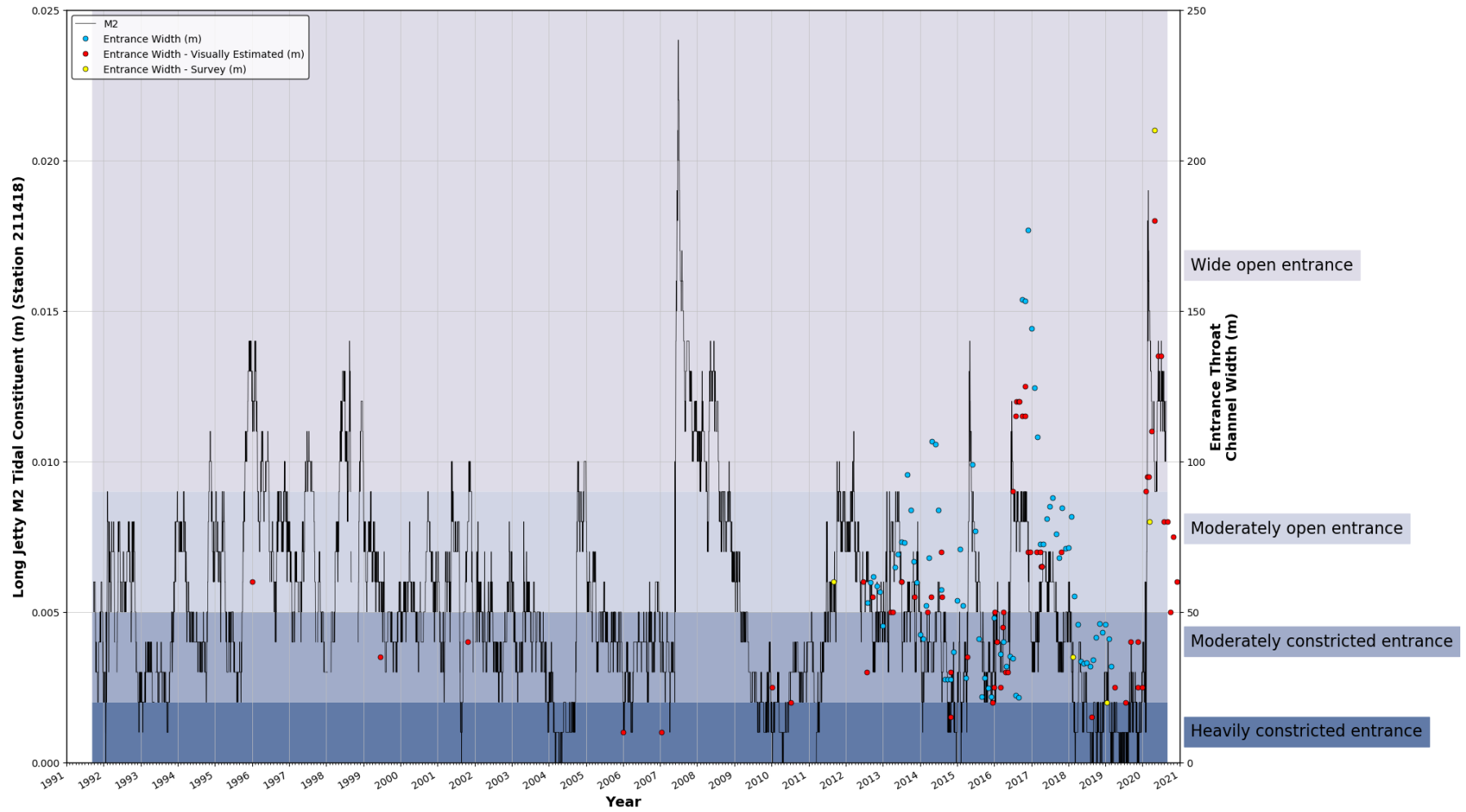


Figure 5.1: Trends in characteristic entrance conditions 1991 - 2020 using tidal harmonics and entrance width

## 5.2.2 Entrance condition monitoring and classification

The dynamic condition of the entrance channel and shoals is an important factor in determining what course of action is taken under the interim procedure. The entrance throat channel and shoal can be classified into five typical states or conditions (Tuggerah Lakes Entrance Management Study, 2022). These include wide open, moderately open, moderately constricted, and heavily constricted entrance conditions as shown in **Table 5.1**.

Under the interim entrance procedure, the condition of the entrance is to be continually monitored through the use of:

- Real-time tidal harmonic analysis of tidal fluctuations in the water level signal at The Entrance Bridge (Station number 561001)

Tidal harmonic analysis provides a useful means of understanding trends and patterns in entrance opening behaviour. It involves quantifying the strength of tidal signal frequencies in a coastal lake or lagoon water level record, to provide an indicator of how open or closed an entrance is to the ocean over time. An increase in the measured M2 constituent indicates an increase in tidal response. On the other hand, a decrease in the M2 constituent indicates reduced tidal response and entrance conditions becoming more constricted to ocean flows.

Entrance condition monitoring under the interim procedure will be supported by real-time harmonic analysis of tidal fluctuations in the water level signal at The Entrance Bridge (Station number 561001). The M2 tidal constituent is to be calculated each day using a moving 28-day analysis window (monthly lunar cycle) to provide ongoing monitoring of monthly trends in entrance conditions. M2 values and entrance behaviour between 1991 - 2020 are shown in **Figure 5.1**.

Preliminary M2 thresholds for entrance condition classification were determined based on the 29-year harmonic analysis of Long Jetty water level records presented in **Section 3.5.2**. Correlation analysis between M2 at Long Jetty and The Entrance Bridge was used to determine the preliminary M2 thresholds, with the M2 signal at The Entrance Bridge proposed to be used for decision-support to inform the interim procedure.

- Width estimates of the entrance throat channel

Estimates of the width of the entrance throat channel at 0 m AHD will be undertaken from satellite imagery and/or site inspections. Preliminary thresholds of entrance throat width (at 0 m AHD) for entrance condition classification were determined based on surveys and visual estimates from historical satellite imagery presented in **Section 3.5.2**. Entrance throat channel width (at 0 m AHD) and entrance behaviour between 1991 - 2020 are shown in **Figure 5.1**.

Preliminary thresholds for entrance condition classification are shown in Flow Chart A (**Figure 5.2**) with the more constricted classification from either M2 or channel width estimates used to indicate prevailing entrance state. It should be noted that M2 is calculated over a 28-day window and provides indication of monthly trends in entrance behaviour and does not capture shorter day-to-day variability. As such these thresholds intend to provide a first-pass proxy of entrance conditions and are to be supplemented by a more detailed site inspection of the entrance condition (including throat and shoal channel locations, berm heights and width,

shorebird nesting locations, condition of access paths to entrance berm etc.) prior to works being undertaken to inform works of onsite specifications. It is recommended that the procedure be supplemented by a periodic entrance survey program (topography and bathymetry) to inform and optimise future entrance management.

Preliminary thresholds for entrance condition classification may be reviewed and refined as required to improve entrance condition classification. Monitoring of entrance conditions under the interim procedure is supported by MHL's established network of gauges throughout the Tuggerah Lakes catchment and live visualisation/decision support via Council's MHL Flood and Coastal Intelligences Tool (MHLFIT) webpage (see **Section 5.3.2**). It is recommended that Council continue to investigate potential new technologies and methods that may improve entrance condition classification as they become available in the future.

Depending on the prevailing condition of the entrance, different entrance management procedures will be undertaken as listed in Flow Chart A (**Figure 5.2**). These management actions are detailed in the following section.

# FLOW CHART A

## Entrance Condition Monitoring

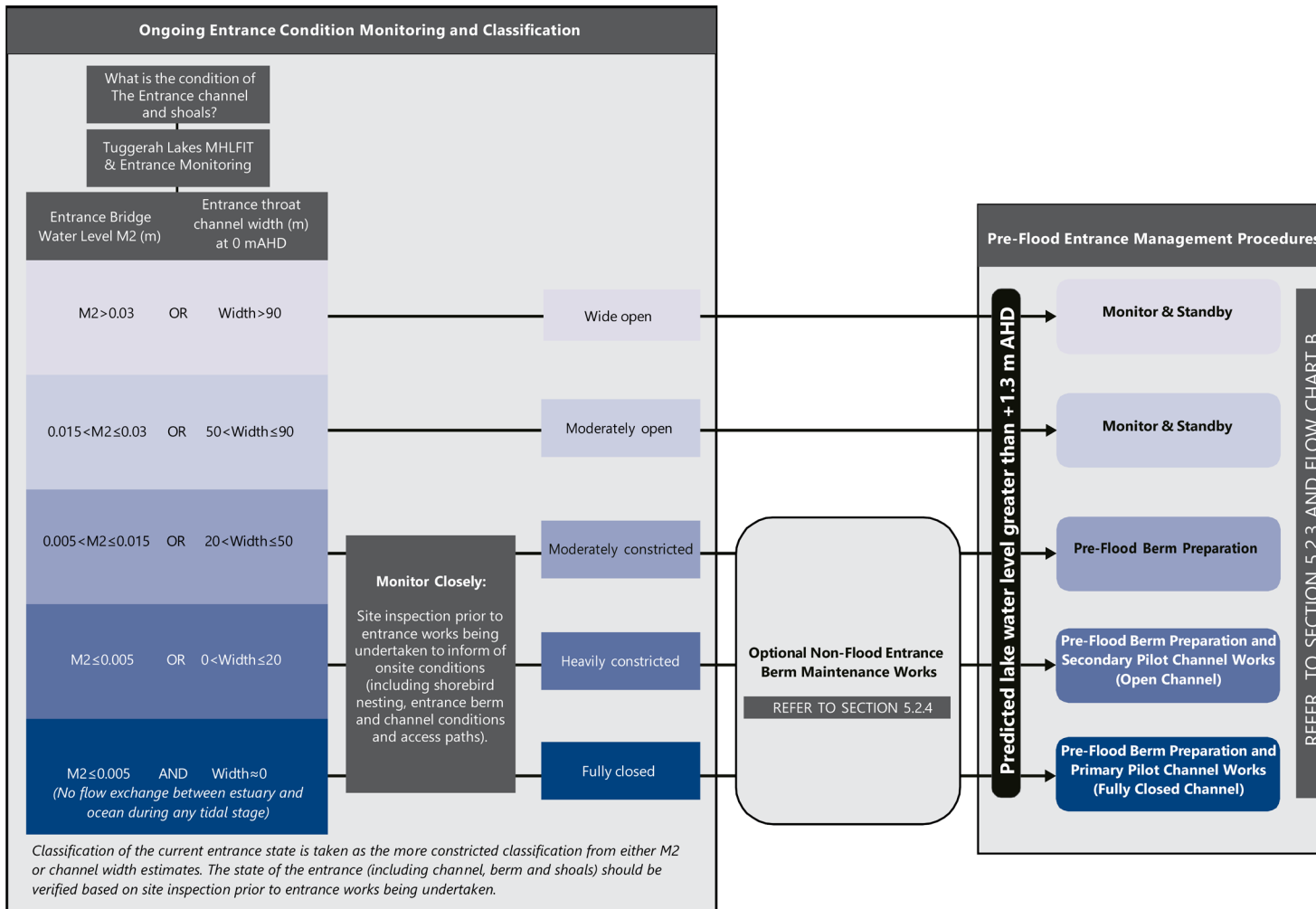


Figure 5.2: FLOW CHART A - Entrance condition monitoring



### 5.2.3 Pre-flood entrance management procedures

An interim entrance management procedure for the indicative time window (approximately 3 - 5 days) prior to a possible flood event is presented in Flow Chart B (**Figure 5.3**). This provides an interim decision-making framework to guide entrance management in the days prior to possible flooding. The following sections detail different aspects Flow Chart B including flood warning, flood predictions, trigger levels and entrance management procedures for different entrance conditions.

Pre-flood entrance management procedures may not proceed should wave and weather conditions be too dangerous to undertake the works, site access to the entrance berm is not possible or there is a high degree of uncertainty for the forecast weather event.

Regular ongoing entrance works to continuously maintain flood-ready conditions were not considered to be feasible given the highly dynamic nature of the entrance including berm rebuilding and channel infilling processes. Optional non-flood entrance berm management works are outlined in **Section 5.2.3.4**.

#### 5.2.3.1 Flood warning

The Bureau of Meteorology (BoM) issue a Flood Watch for Tuggerah Lakes and/or a Severe Weather Warning for very heavy rainfall that may lead to flood flashing in the area. In this event, Council is to continue to monitor BoM rainfall, flood forecasts and warnings, and be aware of measured water levels and rainfall within the catchment via the BoM website and Council's MHLFIT website (relevant BoM web links will be provided via Council's MHLFIT website, see **Section 5.3**).

Flood level prediction tools available via the MHLFIT website will also assist Council in estimating forecasted peak flood levels in Tuggerah Lakes. Decision-support tools include real-time flood modelling utilising the BoM's Australian Digital Forecast Database (ADFD) rainfall predictions, flood extent mapping, inundation hazard, as well as user defined scenario modelling to help inform flood predictions. The MHLFIT tool currently provides a four-day lake level prediction outlook using ADFD catchment rainfall forecasts. Monitoring and real-time decision support for the interim entrance procedure are discussed more in **Section 5.3**.

Upon issue of a severe weather warning and/or flood watch, Council is to:

- confirm and place resources required for entrance works on standby,
- undertake entrance site inspections as required,
- confirm any details of procedures based on the prevailing entrance condition including consultations with relevant authorities and environmental controls related to shorebird breeding (see **Section 5.7**),
- continue to monitor BoM forecasts and warnings
- continue to monitor flood level predictions via the MHLFIT website

It is important to note that MHLFIT lake level predictions have been developed for the purpose of decision support for the Tuggerah Lakes Interim Entrance Management Procedure. MHLFIT lake level predictions do not include prediction of overland catchment flooding, stormwater flow connectivity, hydraulic structures or wind setup. Flood warning information for Tuggerah Lakes should be obtained from the Bureau of Meteorology (BoM).

### **5.2.3.2 Triggers levels**

Estimates of peak flood level predictions for Tuggerah Lakes are to be undertaken and reviewed in the lead up to a flood event, supported by available flood warning information outlined in **Section 5.2.3.1**.

Interim entrance procedures outlined in the following section will be triggered when the forecast flood (using the BoM ADFD forecast for 25% chance of rainfall exceedance) is predicted to peak with a level greater than +1.3 m AHD in Tuggerah Lakes. Should predicted levels be less than +1.3 m AHD, Council will continue to monitor the forecast, flood predictions and measured rainfall and water levels for any changes that may lead to flooding greater than the adopted trigger value. Council may wish to proceed with undertaking the entrance procedures on a precautionary basis in the event where there is a high degree of uncertainty in forecast rainfall and/or peak flood levels.

The predicted peak flood level trigger of +1.3 m AHD has been determined in consultation with Council and relevant stakeholders and is equivalent to the recently reviewed moderate flood level classification for Tuggerah Lakes at Long Jetty. The adopted trigger level is just below a 20% AEP<sup>1</sup> flood level (+1.36 m AHD) for Tuggerah Lakes (Lawson & Treloar Pty. Ltd, 1994).

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<sup>1</sup> Annual Exceedance Probability.

# FLOW CHART B

## Pre-Flood Entrance Management Actions

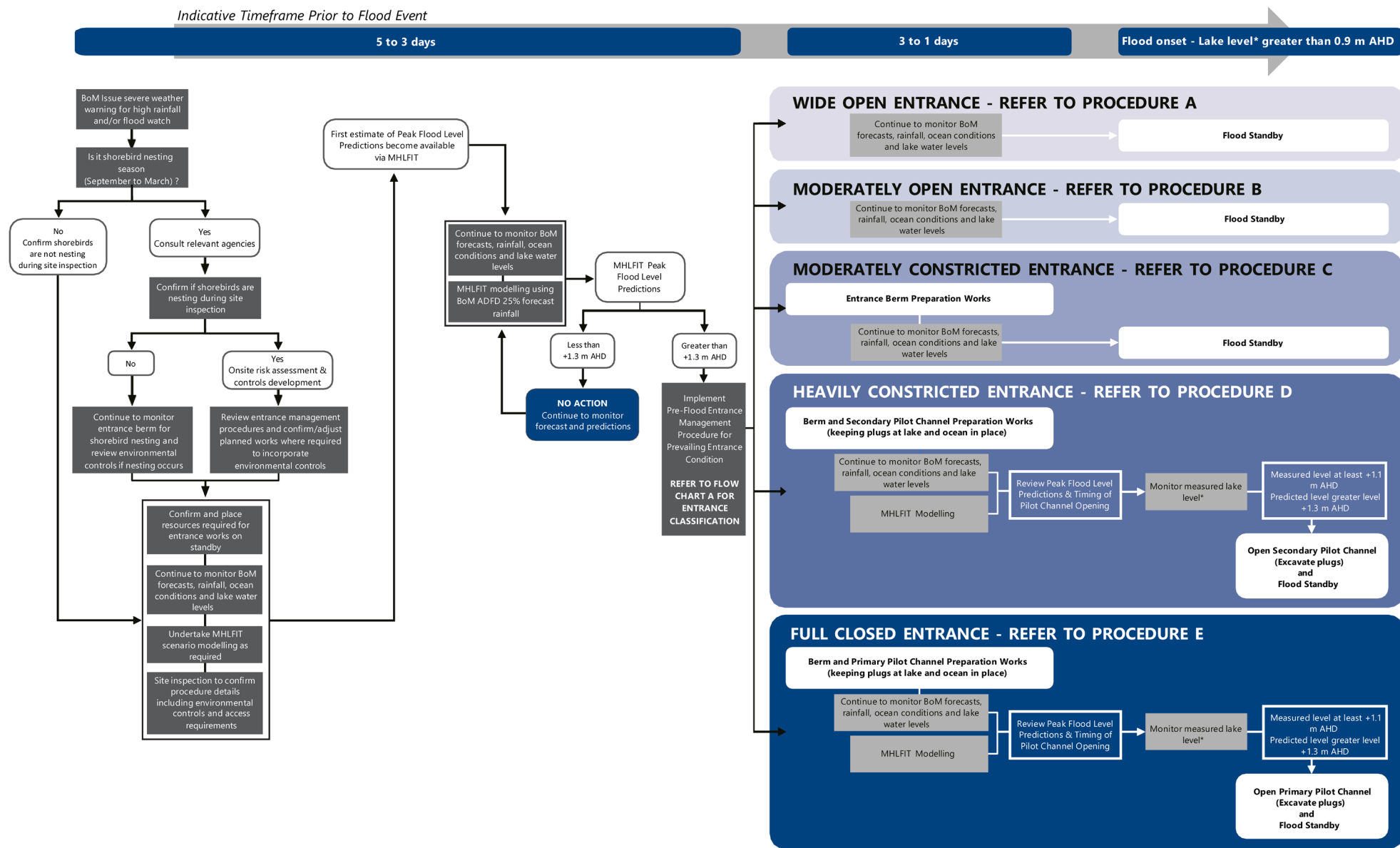


Figure 5.3: FLOW CHART B Pre-flood interim entrance management actions

\* Lake level taken as maximum water level from Long Jetty, Toukley and Wallarah water level gauges

### **5.2.3.3 Entrance management procedures prior to flooding**

Entrance condition monitoring will be undertaken following **Section 5.2.1**. Depending on the prevailing condition of the entrance, different management procedures will be undertaken prior to flooding as outlined below.

#### **Procedure A**

**Entrance condition:** Wide open entrance

**Criteria:**

- 1) The Entrance Bridge M2: Greater than 0.03 m; OR  
Entrance throat channel width at 0 m AHD: Greater than 90 m;

AND

- 2) Predicted peak flood level in Tuggerah Lakes (using the BoM ADFD forecast for 25% chance of rainfall exceedance): Greater than +1.3 m AHD

**Procedure: Monitor and Standby**

- Maintain resources on flood stand-by and monitor entrance throat channel for adverse changes.
- Continue to monitor forecast, flood predictions as well as measured rainfall and water levels.

#### **Procedure B**

**Entrance condition:** Moderately open entrance

**Criteria:**

- 1) The Entrance Bridge M2: 0.015 - 0.03 m; OR  
Entrance throat channel width at 0 m AHD: 50 - 90 m;

AND

- 2) Predicted peak flood level in Tuggerah Lakes (using the BoM ADFD forecast for 25% chance of rainfall exceedance): Greater than +1.3 m AHD

**Procedure: Monitor and Standby**

- Maintain resources on flood stand-by and monitor entrance throat channel for adverse changes.
- Continue to monitor forecast, flood predictions as well as measured rainfall and water levels.

## **Procedure C**

**Entrance condition:** Moderately constricted entrance

### **Criteria:**

- 1) The Entrance Bridge M2: 0.005 - 0.015 m; OR  
Entrance throat channel width at 0 m AHD: 20 - 50 m;

AND

- 2) Predicted peak flood level in Tuggerah Lakes (using the BoM ADFD forecast for 25% chance of rainfall exceedance): Greater than +1.3 m AHD

### **Procedure: Berm Preparation Works**

- Berm preparation works involve the lowering of sand levels by mechanical scraping along the banks immediately adjacent to the existing throat channel opening as illustrated in **Figure 5.4**.
- Berm preparation works should ideally be undertaken around low tide windows within the 1 - 3 days prior to flooding.
- Berm preparation works should be limited to the designated area in the southern region shown in **Figure 5.4**.
- Minimum requirements for berm scraping include:
  - A scraped sand level of +1 to +1.2 m AHD.
  - Cut of 20-30 m wide or more into the berm immediately adjacent to the banks of the existing opening as illustrated in **Figure 5.4**.
  - Edges of the scraped region should be graded to a slope of 1V:3H or flatter for safety.
- Sand won due to works is to be deposited in the northern region in **Figure 5.4** and avoid any impacts on shorebird nesting areas. If time and available plant allow deposition areas may include:
  - North Entrance Beach (prioritising eroded regions) and placed at the toe of the foredune.
  - Accessway from Hutton Rd carpark.
  - Where prior environmental assessment and approvals allow, sand won may also be used to support establishment of shorebird nesting areas.

Otherwise, sand could be deposited on the adjacent berm on the northern side of the works, placed outside the area of impending entrance scour and spread so as to not impede entrance flow.

- Berm works should be avoided during shorebird nesting periods where possible. When this is not possible, exclusion zones and additional controls may be required to minimise impacts. These should be determined via onsite inspections, consultation with qualified professionals and environmental assessments prior to undertaking works outlined in **Section 5.6**.
- Machinery access to the entrance berm is to be undertaken via the designated accessway shown in **Figure 5.4** extending from the Hutton Rd carpark. Council is to regularly maintain access to the entrance berm in this area to support entrance management works. Alternate access may also be possible via the North Entrance Beach accessway on the northern side of the carpark, pending favourable beach and ocean conditions.
- Addition entrance berm management works may be undertaken outside of flooding to support environmental and social outcomes (see **Section 5.2.3.4**).
- Pre and post photographs of works are to be undertaken by Council.
- After completion of works, maintain resources on flood stand-by and monitor entrance throat channel for adverse changes. Continue to monitor forecast, flood predictions as well as measured rainfall and water levels.
- Should time, plant and/or prevailing conditions inhibit berm scraping works to be undertaken effectively, secondary pilot channel excavation may be used as an alternative approach, with works located adjacent to the existing throat channel opening in the southern region of the entrance berm shown in **Figure 5.4**. Secondary pilot channel works should be undertaken in accordance with those detailed in Procedure D.

# Legend

- Site Compound  
Hutton Rd Carpark
- Entrance berm regions
- Machinery Access
- Berm scraping region  
(indicative)

Alternate access via beach pathway (pending beach and ocean conditions)

Site compound - Hutton Rd carpark

Access to entrance berm via Hutton Rd.



Aerial Imagery: Nearmaps 8 April 2018

Access route through berm subject to site inspection and to minimise impact on shorebird nesting sites if present. Access should maintain a single point of entry/egress where possible.

**NORTHERN REGION**  
If time and available plant allow, sand won due to works is to be deposited in this region avoiding any impacts on shorebird nesting areas. Deposition areas may include access route to Hutton Rd carpark and/or North Entrance Beach.

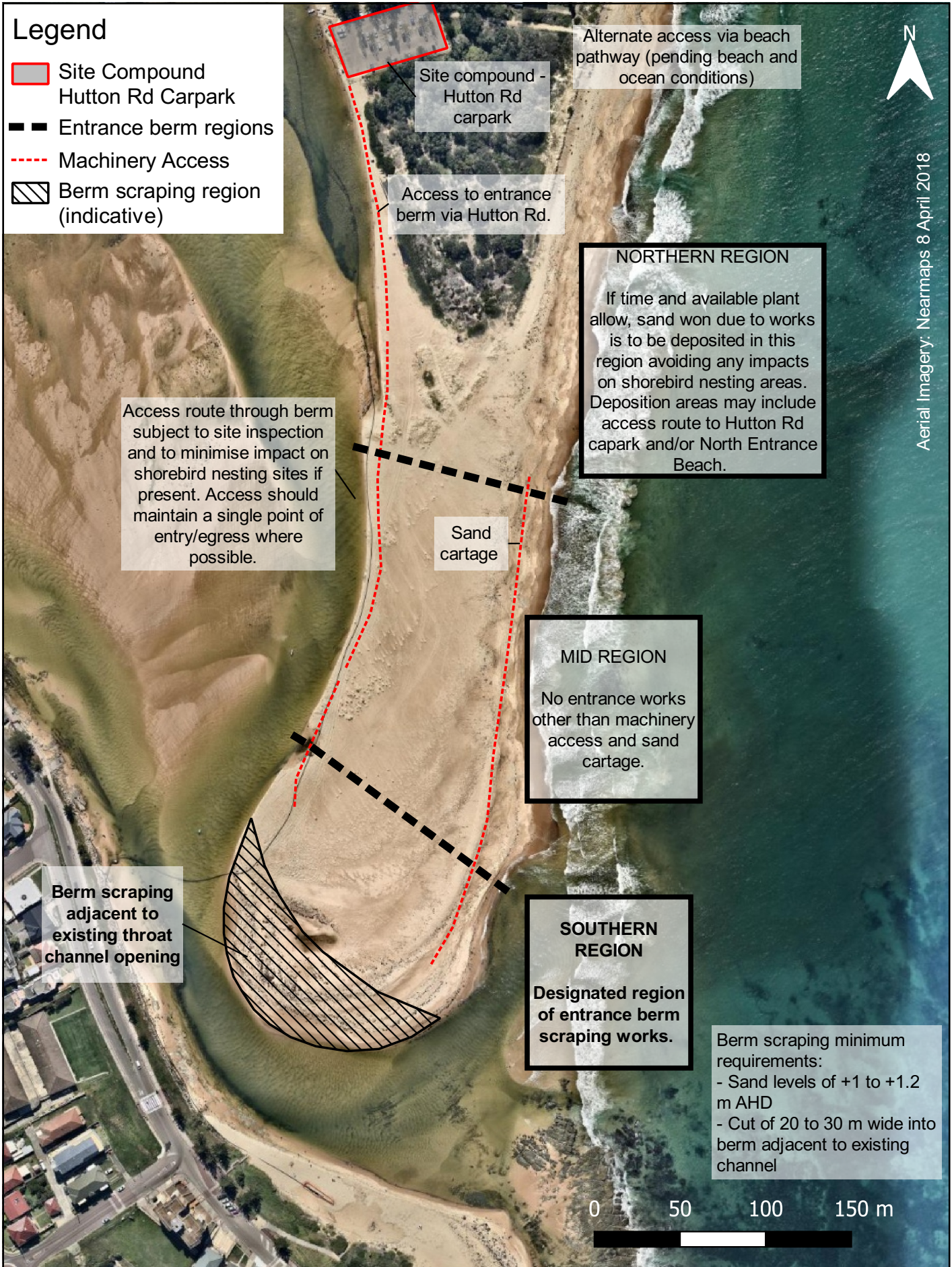
Sand cartage

**MID REGION**  
No entrance works other than machinery access and sand cartage.

Berm scraping adjacent to existing throat channel opening

**SOUTHERN REGION**  
Designated region of entrance berm scraping works.

Berm scraping minimum requirements:  
- Sand levels of +1 to +1.2 m AHD  
- Cut of 20 to 30 m wide into berm adjacent to existing channel



**MODERATELY CONSTRICTED ENTRANCE - PROCEDURE C (INDICATIVE)**

**UNDERTAKEN PRIOR TO PREDICTED FLOODING GREATER THAN +1.3 M AHD IN TUGGERAH LAKES**

**Manly  
Hydraulics  
Laboratory**

Report MHL2811  
Figure 5.4

Report Figure

## Procedure D

**Entrance condition:** Heavily constricted entrance

### **Criteria:**

- 1) The Entrance Bridge M2: Less than 0.005 m; OR  
Entrance throat channel width at 0 m AHD: 1 - 20 m;

AND

- 2) Predicted peak flood level in Tuggerah Lakes (using the BoM ADFD forecast for 25% chance of rainfall exceedance): Greater than +1.3 m AHD

### **Procedure: Berm Preparation and Secondary Pilot Channel Works (Open Channel)**

- Berm works involve the lowering of sand levels by mechanical scraping along the banks immediately adjacent to the existing throat channel opening. This is to be supplemented by the construction of a pilot channel through the berm as a secondary channel adjacent to the existing channel opening. Indicative berm scraping and pilot channel works are outlined in **Figure 5.5**.
- Berm and pilot channel preparation works should be limited to the designated area in the southern region shown in **Figure 5.5**.
- Berm and pilot channel preparation works should ideally be undertaken around low tide windows within the 1 - 3 days with the pilot channel end plugs (lake and ocean) kept in place.
- Minimum requirements for berm scraping include:
  - a scraped sand level of +1 to +1.2 m AHD.
  - Cut of 20 - 30 m wide or more into the berm immediately adjacent to the banks of the existing opening as illustrated in **Figure 5.5**.
- The pilot channel location/orientation within the designated area of the southern region (**Figure 5.5**) is to be determined via site inspection prior to works being undertaken. The pilot channel location should aim to maximise flow conveyance between entrance shoal channels and ocean.
- Optional pilot channel works may consider excavation of a narrow channel at low-tide through shoaled areas as in **Figure 5.5** to improve flow connectivity to the pilot channel. Requirements for low-tide shoal channel excavation is subject onsite inspection prior to works.
- Minimum requirements for pilot channel excavation include:
  - Excavation of a pilot channel with a bed channel width of 5-10 m and bed level at +0.5 to +0.7 m AHD.
  - Sand plugs (crest at least +2.5 m AHD, with higher crest during elevated ocean conditions) are to remain in place at lake and ocean ends during and after excavation to minimise sand ingress prior to opening (see below regarding timing of opening) as shown in **Figure 5.5**.



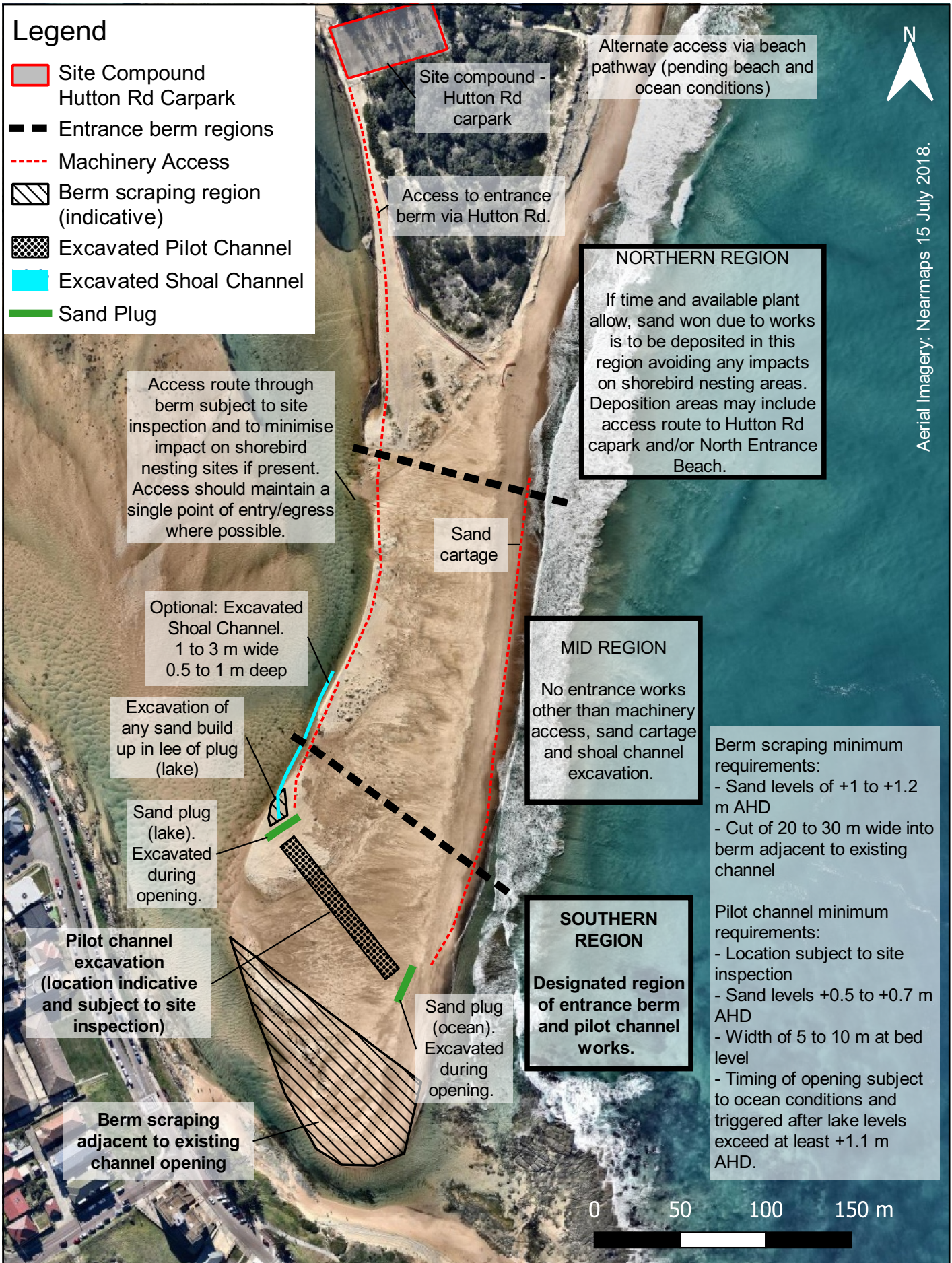
- Opening of the pilot channel is to be undertaken after measured lake levels are at least +1.1 m AHD. Depending on the coastal conditions a successful pilot channel opening may need to wait for the lake level to be above the predicted high tide level to account for wave run up and tidal anomaly from storm surge, otherwise, the pilot channel is likely to close on the incoming high tide. Council is to utilise the MHLFIT decision support tool to inform favourable timing for opening of the pilot channel after this trigger has been met. MHLFIT decision support for pilot channel opening is described in **Section 5.3** and factors both lake, ocean and berm conditions on opening hydraulic efficiency. Measured lake level for determining pilot channel opening is to be taken as the maximum water level recorded from Long Jetty (211418), Toukley (211401) and Wallarah (211420) gauges.
- Opening of the pilot channel is to be undertaken via mechanical excavation of sand plugs.
- Sand won due to works is to be deposited in the northern region in **Figure 5.5** and avoid any impacts on shorebird nesting areas. If time and available plant allow deposition areas may include:
  - North Entrance Beach (prioritising eroded regions) and placed at the toe of the foredune.
  - Accessway from Hutton Rd carpark.
  - Where prior environmental assessment and approvals allow, sand won may also be used to support the establishment of shorebird nesting areas.

Otherwise, sand could be deposited on the adjacent berm on the northern side of the works, placed outside the area of impending entrance scour and spread so as to not impede entrance flow.

- Berm and pilot channel preparation works should be avoided during shorebird nesting periods where possible. When this is not possible, exclusion zones and additional controls may be required to minimise impacts. These should be determined via onsite inspections, consultation with qualified professionals and environmental assessments prior to undertaking works outlined in **Section 5.6**.
- Machinery access to the entrance berm is to be undertaken via the designated accessway shown in **Figure 5.5** extending from the Hutton Rd carpark. Council is to regularly maintain access to the entrance berm in this area to support entrance management works. Alternate access may also be possible via the North Entrance Beach accessway on the northern side of the carpark, pending favourable beach and ocean conditions.
- Addition entrance berm management works may be undertaken outside of flooding to support environmental and social outcomes (see **Section 5.2.3.4**)
- Pre and post photographs of works are to be undertaken by Council.
- After completion of works, maintain resources on flood stand-by and monitor entrance throat channel for adverse changes. Continue to monitor forecast, flood predictions as well as measured rainfall and water levels.

# Legend

- Site Compound  
Hutton Rd Carpark
- Entrance berm regions
- Machinery Access
- Berm scraping region (indicative)
- Excavated Pilot Channel
- Excavated Shoal Channel
- Sand Plug



Alternate access via beach pathway (pending beach and ocean conditions)

Site compound - Hutton Rd carpark

Access to entrance berm via Hutton Rd.

**NORTHERN REGION**  
If time and available plant allow, sand won due to works is to be deposited in this region avoiding any impacts on shorebird nesting areas. Deposition areas may include access route to Hutton Rd carpark and/or North Entrance Beach.

Access route through berm subject to site inspection and to minimise impact on shorebird nesting sites if present. Access should maintain a single point of entry/egress where possible.

Sand cartage

Optional: Excavated Shoal Channel. 1 to 3 m wide 0.5 to 1 m deep

**MID REGION**  
No entrance works other than machinery access, sand cartage and shoal channel excavation.

Excavation of any sand build up in lee of plug (lake)

Berm scraping minimum requirements:  
- Sand levels of +1 to +1.2 m AHD  
- Cut of 20 to 30 m wide into berm adjacent to existing channel

Sand plug (lake). Excavated during opening.

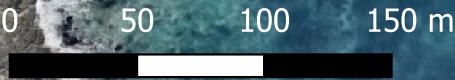
**SOUTHERN REGION**  
Designated region of entrance berm and pilot channel works.

Pilot channel minimum requirements:  
- Location subject to site inspection  
- Sand levels +0.5 to +0.7 m AHD  
- Width of 5 to 10 m at bed level  
- Timing of opening subject to ocean conditions and triggered after lake levels exceed at least +1.1 m AHD.

Pilot channel excavation (location indicative and subject to site inspection)

Sand plug (ocean). Excavated during opening.

Berm scraping adjacent to existing channel opening



Aerial Imagery: Nearmaps 15 July 2018.



## HEAVILY CONSTRICTED ENTRANCE - PROCEDURE D (INDICATIVE)

UNDERTAKEN PRIOR TO PREDICTED FLOODING GREATER THAN +1.3 M AHD IN TUGGERAH LAKES

**Manly Hydraulics Laboratory**

Report MHL2811  
Figure 5.5

Report Figure

## **Procedure E**

**Entrance condition:** Fully closed entrance

- 1) The Entrance Bridge M2: Less than 0.005 m; AND  
Entrance throat channel width at 0 m AHD: Approx. 0 m;

AND

- 2) Predicted peak flood level in Tuggerah Lakes (using the BoM ADFD forecast for 25% chance of rainfall exceedance): Greater than +1.3 m AHD

### **Procedure: Berm Preparation and Primary Pilot Channel Works (Fully Closed Channel)**

- Undertake berm and pilot channel preparation works as outlined in **Figure 5.6**. This involves lowering of sand levels by mechanical scraping construction of a pilot channel through the berm located fronting the closed main channel.
- Berm and pilot channel preparation works should be limited to the designated area in the southern region shown in **Figure 5.6**.
- Berm and pilot channel preparation works should ideally be undertaken around low tide windows within the 1-3 days with the pilot channel end plugs (lake and ocean) kept in place.
- Berm scraping should aim to achieve:
  - a sand level of +1 to +1.2 m AHD or lower if practicable.
  - a minimum 20-30 m wide or more cut into the berm adjacent to the pilot channel (**Figure 5.6**).
- The pilot channel location/orientation within the designated area (**Figure 5.6**) is to be determined via site inspection prior to works being undertaken should aim to maximise flow conveyance between entrance shoal channels and ocean.
- Minimum requirements for pilot channel excavation include:
  - Excavation of a pilot channel with a bed channel width of 5-10 m and bed level at +0.5 to +0.7 m AHD or lower if practicable.
  - Sand plugs (crest at least +1.5 m AHD depending on ocean conditions) are to remain in place at lake and ocean ends during and after excavation to minimise sand ingress prior to opening (see below regarding timing of opening).
- Opening of the pilot channel is to be undertaken after measured lake levels are at least +1.1 m AHD. Depending on the coastal conditions a successful pilot channel opening may need to wait for the lake level to be above the predicted high tide level to account for wave run up and tidal anomaly from storm surge, otherwise, the pilot channel is likely to close on the incoming high tide. Council is to utilise the MHLFIT decision support tool to inform favourable timing for opening of the pilot channel after this trigger has been met. MHLFIT decision support for pilot channel opening is described in **Section 5.3** and factors both lake, ocean and berm conditions on opening hydraulic efficiency. Measured lake level for determining pilot channel opening is to be taken as









the maximum water level recorded from Long Jetty (211418), Toukley (211401) and Wallarah (211420) gauges.

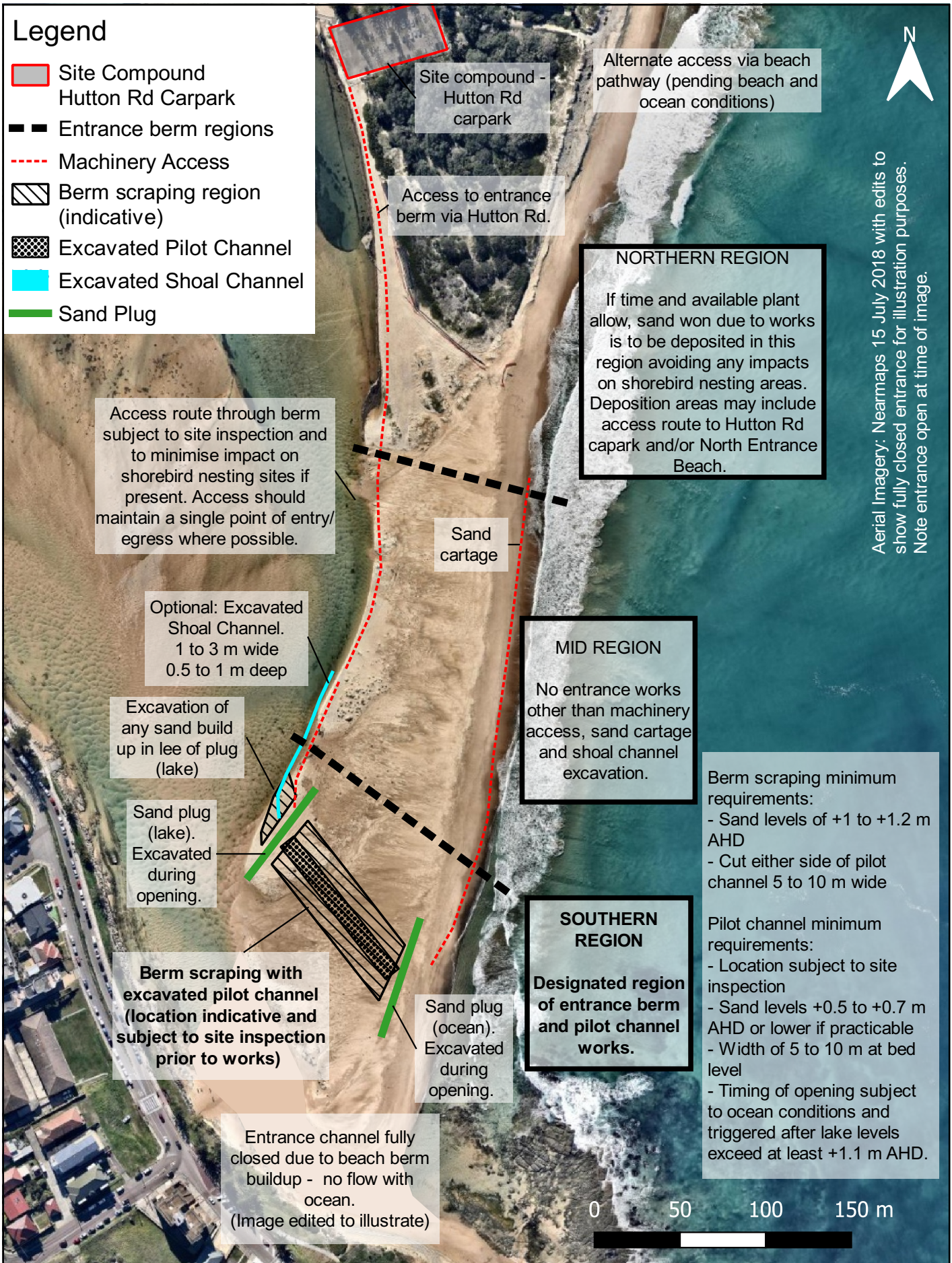
- Opening of the pilot channel is to be undertaken via mechanical excavation of sand plugs.
- Sand won due to works is to be deposited in the northern region in **Figure 5.6** and avoid any impacts on shorebird nesting areas. If time and available plant allow deposition areas may include:
  - North Entrance Beach (prioritising eroded regions) and placed at the toe of the foredune.
  - Accessway from Hutton Rd carpark.
  - Where prior environmental assessment and approvals allow, sand won may also be used to support the establishment of shorebird nesting areas.

Otherwise, sand could be deposited on the adjacent berm on the northern side of the works, placed outside the area of impending entrance scour and spread so as to not impede entrance flow.

- Berm and pilot channel preparation works should be avoided during shorebird nesting periods where possible. When this is not possible, exclusion zones and additional controls may be required to minimise impacts. These should be determined via onsite inspections, consultation with qualified professionals and environmental assessments prior to undertaking works outlined in **Section 5.6**.
- Machinery access to the entrance berm is to be undertaken via the designated accessway shown in **Figure 5.6** extending from the Hutton Rd carpark. Council is to regularly maintain access to the entrance berm in this area to support entrance management works. Alternate access may also be possible via the North Entrance Beach accessway on the northern side of the carpark, pending favourable beach and ocean conditions.
- Addition entrance berm management works may be undertaken outside of flooding to support environmental and social outcomes (see **Section 5.2.3.4**)
- Pre and post photographs of works are to be undertaken by Council.
- After completion of works, maintain resources on flood stand-by and monitor entrance throat channel for adverse changes. Continue to monitor forecast, flood predictions as well as measured rainfall and water levels.

# Legend

-  Site Compound
-  Hutton Rd Carpark
-  Entrance berm regions
-  Machinery Access
-  Berm scraping region (indicative)
-  Excavated Pilot Channel
-  Excavated Shoal Channel
-  Sand Plug



Aerial Imagery: Nearmaps 15 July 2018 with edits to show fully closed entrance for illustration purposes. Note entrance open at time of image.



FULLY CLOSED ENTRANCE - PROCEDURE E (INDICATIVE)  
UNDERTAKEN PRIOR TO PREDICTED FLOODING GREATER THAN +1.3 M AHD IN TUGGERAH LAKES

**Manly  
Hydraulics  
Laboratory**

Report MHL2811  
Figure  
5.6

Report Figure

#### **5.2.3.4 Designated area of entrance works**

The designated area for entrance berm scraping and pilot channel works (Procedure C, D and E) is illustrated in **Figure 5.4 - Figure 5.6** and is located in the southern region of the entrance berm. This region promotes a typical entrance channel configuration with the opening against the southern shore and a characteristic entrance berm that increases in height from south to north. The designated area is prone to scour during flooding as the entrance channel widens naturally and is typically outside shorebird nesting areas (to be confirmed via site inspection, consultation with qualified professionals and environmental assessments prior to works).

Entrance berm scraping and pilot channel works are not to be undertaken in the mid to northern regions of the entrance berm in order to minimise potential impacts on shorebird nesting areas and coastal processes at the North Entrance Beach.

#### **5.2.3.5 Wave and coastal effects**

Flood events may coincide with elevated ocean water levels with high wave activity and large tides. During high energy ocean conditions, entrance works may not proceed because it is deemed unsafe. In the case that works can proceed safely, entrance works during high wave activity are to consider where appropriate:

- Undertaking works around low tide
- Avoid driving machinery in the regions of wave runup on the ocean side of the berm.
- Maintain (or form) an elevated sand bund on the ocean side of berm scraping works (Procedure C, D and E) to reduce wave overwash and sand ingress while entrance works are being undertaken. Once works are completed the sand bund may be removed via excavation.
- Increasing sand plug crest heights on pilot channels as required (Procedure D and E) to reduce berm overwash and sand ingress during works and prior to opening.

Effects of ocean conditions including tides, tidal anomalies and wave setup on predicted flooding are factored into the MHLFIT lake level predictions. Opening of the pilot channel is to be undertaken after measured lake levels are at least +1.1 m AHD. Depending on the coastal conditions a successful pilot channel opening may need to wait for the lake level to be above the predicted high tide level to account for wave run up and tidal anomaly from storm surge, otherwise, the pilot channel is likely to infill on the incoming high tide. Council is to utilise the MHLFIT decision support tool to inform favourable timing for opening of the pilot channel after this trigger has been met.

#### **5.2.4 Optional non-flood entrance berm management works**

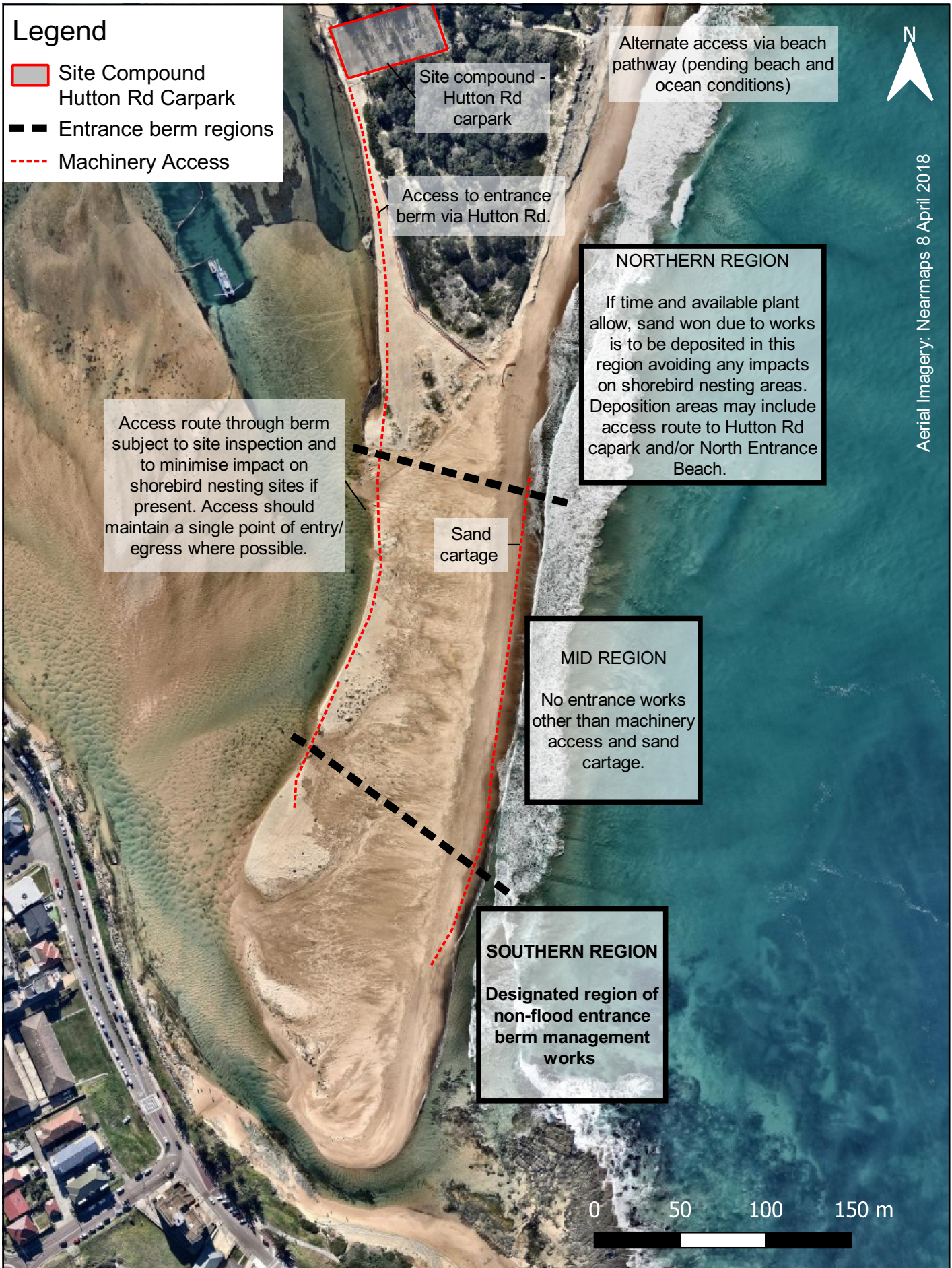
Should the entrance enter a moderately constricted, heavily constricted or full closed state, Council may wish to undertake entrance berm management works as required to support entrance social and environmental outcomes. Entrance berm management works are to be undertaken in the designated region shown in **Figure 5.7**. Entrance berm management works may include but are not limited to:

- Entrance berm scraping works to widen the existing entrance throat channel guided by pre-flood procedures for a moderately constricted entrance outlined in **Section 5.2.3.3** (excluding criteria for predicted flood trigger level).
- Entrance berm scraping works to promote a typical entrance channel configuration with the opening against the southern shore and a sand spit berm height that increases from south to north, helping to prevent wave overwash and entrance breakout across the mid and northern sections.
- Entrance berm scraping works to source sand to enhance and support favourable shorebird nesting conditions where prior environmental assessment and approvals allow.
- Entrance berm scraping works to source sand to maintain access path at Hutton Rd carpark and/or nourish North Entrance Beach.
- Pilot channel preparation works if the entrance is in a heavily constricted or fully closed state. These are to be guided by pre-flood procedures for a heavily constricted or fully closed entrances outlined in **Section 5.2.3.3**.
- Other requirements for non-flood entrance works were identified as part of the review and update of this procedure.

Non-flood works are required to be undertaken in accordance with relevant policies.

# Legend

- Site Compound  
Hutton Rd Carpark
- Entrance berm regions
- Machinery Access



Alternate access via beach pathway (pending beach and ocean conditions)

Site compound - Hutton Rd carpark

Access to entrance berm via Hutton Rd.

Access route through berm subject to site inspection and to minimise impact on shorebird nesting sites if present. Access should maintain a single point of entry/egress where possible.

**NORTHERN REGION**  
If time and available plant allow, sand won due to works is to be deposited in this region avoiding any impacts on shorebird nesting areas. Deposition areas may include access route to Hutton Rd carpark and/or North Entrance Beach.

Sand cartage

**MID REGION**  
No entrance works other than machinery access and sand cartage.

**SOUTHERN REGION**  
Designated region of non-flood entrance berm management works

0 50 100 150 m

Aerial Imagery: Nearmaps 8 April 2018



## DESIGNATED REGION FOR OPTIONAL NON-FLOOD ENTRANCE BERM MANAGEMENT WORKS

**Manly Hydraulics Laboratory**

Report MHL2811  
Figure 5.7

Report Figure



## 5.3 Monitoring and real-time decision support

### 5.3.1 Rainfall and water level monitoring

The interim entrance management procedure is informed and supported by Central Coast Council's monitoring network which currently includes 12 rainfall stations and 10 water level stations located within the Tuggerah Lakes catchment shown in Figure 3.3 (owned by the NSW Department of Planning and Environment Biodiversity and Conservation Division and Central Coast Council). The network is maintained routinely by Manly Hydraulics Laboratory (MHL) to meet or exceed a target of 95% data capture.

Rainfall stations provide continuous (event-based) sampling with data recorded after every 0.5 mm tip of rainfall with an accuracy of  $\pm 3\%$ . Data is transferred to MHL via Internet Protocol typically within 5 minutes of each 0.5 mm of rainfall. Water level data is sampled typically every 15 minutes with an accuracy of  $\pm 20$  mm and transferred via Internet Protocol. Water level stations are located at key catchment locations for flood warning including monitoring of Tuggerah Lakes waterbodies and tributaries. These provide near real-time warning of flood levels when pre-determined thresholds are exceeded. Rainfall and water level stations have automated alarm messaging capabilities should this be required to support entrance management procedures.

The monitoring is supported by MHL's cloud-based database storage which boasts near real-time environmental data retrieval for over 1000 sites across the state sourced from the Bureau of Meteorology (BoM), Water NSW, as well as MHL's own sites. This database also supports the NSW Floods Near Me app developed by MHL. Rainfall and water level data is also transferred and maintained to the Bureau of Meteorology (BoM) to assist in the delivery of NSW non-flash flood riverine forecasting and warning services.

Water level, rainfall and ocean tide monitoring data can be visualised in real-time via Central Coast Councils MHLFIT web portal described in the following section.

### 5.3.2 MHLFIT decision support

The Central Coast MHL Flood and Coastal Intelligence Tools (MHLFIT) provide important real-time decision support to help inform and support the interim entrance management procedure (see **Figure 5.8**). At present, the MHLFIT system includes the following components to inform entrance management:

- Realtime visualisation of water level and rainfall monitoring data throughout the Tuggerah Lakes Catchment (**Figure 5.9**)
- Realtime M2 tidal harmonic analysis at The Entrance Bridge water level gauge (Station number 561001) to provide an indication of prevalent trends in entrance condition (**Figure 5.10**).
- Realtime hydrologic, hydraulic and entrance modelling incorporating forecast tides and BoM forecast rainfall (from the Australian Digital Forecast Database - ADFD), to provide advanced flood warning and decision support (**Figure 5.11**).
- Flood level extent visualisation (**Figure 5.12**).

- On-demand user-defined what-if scenario modelling to inform flood level predictions (Figure 5.13).

This information is used to provide decision support for Council and emergency services as to the predicted level of flooding that may be experienced.

The accuracy of the MHLFIT flood predictions is subject to rainfall forecast variability, entrance, ocean and catchment conditions. Due to the uncertainty inherent in water level predictions of this nature, real-time water level predictions are run for different rainfall forecast scenarios and supplemented sensitivity testing using what-if scenarios and on-demand lake level predictions.

Council may wish to pursue further additions to the Central Coast MHLFIT decision support tool should these be required to inform entrance management. These may include remote entrance channel and berm monitoring techniques supported by satellite/aerial imagery, drone surveying or lidar applications.

It is important to note that MHLFIT lake level predictions have been developed for the purpose of decision support for the Tuggerah Lakes Interim Entrance Management Procedure. MHLFIT lake level predictions do not include prediction of overland catchment flooding, stormwater flow connectivity, hydraulic structures or wind setup. Flood warning information for Tuggerah Lakes should be obtained from the Bureau of Meteorology (BoM).

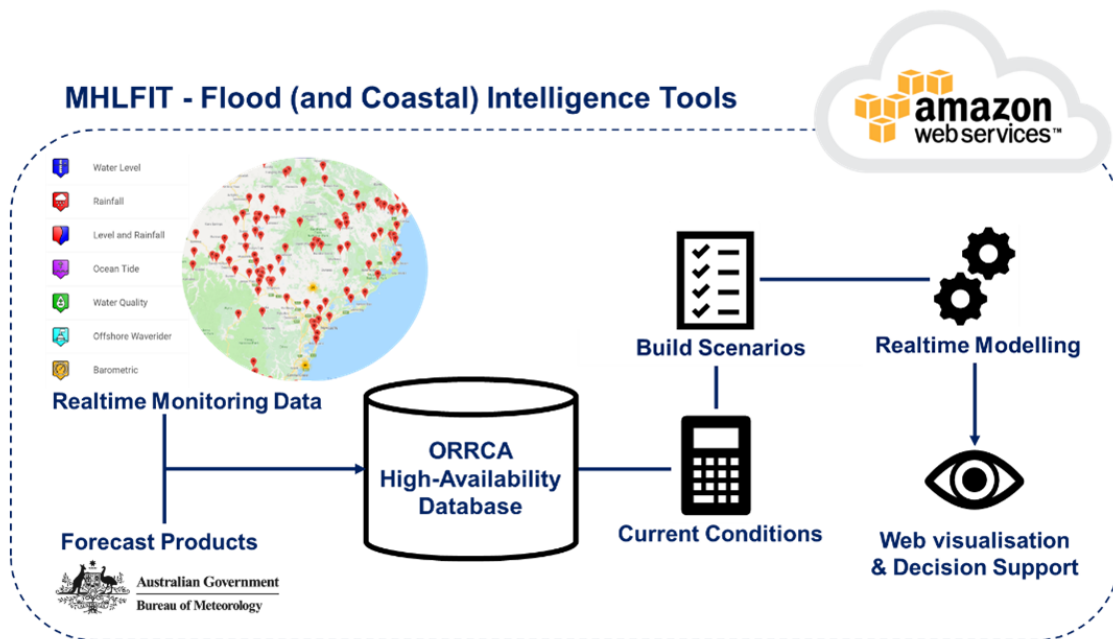
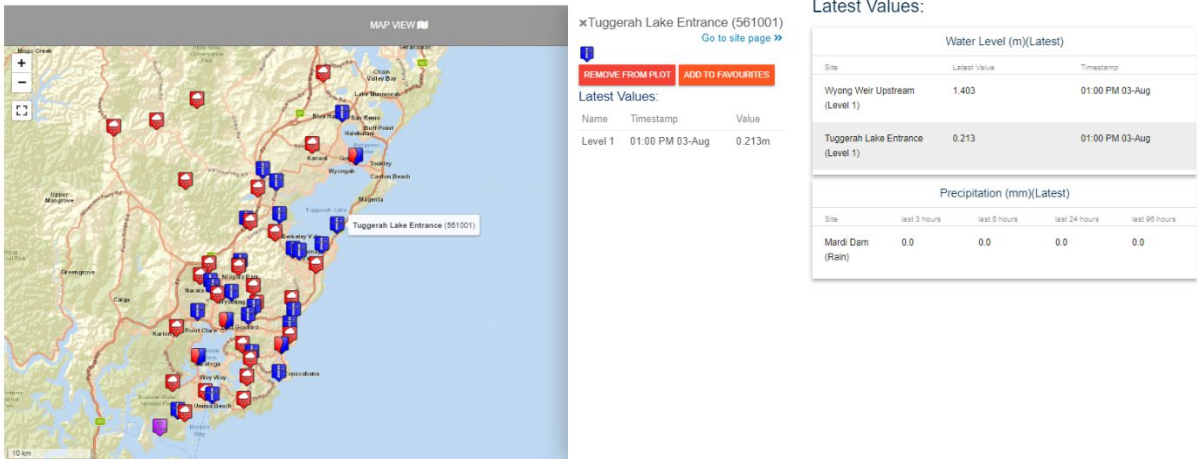
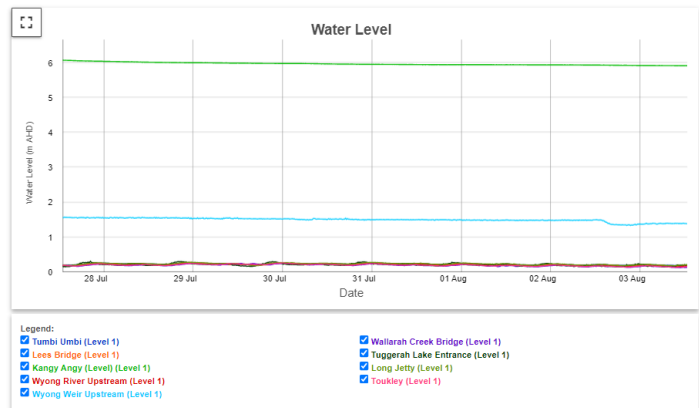


Figure 5.8: Framework for MHLFIT - MHL Flood (and Coastal) Intelligence Tools



#### Latest Water Levels

Water Level (m)(Latest)		
Site	Latest Value	Timestamp
Wyong Weir Upstream (Level 1)	1.390	12:45PM 03/08/2022
Lees Bridge (Level 1)	0.183	12:45PM 03/08/2022
Toukley (Level 1)	0.166	12:45PM 03/08/2022
Long Jetty (Level 1)	0.220	12:45PM 03/08/2022
Tumbi Umbi (Level 1)	0.215	12:45PM 03/08/2022
Wallarah Creek Bridge (Level 1)	0.140	12:45PM 03/08/2022
Tuggerah Lake Entrance (Level 1)	0.217	12:45PM 03/08/2022
Kangy Angy (Level) (Level 1)	5.918	12:45PM 03/08/2022
Wyong River Upstream (Level 1)	0.170	12:45PM 03/08/2022



#### Latest Catchment Rainfall

Precipitation (mm)(Latest)				
Site	last 3 hours	last 6 hours	last 24 hours	last 96 hours
Whitemans Ridge (Rain)	0.0	0.0	0.0	0.0
Yarramalong (Rain)	0.0	0.0	0.0	0.5
Toukley (Rain)	0.0	0.0	0.0	0.0
Berkeley Vale (Rain)	0.0	0.0	0.0	0.0
Hamlyn Terrace (Rain)	0.0	0.0	0.0	0.0
Wyee (Rain)	0.0	0.0	0.0	0.0
Mardi Dam (Rain)	0.0	0.0	0.0	0.0
Kulnura (Rain)	0.0	0.0	0.0	0.0
Bateau Bay (Rain)	0.0	0.0	0.0	0.0
Kangy Angy (Rain)	0.0	0.0	0.0	0.0

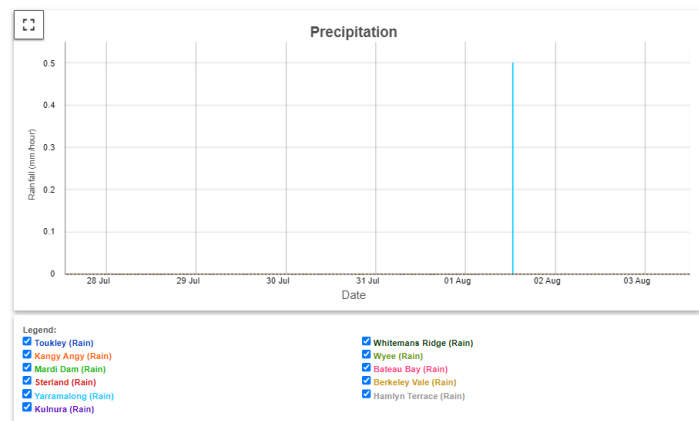


Figure 5.9: Example Tuggerah Lakes MHLFIT realtime monitoring data visualisation

Latest Entrance Conditions

Current State:

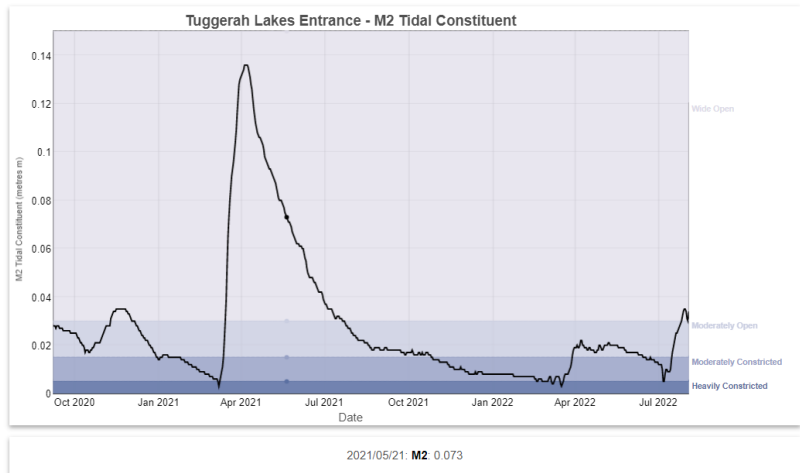
- WO Wide Open
- MO Moderately Open
- MC Moderately Constricted
- HC Heavily Constricted
- FC Fully Closed
- NS Not Specified

\*Note: Classification of the current entrance state is taken as the most constricted classification from either M2 or channel width estimates. The state of the entrance (including channel, berm and shoals) should be verified based on site inspection prior to entrance works being undertaken.

Entrance Parameter	Value	Latest Data
M2 Tidal Constituent at The Entrance Bridge (Station No. 561001)	0.034 m	Average of last 7 days to 03 Aug 2022
Entrance Throat Channel Width (Visually Estimated at 0 mAHD)	70 m	07 Jul 2022

\*Note: M2 is calculated over a 28-day window and provides indication of monthly trends in entrance behaviour. The value does not capture shorter day-to-day variability and may be subject to noise during flooding events.

UPDATE ENTRANCE CHANNEL WIDTH

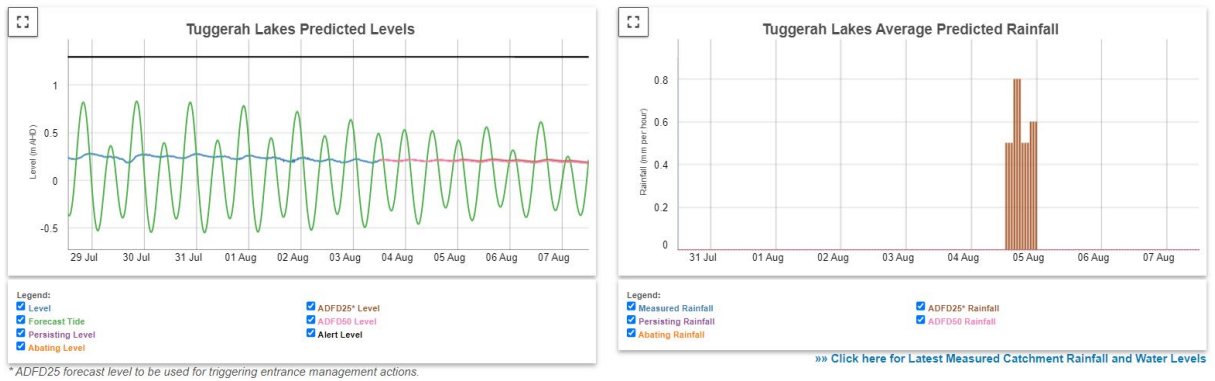


»» Latest Entrance Images

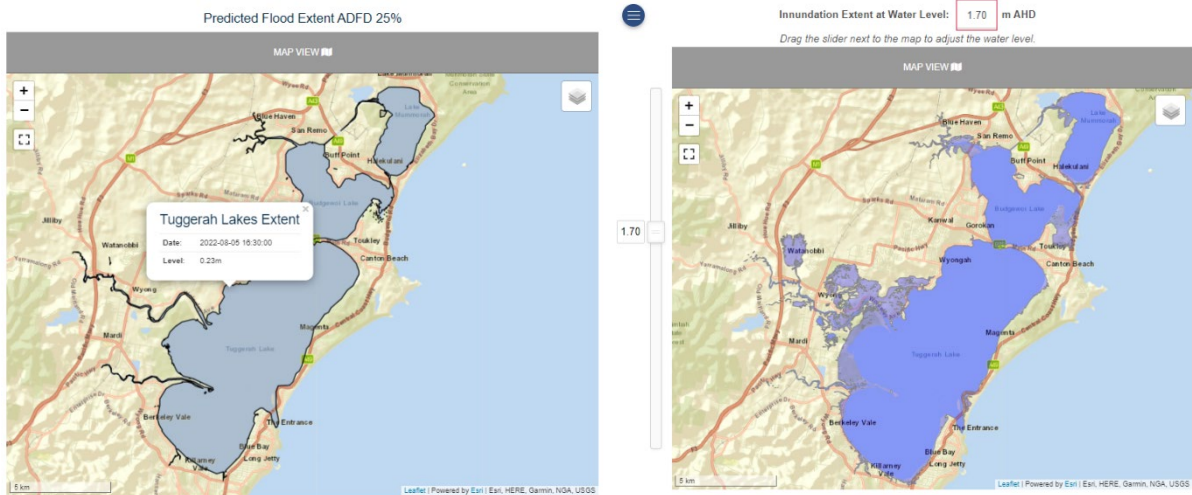
»» Latest Nearmap Images

»» Latest Satellite Images (Planet Explorer)

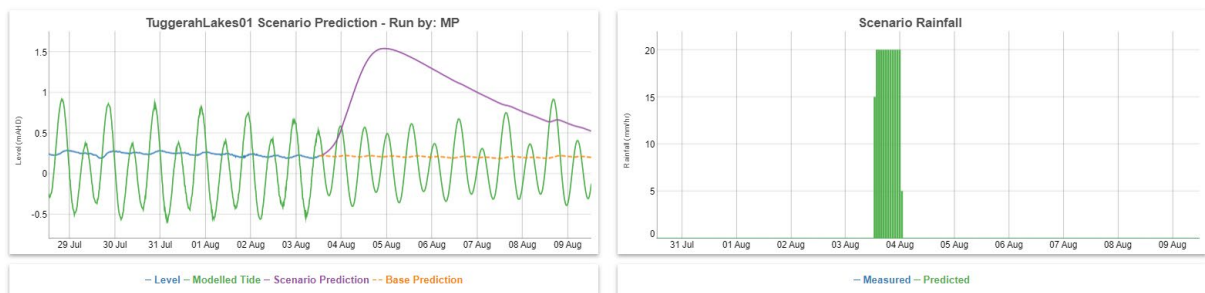
**Figure 5.10: Example Tuggerah Lakes MHLFIT realtime analysis and decision support**



**Figure 5.11: Example Tuggerah Lakes MHLFIT realtime lake level predictions**



**Figure 5.12: Example Tuggerah Lakes MHLFIT inundation extent mapping**



Current Scenario for TuggerahLakes01:

Tidal Anomaly	Not set in current scenario
Starting entrance channel width (at 0 m AHD)	60 m
Rainfall 1 - Intensity	20 mm/hr for 12 hours
Rainfall 2 -	Not set in current scenario

Scenario created at 12:54, 03 Aug  
by MP

SUBMIT

**Figure 5.13: Example Tuggerah Lakes MHLFIT customised on-demand lake level modelling**

## 5.4 Environmental considerations

This section provides a preliminary overview of potential environmental impacts as a result of the proposed interim management procedure. A more detailed environmental assessment will be undertaken as part of a Review of Environmental Factors (REF) to be completed in accordance with the Environmental Planning and Assessment Act 1979. Relevant environmental policies related to the interim entrance management procedure are listed in **Section 5.8**.

**Table 5.2** outlines potential environmental impacts and relevant controls related to the interim procedure.

**Table 5.2: Potential environmental impacts**

Environmental consideration	Potential Impacts	Environmental Controls
Seagrass and Vegetation	Unlikely to have any impacts given the works are not located in any seagrass beds. The proposed works will have minimal impacts on dry-weather lake level variability affecting seagrass beds and fringing lake habitats.	N/a.
Water Quality and Turbidity	Unlikely to have any adverse impacts on water quality. Assisted entrance opening prior to flood events may temporarily improve ocean discharge during such events. Exposure of buried organic sediment in the entrance berm exposed during scraping/excavation is unlikely and any impacts would be similar to those that occur with natural entrance scour in this region.	N/a.
Aquatic and Wetland Ecology	Unlikely to have any adverse impact on aquatic and wetland ecology. Entrance openings will assist ocean discharge with the onset of flooding.	N/a.
Non-flood lake level characteristics	Unlikely to have adverse impacts on dry-weather lake level variability in Tuggerah Lakes. Management works do not alter dry-weather entrance conditions beyond their natural state.	N/a.
Shorebird breeding and ecology	Potential impacts on the breeding area of the <i>Sternula albifrons</i> - Little Tern, listed endangered under the <i>Biodiversity Conservation Act 2016</i> . This migratory shorebird typically breeds on the northern section of the entrance berm, with council erecting temporary fencing to protect the area during breeding months between mid-October to mid-February. The common red-capped Plover <i>Charadrius ruficapillus</i> also may nest on the entrance berm during these months.	<p>Entrance berm is to be regularly monitored via onsite inspection for the presence of shorebird nesting sites prior to works being undertaken to determine appropriate environmental controls to mitigate impacts on nesting. This is to be undertaken in consultation with relevant environmental agencies.</p> <p>Entrance works are to be undertaken in the designated region at the southern end of the entrance berm outside and an agreed buffer (TBD) of shorebird nesting (see procedure figures).</p> <p>Designated access routes and operational procedures are to be determined following site inspections to avoid disturbances of machinery access to the berm on the breeding area.</p> <p>Should environmental assessment and approval allow, sand won</p>

Environmental consideration	Potential Impacts	Environmental Controls
		<p>during works may be used to support the establishment of shorebird nesting areas for improved environmental outcomes.</p> <p>Any further impacts on the breeding area would require to be mitigated or offset in accordance with the <i>Biodiversity Conservation Act 2016</i>.</p>
Dune and berm ecology	<p>Disturbances to berm ecology associated with machinery access and beach scraping/excavation.</p> <p>The proposed works are unlikely to impact upon dune ecology.</p>	<p>The entrance works are to be located in the southern region of the entrance berm close to the typical location of the throat channel. This location is likely to have the least impact on berm ecology considering the increased natural variability of the berm in this region that occurs with entrance widening, flood scour and throat channel migration.</p> <p>Berm scraping and pilot channel excavation levels are to be within the natural variability of berm scour that would occur during flood events.</p> <p>Designated access routes and operational procedures are to be determined following site inspections to minimise erosion and disturbances to berm ecology.</p> <p>Any further impacts of berm works would be addressed in more detail under a REF as part of the interim procedure.</p>
Terilbah Island	<p>The entrance management works are unlikely have adverse impacts on the Terilbah Island (Wyrabalong National Park) located further upstream. Minor increases in entrance flows may result due to the works with the onset of flooding with negligible impacts at the upstream location of Terilbah Island.</p>	N/a.
Sediment contamination & acid sulfate soils	<p>Excavation of channel openings and berm management is likely to be clean, marine sand and does not contain any contaminants.</p> <p>The works are unlikely to results in impacts related to acid sulfate soils.</p>	N/a.
Air Quality	<p>Emissions associated with machinery used to open the entrance and transport emissions.</p>	Council may seek avenues to offset these emissions.



Environmental consideration	Potential Impacts	Environmental Controls
Recreational and beach user	Disruption to public and beach users associated with closure of Hutton Rd carpark, restricted access to entrance berm and presence of machinery on beach.	Council to notify public of timing of intended works and any disruptions associated with the works.
Entrance Hydraulics	The entrance works will assist the natural entrance breakout/scour during the onset of flooding. The works will artificially provide earlier entrance breakout and assisted opening to improve ocean discharge with the onset of flooding.	<p>Entrance works are to be undertaken according to the prescribed procedures to avoid migration of the main throat channel outside of its typical opening location which is generally towards the southern region of the entrance berm.</p> <p>Continued monitoring of the entrance region and realtime decision-support tools will help to guide entrance operations to reduce / adverse impacts on entrance hydraulics.</p>
Bank Erosion/bridge footings	The proposed entrance works are unlikely to cause additional bank erosion or undermining of structural footings located within the entrance.	N/a.
Flooding	<p>Refer to Tuggerah Lakes Entrance Management Study (MHL, 2022) for a detailed assessment on flood impacts.</p> <p>The works are likely to result in minor reduction peak flood levels (typically less than 0.2 m) and associated flood damages.</p> <p>The interim procedure does not intend to eliminate risk associated with flooding in Tuggerah Lakes and is to be implemented alongside other floodplain risk management controls identified in the FRMSP (WMAwater, 2014)</p>	Entrance works are considered beneficial.
Coastal processes	Artificial migration of entrance channel to the northern region of the entrance berm may result in adverse impacts on coastal processes associated with shifting the main entrance opening away from its typical location which is generally in the south. Such openings may cause adverse changes to nearshore currents and sediment dynamics along adjacent beaches.	<p>Entrance works are to be undertaken according to the prescribed procedures to avoid migration of the main throat channel outside of its typical opening location which is generally toward the southern region of the entrance berm.</p> <p>Sand won during works may be placed on eroded sections of North Entrance Beach.</p>

## **Restricted and environmentally sensitive areas**

A number of environmentally sensitive habitats line shallow waters and foreshores of Tuggerah Lakes. Estuarine habitats, endangered ecological communities and estuarine vegetation mapping are provided in **Appendix E**

A preliminary summary of environmentally sensitive areas includes:

- Seagrass beds are outlined by estuarine vegetation mapping in **Appendix E** (NSW DPI).

The mapping indicated that meadows of these species cover approximately 17.7 km<sup>2</sup>, with mangroves and saltmarsh covering approximately 0.001 km<sup>2</sup> and 0.108 km<sup>2</sup> respectively (Williams et. al., 2006). These are located outside of the proposed entrance channel and berm management works.

- Waterway and Fish Habitat Classification – Class 1 Major Key Fish Habitat containing Type 1 (Highly sensitive key fish habitat) and Type 2 (Moderately Sensitive Key Fish Habitat).

- Terilbah Island, Wyrabalong National Park

- Matters of environmental significance (EPBC Act Protected Matters Report generated 22 August 2021 **Appendix E**):

- No world heritage properties
- No national heritage places
- Not located within 1 km of wetlands of international importance
- Not located within 1 km of the Great Barrier Reef Marine Park
- The Commonwealth Marine Area is not located within 1 km of the proposed works
- Two threatened ecological communities are within 1 km of the proposed works. These include:
  - Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community (Endangered)
  - River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria (Critically Endangered)
- 71 listed threatened species
- 74 listed migratory species

Other Matters listed under the EPBC Act 1999 relevant to the proposal include:

- Tuggerah Lakes is classified as a nationally important wetland
- 94 listed marine species
- 14 whales and other cetaceans
- No critical habitats
- No Commonwealth Reserves (Terrestrial), Commonwealth Land, Commonwealth Heritage Places, nor Australian Marine Parks.

- Closest coastal wetlands under SEPP 14 (Coastal Wetlands) is at Chittaway Point, 3 km from the proposed works.

## - Heritage

### Indigenous heritage

- A search of the NPWS Aboriginal Heritage Information Management System identified three Aboriginal sites in the immediate vicinity of the entrance region with one in close proximity to the entrance throat channel (AHIMS basic search 22 August 2021). Further investigation is to be undertaken as part of a Review of Environmental Factors (REF) to address any potential impacts associated with the entrance works.

### Non-Indigenous heritage

- The EPBC Act Protected Matters Search Tool identified no Commonwealth Heritage Places or National Heritage Places.

A more detailed environmental assessment will be undertaken as part of a REF after the interim entrance management procedure is finalised.

## 5.5 Safety

All entrance management works will be conducted in accordance with Council's work health and safety and environmental policies and procedures and any relevant state legislation. These are to be undertaken consistent with Council's current safety measures for similar works at Coastal Lagoons entrances. All staff must wear appropriate PPE during entrance management activities.

Prior to the commencement of works, the site will be cordoned off using para webbing or similar and signs will be placed on either side of the work site indicating that this section of beach is closed and that there are dangers associated with strong currents, rough water and unstable, collapsing ground.

If necessary, temporary lighting, sufficient to highlight the location of the work, will be erected.

Council Lifeguards must be on-site prior to pilot channel openings being completed whenever openings are conducted during day light hours. Once the pilot channel opening is affected and the plant has been moved away from the pilot channel opening area, the Council Lifeguards will take control of the site.

## 5.6 Roles and responsibilities

Roles and responsibilities related to the interim entrance management procedure are outlined in **Table 5.3**.

Council's community engagement team are to be responsible for arranging relevant communication and public messaging to inform the General Public when entrance works are being undertaken.

The advice on impending entrance works is to be given to:

- Local fisheries officer
- Local shorebird environmental consultant and/or National Parks and Wildlife Services
- Department of Planning and Environment - Biodiversity and Conservation – Coastal Representative
- Contractors or in-house staff responsible for undertaking entrance works
- Council Lifeguards and Lifesavers, if they are on duty at the time of the impending
- Council comms and engagement team and customer contact

**Table 5.3: Outline of roles and responsibilities**

<b>Role / Organisation / Section</b>	<b>Responsibilities</b>
<b>Ongoing as required</b>	
Manly Hydraulics Laboratory	Maintenance and provision of MHLFIT system including water level and rain gauges.
CCC Environmental Infrastructure	Routine site inspections and environmental procedures to support shorebird nesting following existing environmental protocols.
CCC Environmental Infrastructure	Review of interim entrance management procedures as required to minimise impact on shorebird nesting sites when present.
CCC Flood Strategy and Planning (with assistance from Catchments to Coast)	Monitoring of entrance condition via MHLFIT webpage with site inspections as required.
CCC Flood Strategy and Planning (with assistance from Catchments to Coast)	Routine (e.g., fortnightly/monthly during dry-weather and daily during flood events) entrance width estimates to update width classification shown on MHLFIT webpage.
CCC Environmental Infrastructure	Maintenance of access to entrance berm at Hutton Rd carpark.
CCC Catchments to Coast	Prepare and maintain environmental approvals.
CCC Communications and Engagement	Preparation and distribution of public communications pre, during and post event.
<b>Pre-flood</b>	
Bureau of Meteorology	Issue Flood Watch and/or Severe Weather Warning for very heavy rain that may lead to flash flooding
CCC Flood Strategy and Planning	Issue internal flood standby notice.
CCC Flood Strategy and Planning	Undertake pre-flood site inspection of the entrance to determine any procedure details.
CCC Environmental Infrastructure	Undertake pre-flood site inspection to determine environmental controls regarding shorebird nesting.
CCC Environmental Infrastructure	Confirm resources for entrance works and undertake preparations.
CCC Flood Strategy and Planning and LEMO	Continue to monitor BoM forecasts and warnings, and MHLFIT webpage.
CCC Flood Strategy and Planning	Interpretation and use of MHLFIT modelling to inform estimates of peak flood level predictions.
Manly Hydraulics Laboratory/CCC Flood Strategy and Planning/Catchments to Coast/Environmental Infrastructure	Flood and coastal engineering consultation and guidance on entrance works including pilot channel locations and timing of opening.
CCC Unit Manager Environmental Management Unit/CCC Executive Team	Confirmation of entrance works “go-ahead” and mobilisation of resources based on peak flood level predictions.
CCC Environmental Reporting and Emergency Management	Notifying relevant agencies of planned works.
CCC Environmental Infrastructure	Confirmation of timing of pilot channel opening/berm lowering (if undertaken).
CCC Environmental Infrastructure and/or Council supervised subcontractors	Undertake entrance works following safety and environmental protocols.
CCC Lifeguards	Managing public safety after entrance are completed and plant is removed.
<b>Post-flood</b>	
CCC Flood Strategy and Planning, Environmental Infrastructure and Catchments to Coast	Review and evaluate interim procedure as required.

## 5.7 Land zoning

Land zoning within the Tuggerah lakes catchment and entrance region of the proposed entrance management works is shown in **Figure 5.14** (Royal Haskoning, 2020).

The interim entrance management procedure will be located on land both above and below the Mean High Water Mark (MHW). Berm scraping and pilot channel works may include Land below the MHW and will need to be licenced via the Department of Planning and Environment - Crown Lands. Entrance shoal channels are located within the entrance channel on land zoned as Recreational Waterway (W2).

Significant areas of the foreshore are zone Public Recreation (RE1) and are crown reserves under the management of Central Coast Council. These areas include Terilbah Reserve, Karagi Foreshore Park (including the estuary eastern beach), Picnic Point Reserve, and the southern foreshore of the estuary behind the seawall in the vicinity of Marine Parade.

Land above MHW on which the entrance management works would be undertaken is Crown Land (Lot 7313/-/DP1147369 and Lot 7314/-/DP1147369) under the management of the Council. It is classified Public Recreation (RE1) under the Wyong Local Environmental Plan 2013. Berm preparation and pilot channel fall on Lot 7313/-/DP1147369. Placement of sand won from berm scraping at North Entrance Beach falls on Lot 7314/-/DP1147369.



**Figure 5.14: Land use zoning Tuggerah Lakes Entrance from Royal Haskoning (2020)**

Terilbah Island is zoned (E1) (National Parks) and is part of the “Protected Area” of Wyrabalong National Park, gazetted in 1991, and is under the control of the NSW Department of Planning and Environment (DPE).

## **5.8 Relevant Policies**

The interim entrance management procedure will require a Review of Environmental Factors (REF) to be completed in accordance with the Environmental Planning and Assessment Act 1979. Relevant policies related to the interim entrance management procedure are listed below.

### **Environmental Planning and Assessment Act 1979**

The NSW Environmental Planning and Assessment Act 1979 (EP&A Act) creates the mechanism for development assessment and determination by providing a legislative framework for the development and protection of the environment from adverse impacts arising from development. The EP&A Act outlines the level of assessment required under State, regional and local planning legislation and identifies the responsible assessing authority.

### **Wyong Local Environmental Plan 2013**

The EP&A Act is the governing legislation for planning and controlling land uses and development within NSW. Central Coast Council's planning provisions as enabled by this Act include the Wyong Local Environmental Plan 2013.

The Wyong Local Environmental Plan 2013 has been developed in accordance with NSW Planning Industry and Environment (DPE) requirements to control development via land zonings and other relevant planning provisions.

### **SEPP (Resilience and Hazards) 2021 – Chapter 2 Coastal Management**

SEPP (Resilience and Hazards) 2021 Ch. 2 Coastal Management aims to promote an integrated and coordinated approach to land use planning in the coastal zone. For areas mapped as ‘coastal wetland and littoral rainforests’ – including sizeable areas in the study area near the three lakes – development consent is required for the clearing of native vegetation, and for earthworks, construction of a levee, draining the land and environmental protection works, and for any other development. For areas mapped as ‘coastal environment areas’ – covering much of the study area – development consent must not be granted unless the consent authority has considered whether the proposed development is likely to cause an adverse impact on “the integrity and resilience of the biophysical, hydrological (surface and groundwater) and ecological environment” amongst other factors. The development must be designed, sited and managed to either avoid, minimise or mitigate adverse impacts.

### **SEPP (Infrastructure) 2007**

SEPP (Infrastructure) 2007 aims to facilitate the effective delivery of infrastructure within NSW by public authorities. It does this by prescribing the infrastructure related works that may be undertaken without development consent, although the public authority may still be required to obtain an approval, licence or permit under another Act, such as the Fisheries Management Act 1994.

Under Clause 49, Division 7 of State Environmental Planning Policy (SEPP) Infrastructure 2007, flood mitigation work is defined as;

*“work designed and constructed for the express purpose of mitigating flood impacts. It involves changing the characteristics of flood behaviour to alter the level, location, volume, speed or timing of flood waters to mitigate flood impacts. Types of works may include excavation, construction or enlargement of any fill, wall or levee that will alter riverine flood behaviour, local overland flooding, or tidal action so as to mitigate flood impacts.”*

Under Clause 50, Division 7 of SEPP Infrastructure 2007, development for the purpose of flood mitigation may be carried out by or on behalf of a public authority without consent on any land. This includes reference to development for any of the following purposes if the development is in connection with flood mitigation work:

- Construction works
- Routine maintenance works
- Environmental management works

Under Clause 129, Division 25 of SEPP Infrastructure 2007, waterway or foreshore management activities (including instream management or dredging to rehabilitate aquatic habitat or to maintain or restore environmental flows or tidal flows for ecological purposes) undertaken by a public authority are permissible without consent.

Should the works be deemed not to require development consent, a Review of Environmental Factors (REF) is prepared in accordance with the requirements of the Environmental Planning and Assessment Act, 1979.

### **Permits and licences**

For the proposed entrance management works, Central Coast Council is considered to be a determining authority as the activity is to be carried out by Council. The following agencies are also determining authorities as permits and licenses may also be required for the works from:

- NSW Department of Planning and Environment (DPE) – Crown Lands Licence
- Department of Primary Industries (DPI) – Fisheries Permit
- DPE, Environment, Energy and Science (EES) Group, NSW EPA – Environment Protection Licence

### **NSW Flood Prone Land Policy**

The NSW Government Flood Prone Land Policy aims to provide solutions to existing flood problems in developed areas and ensure that new development is compatible with the flood hazard and does not contribute to an increase in flood risk. Under the Policy, the management of flood prone land is the responsibility of the Local Government. The State Government supports the implementation of flood management measures to alleviate existing flooding problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy outlines the following floodplain management ‘process’ for the identification and management of flood risks.



The Tuggerah Lakes Floodplain Risk Management Study and Plan (WMAWater, 2014) forms an important stage in the floodplain risk management process providing proposed floodplain risk management measures. A high priority measure recommended under the Tuggerah Lakes FRMSP, was the formalising of an Entrance Management Strategy to manage flooding.

The proposed works of this study seek to provide an interim entrance management procedure to alleviate flood impacts while a formalised entrance long-term entrance management strategy is being developed.

### **Other State legislative and policy requirements**

- *Protection of the Environment Operations Act 1997* (POEO Act) - Activities should be carried out in a manner which does not result in the pollution of waters.

- *National Parks and Wildlife Act 1974* (NPW Act) and *Amendment 2010* – Provides for protection of Aboriginal cultural heritage in NSW. DPE administers the NPW Act and requires Aboriginal consultation to be undertaken in accordance with statutory requirements. Harm is permissible under an approved Aboriginal Heritage Impact Permit (AHIP). An AHIP is not required for the works as no potential harm to Aboriginal sites has been identified.

- *Crown Lands Management Act 2016* – Activities below the MHWM, a licence is required from the NSW Department of Planning and Environment (DPE).

- *Biodiversity Conservation Act 2017* -The works will require environmental assessment for potential impact on threatened species, or ecological communities listed in the *NSW Fisheries Management Act* or *NSW Biodiversity Conservation Act*, or their habitats. Measures to mitigate any potential impacts will require to be developed as part of the proposed management works.

- *Fisheries Management Act 1994* (FM Act)

If dredging (including excavation) or reclamation is to be undertaken below the highest astronomical tide, ss199, 200, and 201 of the FM Act may apply. These sections apply to any dredging works carried out in water land. For public authorities, other than local councils, the FM Act requires prior referral of dredging works to the Minister for Primary Industries for consultation prior to the issuing of any approvals/authorisations. For local councils or persons, the Act requires a permit from the Minister for Primary Industries (unless the work has already been authorised under the Crown Lands Act 1989 or by a local authority). The maximum penalty for unauthorised dredging is \$220,000 for local government authorities or corporations and \$110,000 for individuals.

Under the FM Act, NSW DPI has the power to regulate activities that can impact on waterways through the issuing of permits and associated conditions. Where approved, activities such as sediment extraction, dredging and reclamation works, harm to marine vegetation or blockages to fish passage are conditioned to ensure that water quality of receiving waters is protected.

- *Policy and guidelines for fish habitat conservation and management* (DPI, 2013)

The policy states:

*“In addition to the general policies stated in Chapter 3, the following policies apply to ICOLL management:*

1) Any proposals to artificially open ICOLLs must be authorised by a permit from the Minister or authorised by NSW DPI or other public authority after consultation with the Minister under the FM Act.

2) NSW DPI supports minimal interference with ICOLL barriers and advocates natural processes being allowed to operate to the greatest extent possible.

3) NSW DPI does not support the artificial opening of an ICOLL unless the proponent can demonstrate that the social, environmental and economic benefits greatly outweigh any potential adverse impacts.

4) NSW DPI supports using estuary management plans and environmental assessment processes to analyse the issues relating to opening a particular ICOLL, and to develop an entrance management plan. Proposals for artificial openings which are to be carried out according to a formulated entrance management plan are more likely to be approved.

Guidelines for implementing the above policies include:

a) Illegal openings should be guarded against by the erection and maintenance of signs near the ICOLL entrance warning people that unauthorised opening is illegal and may result in prosecution.

b) The decision to open an ICOLL should be made on the basis of factual data on:

- verified water levels and the nature and extent of associated flooding impacts - which should be referenced to a standard datum (e.g., Australian Height Datum) obtained from appropriately sited staff gauges, or automatic water level recorders, and
- quantitative evidence of changes to relevant water quality parameters (especially nutrient and bacterial levels) produced by monitoring programs designed specifically to assess water quality pre- and post-opening.

c) In the short-term (i.e., prior to an entrance management plan being put in place), an interim strategy for each problematic ICOLL should be formulated, documented and agreed to. The interim strategy should be made in consultation with all relevant natural resource management agencies, representatives of local community interest groups and affected landholders and provide a clear guide to where, when and under what conditions to open the ICOLL entrance. Criteria to be met may include:

- a preset water level above which a breach is recommended;
- a preset range between which a breach is recommended if heavy rainfall is predicted;
- a preset duration of high water level and/or wetland/pasture inundation over which a breach may be recommended;
- other environmental parameters (e.g., avoiding the breeding season of threatened birds such as the Little Tern).

d) The main purpose of the interim strategy should be to account for critical environmental issues and if required, to facilitate a sanctioned opening at very short

notice (e.g., Coila Lake Entrance Management Policy gives the relevant 'approval' bodies 3 days to respond to a breach request).

e) In the event that the criteria for an artificial opening are met, breaching should be conducted during a falling tide (if possible, around a spring tide) so that the potential for establishing an entrance channel long enough to flush the water body is achieved.

f) In the long-term, local councils and government agencies should aim to reduce the need for artificial manipulation by taking active measures to remove, relocate or otherwise manage items of low-lying infrastructure that currently necessitate breaches below the natural breakout range, and adopting catchment management practices that:

- reduce the inputs of nutrients and pollutants from point and diffuse sources,
- prevent transfer of flood prone and riparian land on the margins of ICOLLs into private ownership,
- prevent the future development or subdivision of flood-prone and riparian lands by adopting appropriate zonings and buffers in relevant land use planning instruments,
- implement community awareness campaigns to gain broad based understanding and support for the environmentally responsible management of ICOLLs.”

- *Marine Estate Management Act 2014 and Marine Estate Management Regulation 1999* –

The Act Declares and manages NSW marine parks. The Regulation outlines requirements for protection of various zones within marine parks. As the works are outside any Marine Park, no approvals are required.

- *Water Management Act 2000* – Under the Water Act, approval is required to undertake controlled activities on waterfront land. However, the Water Management Regulation 2011 outlines a number of exemptions for controlled activities. Where a public authority is carrying out the controlled activity on or in waterfront land, approval from the Office of Water is not required.

- *Coastal Management Act 2016* - The Coastal Management Act 2016 replaced the Coastal Protection Act 1979 and establishes a new strategic framework and objectives for managing coastal issues in NSW. The Act defines the coastal zone as comprising four coastal management areas. SEPP (Resilience and Hazards) 2021 Ch. 2 Coastal Management gives effect to the objectives of the Act from a land use planning perspective, by specifying how development proposals are to be assessed if they fall within the coastal zone. The four coastal management areas are:

1. Coastal wetlands and littoral rainforests area — areas which display the characteristics of coastal wetlands or littoral rainforests that were previously protected by SEPP 14 and SEPP 26
2. Coastal vulnerability area — areas subject to coastal hazards such as coastal erosion and tidal inundation
3. Coastal environment area — areas that are characterised by natural coastal features such as beaches, rock platforms, coastal lakes and lagoons and undeveloped

headlands. Marine and estuarine waters are also included

4. Coastal use area — land adjacent to coastal waters, estuaries and coastal lakes and lagoons.

The proposed works fall within the coastal environment area and coastal use area. The objectives of the coastal environment area are:

- to protect and enhance the coastal environmental values and natural processes of coastal waters, estuaries, coastal lakes and coastal lagoons
- enhance natural character, scenic value, biological diversity and ecosystem integrity
- to reduce threats to, and improve the resilience of, coastal waters, estuaries, coastal lakes and coastal lagoons, including in response to climate change to maintain and improve water quality and estuary health
- to support the social and cultural values of coastal waters, estuaries, coastal lakes and coastal lagoons
- to maintain the presence of beaches, dunes and the natural features of foreshores, taking into account the beach system
- to maintain and, where practicable, improve public access, amenity and use of beaches, foreshores, headlands and rock platforms.

The objectives of the coastal use area are:

- to protect and enhance the scenic, social and cultural values of the coast by ensuring that—
  - (i) the type, bulk, scale and size of the development are appropriate for the location and natural scenic quality of the coast, and
  - (ii) adverse impacts of development on cultural and built environment heritage are avoided or mitigated, and
  - (iii) urban design, including water sensitive urban design, is supported and incorporated into development activities, and
  - (iv) adequate public open space is provided, including for recreational activities and associated infrastructure, and
  - (v) the use of the surf zone is considered,
- to accommodate both urbanised and natural stretches of coastline.

The proposed entrance management works will need to meet the objectives of the coastal use and coastal environment area. They will also need to be consistent with the Tuggerah Lakes Estuary Management Plan (2006) - which is a gazetted document and has the status of a certified Coastal Zone Management Plan (under the transitional provisions outlined in the Coastal Management Act 2016) until such time as it is replaced by a certified Coastal Management Program.

### **Commonwealth Legislation**

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires that proposals for development or “actions” that have, will have, or are likely to have, a significant impact on any matter of national environmental significance are to be referred to the

Commonwealth Environment Minister for consideration and approval.

The EPBC Act identifies the following matters of national environmental significance:

- World heritage;
- National heritage;
- Wetlands of international importance;
- Listed threatened species and communities;
- Listed migratory species;
- Protection of the environment from nuclear actions; and
- Marine environment.

An assessment of the significance of the proposed works shall be undertaken in accordance with the EPBC Act, to determine any significant impacts requiring referral to the Federal Minister for approval.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

## 5.9 Adaption for climate change impacts

The Tuggerah Lakes Floodplain Risk Management Plan (2014) carried out a sensitivity analysis for sea level rise using estimates from the *NSW Coastal Planning Guideline: Adapting to Sea Level Rise* (2010). These consisted of:

- 0.4 m sea level rise by 2050
- 0.9 m sea level rise by 2100

Estimates for sea level rise under different emissions scenarios for the NSW coast were examined in *Sea Level Rise Science and Synthesis for NSW* (Glamore et al., 2016). The study estimated sea level rise for a high-end emissions scenario (RCP8.5) (central value with 66% confidence limit shown in brackets):

- 0.27 [0.19 - 0.36] by 2050
- 0.78 [0.54 - 1.06] by 2100

More recent sea level rise predictions are also provided for Sydney, Fort Denison as part of the Inter Intergovernmental Panel on Climate Change (IPCC) 6<sup>th</sup> Assessment report (Fox-Kemper et al., 2021). The IPCC report (subject to final editing) found that for a high-end emissions scenario (SSP5-8.5) (central value with 66% confidence limit shown in brackets):

- 0.23 [0.17 - 0.31] by 2050
- 0.78 [0.59 - 1.06] by 2100

Under sea level rise projections, Bruun rule approximations assume that the beach profile and entrance berm level will shift landward and upward. The Wyong Coastal Hazard Study (SMEC, 2010) indicated a Bruun rule recession factor of 29.5 for the North Entrance beach region near the Tuggerah Lakes entrance channel (Block A), such that for every 1 m of sea level rise the entrance berm retreats by 29.5 m.

Under a high-end emissions scenario of SSP5-8.5 (central value), berm levels at the entrance are estimated to shift upward by approximately 0.8 m and retreat landward by approximately 23.6 m by 2100. Design berm scraping and pilot channel levels could be incrementally raised to adapt to this increase. Long-term period berm monitoring would provide a useful dataset to confirm any trends in entrance berm elevations with sea level rise and adapt berm management procedures accordingly.

It is important to note that the expected benefit of the interim entrance management works in alleviating flood damages are expected to diminish as sea level rise continues over the next 50 - 100 years. As such, the impacts of flooding will continue to be experienced even under the implementation of the proposed works and will likely worsen with sea level rise as time progresses. It is important that the community in the Tuggerah Lakes Floodplain understand their level of flood risk as well as adapt and prepare to live with the impacts of flooding.

## 5.10 Conclusion and further recommendations

The Tuggerah Lakes Interim Entrance Management Procedure provides a rational decision-making framework for Central Coast Council to undertake entrance management works to the entrance throat channel and berm at the Tuggerah Lakes entrance. The procedure is supported by MHLFIT decision support tools that utilising real-time quantitative data and predictive lake level modelling to facilitate a rational, proactive and informed approach to management actions. It provides an interim entrance management approach until an Entrance Management Strategy is formalised through the CMP process.

The interim procedure aims to reduce the risk to life, public and private infrastructure associated with flooding in accordance with the FRMSP (WMAwater, 2014). Flood level reductions associated with the procedure are expected to be small (typically less than 0.2 m), however, are considered beneficial in assisting to reduce flood damages. These reductions are likely to diminish for floods coinciding with extreme coastal anomalies and/or with projected sea level rise over the next 50 - 100 years.

It is important to note that flooding in Tuggerah Lakes cannot be eliminated. The impacts of flooding will continue to be experienced even under the implementation of the proposed interim management procedure and will likely worsen with sea level rise. It is important that the community in the Tuggerah Lakes Floodplain understand their level of flood risk as well as adapt and prepare to live with the impacts of flooding. The interim procedure is to be implemented alongside of other floodplain risk management controls identified in the FRMSP to reduce flood risk. Reviewing and updating planning controls will be vital for future flood risk management in Tuggerah Lakes given the significant low-lying development situated in the Tuggerah Lakes foreshores.

The interim procedure recognises the ecological importance of the dynamic variability of the Tuggerah Lakes entrance and has developed procedures to provide tailored works for different entrance conditions. The interim procedure does not seek to maintain a permanently open entrance and the entrance channel will naturally constrict with sand, particularly during dryer periods with low rainfall and scour to a wider entrance during wetter periods with increased rainfall. The interim procedure seeks to allow natural entrance processes to operate with minimal disturbances in accordance with the *Policy and guidelines for fish habitat conservation and management* (DPI, 2013).

Entrance works are to be undertaken immediately prior to flooding to assist in providing flood risk reduction. Regular ongoing entrance berm works to continuously maintain flood-ready berm conditions were not considered to be feasible given the highly dynamic nature of the entrance including berm rebuilding and channel infilling processes. The interim entrance management procedure is to be reviewed following flood events as required.

It is recommended that further work as part of the Floodplain Risk Management process and Coastal Management Program include review/provision of priority floodplain risk management controls identified in the FRMSP (WMAwater, 2014), review of sea level rise impacts on flooding and coastal inundation in Tuggerah Lakes, and investigation of entrance shoal dredging to support entrance management including recreational, environmental, and social outcomes. It is also recommended that Council continue to investigate potential new technologies and methods that may improve entrance condition monitoring and support management works as they become available in the future.

The next steps are likely to involve developing public messaging and protocols to inform the community of interim entrance procedures and when works are being undertaken. Council may wish to consider developing a public MHLFIT web interface with live rainfall, lake level and entrance monitoring data. Ongoing community engagement is to form a key component in formalising an Entrance Management Strategy as part of the CMP process.