MEMO - DRAFT

Subject	Lower Shoalhaven River Entrance Management Policy Trigger Level Review
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Distribution	Shoalhaven City Council and NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW)

1. Project Overview

1.1. Background

The natural entrance of the Shoalhaven River was historically located at Shoalhaven Heads. However, since the excavation of Berry's Canal in 1822, which connected the Shoalhaven River to the Crookhaven River, the canal has gradually widened to several hundred metres due to erosion. This morphological change, along with the construction of the north breakwall at Crookhaven Heads in 1912, resulted in the Crookhaven River becoming the permanent entrance to the Tasman Sea. Today, estuarine, coastal, and flood processes cause the Shoalhaven River entrance at Shoalhaven Heads to intermittently open and close to the sea. There is limited historical evidence as to how the entrance behaved over long term periods prior to construction of Berry's Canal.

Council is responsible for managing the Shoalhaven River entrance at Shoalhaven Heads for the purpose of flood mitigation for low-lying properties in accordance with authorisations provided by the NSW Government. The mechanical opening of the Shoalhaven River entrance will not prevent flooding of houses. Even if the entrance is fully open at the start of a large flood (i.e., it has recently been scoured by a preceding flood) there are existing houses that will still be flooded. Accordingly, the Entrance Management Policy (EMP) aims to reduce, not eliminate, the impacts of flooding in a short- to medium-term perspective. In accordance with NSW Government policies, the long-term strategy is to raise or relocate low-lying property and infrastructure to prevent the need for mechanical entrance intervention altogether.

The EMP identifies the conditions under which the entrance can be opened for flood mitigation purposes. This includes Shoalhaven River levels, referred to as 'trigger levels'. The existing trigger levels are defined as part of Shoalhaven River Entrance Management Plan for Flood Mitigation (Shoalhaven City Council, 2006) and is set at an actual or forecast level of 2 m Australian Height Datum (AHD) at Shoalhaven Heads or 3 mAHD at Nowra Bridge.

The EMP (2006) also sets out the management of a dry notch immediately upstream of the entrance berm. The purpose of the dry notch is to:

- Reduce the burden of sand required to be removed at the time of a flood to enable efficient mechanical openings; and,
- Control the location of the entrance channel for the protection of the beach and associated assets.

The EMP (2006) states that the dry notch should be excavated to a level of 2mAHD for a north south width of 50m.

The EMP (2006) also noted that the dry notch should not be carried through the entrance berm (due to both environmental and maintenance considerations), but should rather:

- Be excavated to within 10m of the berm crest between the months of March and October (shorebird non-nesting period); and,
- Be excavated to within 20m of the berm crest between the months of October and March (shorebird nesting period), if this can be done without disturbance to nesting birds.

This memo investigates the flood implications of a range of trigger levels and assumed catchment conditions (refer Section 4) to assess the influence of the entrance condition on flood behaviour.

The assessment has been undertaken as part of the Lower Shoalhaven River Floodplain Risk Management Study and Plan (FRMSP).

1.2. Purpose

A review of the trigger levels for the Shoalhaven River entrance was undertaken as part of the Lower Shoalhaven River FRMSP. The assessment focused on reviewing the trigger levels from a flood risk perspective. Other considerations may also influence the adopted trigger level including environmental impacts and operational flexibility and feasibility.

This review was undertaken to define flood impacts of a range of trigger levels at Shoalhaven Heads from 1.5 to 2.6 mAHD.

Flood impacts have been assessed for:

- Peak water level;
- Warning time and period of inundation;
- Impact on road overtopping; and,
- Over floor flooding of habitable buildings. It is noted that non-habitable buildings may also be impacted. However, the focus of this assessment is on habitable buildings, due to the higher risks posed by flooding of these spaces. Furthermore, there is no requirement for a minimum non-habitable floor level for non-habitable structures/buildings (i.e., they can basically be constructed at sea level). As such, it is unrealistic to implement flood mitigation actions to protect non-habitable structures when these can lawfully be constructed at extremely low levels at the property owner's own risk in accordance with the NSW Government planning framework.

The review also aimed to respond to community comments raised as part of a community petition for Council to review the Shoalhaven River EMP, which was received after the EMP trigger level review had already commenced. This petition requested that Council investigate:

- Opportunities to reduce the trigger levels; and,
- To undertake opening on a Flood Watch, instead of a Flood Warning.

A Flood Watch is issued by the Bureau of Meteorology (BoM) when forecast rainfall suggests that local and riverine flooding is possible. Its purpose is to provide early advice of a developing situation that may lead to flooding. A Flood Watch isn't a warning of imminent flooding.

The BoM issue a Flood Warning when they are more certain that flooding is expected at a particular location. Flood Warnings are more targeted and are issued for specific catchments and locations within catchments. The BoM forecast how severe the flood is expected to be in each Flood Warning and provide forecast peak flood levels at forecast locations, which includes Nowra and Terara.

It is noted that the community also raised comments around the feasibility of a permanently open entrance. This assessment is focused on a review of EMP trigger levels; however, investigations into the feasibility of a permanently open entrance were undertaken as part of numerous previous investigations and the Lower Shoalhaven River Coastal Management Program (CMP).

2. Data Review

2.1. Previous Studies

Several previous studies have been conducted for the Lower Shoalhaven River entrance. These reports were reviewed as a part of this EMP trigger level review and relevant information incorporated as appropriate.

Previous studies that are relevant to the trigger level assessment are summarised in **Table 2-1**.

Table 2-1 Previous Studies

Study	Description
Lower Shoalhaven River CMP (Rhelm, 2024)	The Lower Shoalhaven River CMP provides strategic direction and specific actions to address threats to the estuary and maintain the ecological, social and economic values of the Lower Shoalhaven River coastal zone. The CMP is a plan of action for Council, public authorities and land managers responsible for management of the Lower Shoalhaven River coastal zone. A total of 215 potential management options spread across the entire Lower Shoalhaven River coastal zone were compiled via an audit of previous management plans and studies, engagement with the community and agency stakeholders, and the outcomes of the Stage 2 CMP Vulnerability Assessments. Potential options were assessed in terms of feasibility, viability, and acceptability as per the requirements of the NSW Coastal Management Manual. Based on this assessment, 48 management options were recommended for inclusion as actions in the CMP. Actions consist of a range of knowledge building activities, investigations and engineering designs, on-ground works, and monitoring programs.
Lower Shoalhaven River CMP: Detailed Risk Assessment	The Lower Shoalhaven River CMP: Detailed Risk Assessment was a sub-report prepared in Stage 2 of the CMP. The report examined the various coastal risks present in the coastal zone of the Shoalhaven River. Coastal and tidal inundation were investigated as part of this study. The coastal flooding risk was classified at “High” under existing conditions and for the 2040 and 2070 planning horizons. It increased to “extreme” in the 2100 planning horizon.
Shoalhaven LGA Floor Level Survey for Flood Planning (Stantec, 2024)	Survey captured floor level data for all existing properties located below the 0.2% AEP flood level in the Lower Shoalhaven River floodplain. This data was used to investigate flood impacts to habitable floor levels for the various trigger levels tested.

Study	Description
Lower Shoalhaven River Flood Study (Stantec, 2022)	Shoalhaven City Council engaged Stantec to assist with the preparation of the Lower Shoalhaven River Flood Study. The Flood study was undertaken to define flood behaviour and flood risk in the catchment. Both hydrologic and hydraulic models developed for the study were calibrated and validated to four historical events. The study incorporated Delft3D modelling to dynamically define the scoured entrance profile for the full range of design events. Testing for the 1% Annual Exceedance Probability (AEP) indicated that for this event the peak flood levels were comparable for both an open entrance and a closed entrance that scoured open during the storm. Based on similar results for other design flood events, the study adopted an open entrance for all design runs.
Management Options for Improving Flows of the Shoalhaven River at Shoalhaven Heads (WRL-UNSW, 2015)	This study details the previous studies, community feedback, identified concerns and potential engineered management options for increasing flow circulation at Shoalhaven Heads to improve water quality in the area. The study recommended reviewing 1990 flood study to incorporate modern computational methods and address following concerns: • Refined entrance design levels, opening and dredging effects; • Considering Berry's Canal as the preferential flow path during moderate to large floods. Also analyse the implications to discharge at Shoalhaven Heads entrance; • Implications of Broughton Creek flooding levels and alternative triggers for localised floods; • Climate change implications; and, • Concerns with vegetation encroachment at the entrance and infilling dynamics of the bay.
Lower Shoalhaven River Floodplain Management Study and Plan – Climate Change Assessment (WMAwater, 2011)	This study was undertaken to amend the adopted Lower Shoalhaven River FRMSP (WMAwater, 2008) to incorporate the predicted impacts of climate change. The climate change induced sea level rise previously benchmarked by NSW Government by the year 2050 is 0.4m and by the year 2100 is 0.9m. The report suggests that considerations should be given to whether a corresponding rise in the Shoalhaven Heads berm level should be included together with the ocean level rise.
Lower Shoalhaven River Floodplain Risk Management Study and Plan (WMAwater, 2008)	This study was built on 1990 FRMSP study (NSW Public Works Department), investigating key flooding issues and potential risk management options. The hydraulic model included a scenario where Shoalhaven Heads were initially closed but scoured out as flood progressed. The study found that there were minimal changes in the 1% AEP peak flood level between the open and closed /scoured scenarios.
Shoalhaven River Entrance Management Plan for Flood Mitigation (Shoalhaven City Council, 2006)	The purpose of this study was to facilitate; • Swift and effective mechanical intervention in the path of floodwaters to reduce the impact of flooding of Shoalhaven communities; and, • Responsible environmental management of the entrance berm and shorebird habitat, and protection of structural integrity of the coastal dune system.

Study	Description
Independent Inquiry into the Shoalhaven River System (Healthy Rivers Commission of New South Wales, 1999)	The Independent Inquiry into the Shoalhaven River System was undertaken in 1999 by the Healthy River Commission of NSW. The aim was to "help the Government and community to make informed choices about ecological, social and commercial goals for the river system." Of key reference to the current trigger level assessment, the report: • Recommended that the establishment of a permanently open entrance should not be pursued, due to the adverse environmental impacts of such a significant change to the entrance's natural operation; and, • Recommended the establishment of a dry notch, set at 2 mAHD, to enable a quicker, safer manual opening in advance of a predicted or actual flooding.
Shoalhaven River Entrance Study (WRL-UNSW, 1986)	The entrance study was undertaken by the Water Research Laboratory for the Public Works Department. The study supported the maintenance of the notch, revegetation of the dunes to reduce sand drift into the waterway, and recommendations were made to make the community more aware of the works Council is undertaking.

2.2. Historical Berm Surveys

Council has collected terrain survey of the Shoalhaven River entrance berm approximately 100 times since 2001. Council undertakes a topographic survey of the Shoalhaven River entrance berm and dry notch monthly when the entrance is closed to the Tasman Sea, and immediately prior to potential flood events where possible.

This record of historical berm heights (with dates attached) was used to investigate historical berm behaviour. An assessment of the available survey data indicated that:

- The minimum berm height across all the surveys was 0.27 mAHD;
- The average berm height across all the surveys was 2.07 mAHD;
- The berm level was below 2.3 mAHD in 80% of the survey records; and,
- The highest recorded berm level was 2.63 mAHD, though this level dropped to 2.46 mAHD in 4 weeks and 2.19 mAHD in 2 months.

This data has been used to select a range of potential trigger levels for use in the assessment (refer **Section 4.1**).

2.3. TUFLOW Model

A TUFLOW model of the Lower Shoalhaven River was prepared as part of the 2022 Flood Study (Stantec).

As part of the ongoing Lower Shoalhaven River FRMSP, minor revisions have been made to the model. These changes have been adopted as part of the FRMSP for the definition of design flood events.

The model used for this trigger level assessment incorporates these minor revisions.

To enable the model to assess the impacts on simulated flood levels for a range of trigger levels, additional modifications were made to the TUFLOW model specifically for this purpose. These modifications are discussed below.

3. TUFLOW Model Updates

To assess the impact of various trigger levels on flood risk, modifications were made to the hydraulic model.

The TUFLOW model developed for the Lower Shoalhaven River Flood Study (Stantec, 2022) adopted an open entrance for all design runs. This was assumed based on an assessment of the 1% AEP which showed similar peak levels from both an open and a dynamic entrance.

Testing various trigger levels was not possible in the supplied Flood Study model, due to the open entrance assumption incorporated into the model setup.

To enable the assessment of various trigger levels, the TUFLOW model was updated with a variable layer that:

- Adopted the closed entrance at the start of the flood event; and,
- Dynamically opens once a specific trigger level is reached.

Delft3D entrance breach modelling undertaken as part of the Lower Shoalhaven River Flood Study (2022) found that the entrance scour cut an initial narrow and deep channel to a hard layer before expanding laterally.

The Lower Shoalhaven River Flood Study (2022) reported scour depth, width and time for the 20%, 5% and 1% AEP events and the PMF event. Final scour depths and widths were available for all events based on bathymetric grids included in the TUFLOW model.

To approximate the progression of this scour profile, multiple variable layers were used in the model:

- A central narrow layer to represent the rapid erosion of the central channel; and,
- Separate layers to the north and south of the central channel to represent the expansion of the initial scour.

A summary of the scour depths, widths and failure times used in the model are presented in **Table 3-1**.

The model assumes a linear scour progression over the time specified in **Table 3-1**.

Note that the 20% AEP event does not have any lateral expansion of the entrance scour, and the entrance breach is represented by the central section only, in accordance with the Delft3D modelling.

An indicative model layout for the 1% AEP is shown in **Figure 3-1**.

All other aspects of the TUFLOW model remained as per the updated Flood Study model.

Table 3-1 Entrance Scour Summary (adapted from Delft 3D modelling, Stantec, 2022)

AEP	Scour Depth (mAHD)	Scour Width (m) Total	Scour Width (m) Central / North / South	Scour Time (hours) Central / North / South
20	-2.9	70	70 / - / -	5 / - / -
10	-3.5	210	60 / 55 / 95	5 / 20 / 20
5	-3.5	320	50 / 120 / 150	5 / 20 / 20
1	-3.5	400	70 / 180 / 150	5 / 30 / 30

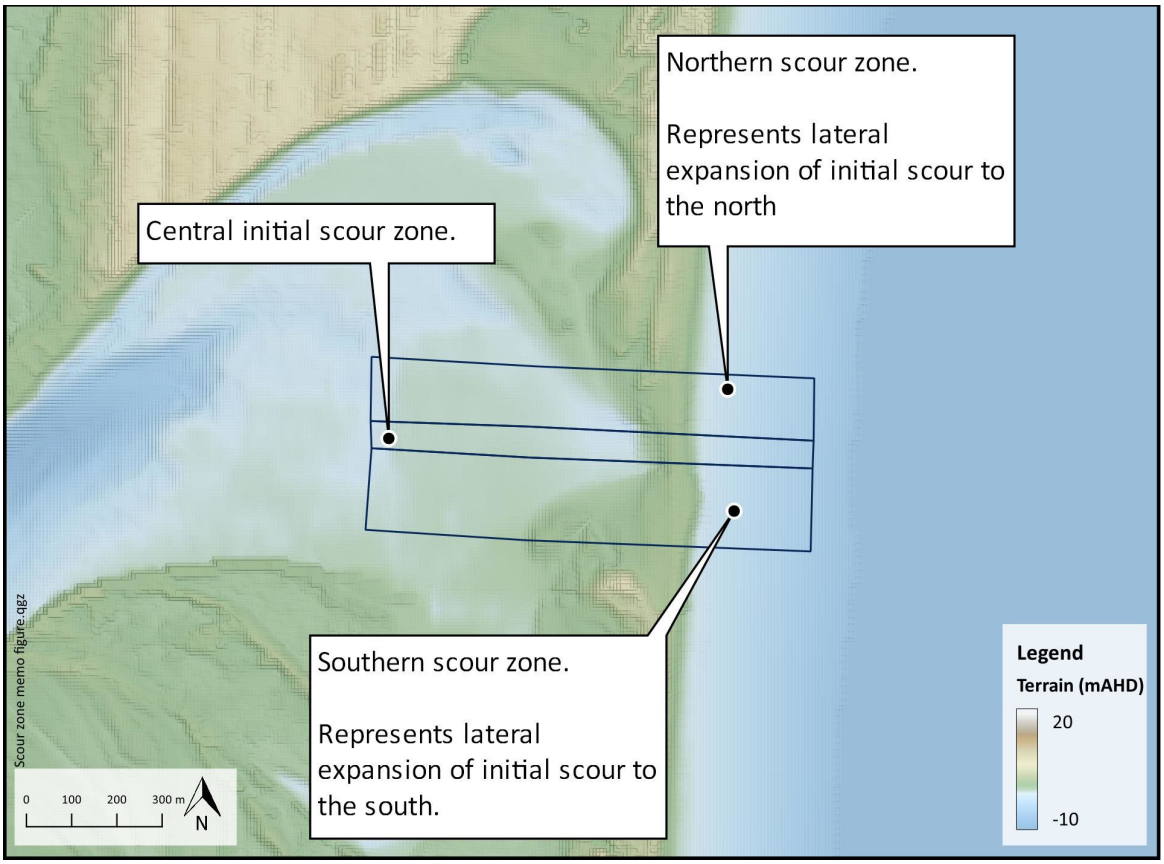

Figure 3-1 **1% AEP TUFLOW Entrance Scour Layout**

4. Assessment

4.1. Trigger Levels Assessed

To assess the impact of trigger levels on flood behaviour, a series of trigger levels at Shoalhaven Heads were assessed in the TUFLOW model. The assessed Shoalhaven Heads triggers (and their respective levels at Nowra Bridge) were:

- 1.5 mAHD (2.5 mAHD);
- 1.7 mAHD (2.7 mAHD);
- 2.0 mAHD (3.0 mAHD) (the current trigger level);
- 2.3 mAHD (3.8 mAHD); and,
- 2.6 mAHD (4.9 mAHD).

These values represent a range of trigger levels, both higher and lower than the current EMP (2006) trigger level of 2.0 mAHD. The flood model has been constructed such that scour of entrance does not commence until the above trigger levels are reached upstream.

The model further assumed that the dry notch is maintained to a level no higher than each trigger level assessed. As such, the dry notch does not influence flood outcomes.

The 2.6 mAHD trigger at Shoalhaven Heads (a 4.9 mAHD trigger level at Nowra Bridge) represents a scenario whereby Council were unable to open the entrance due to safety or time constraints, with 2.6

mAHD representing the highest recorded entrance level from Council's survey data (collected between 2001 and 2024). It is noted that a higher berm may have occurred before these records commenced however, this level is considered conservative and representing the upper limit of likely berm levels.

For each trigger level, the variable layer in TUFLOW was revised to initiate the scour of the entrance when the river level reached the applicable level upstream of the entrance berm.

Several assessments were undertaken to determine the impact of these trigger levels on flood behaviour, namely:

- Impacts on peak flood levels;
- Impacts on the time to inundation and the period of inundation;
- Impacts on the flow distribution between the Shoalhaven River entrance at Shoalhaven Heads and the Crookhaven River entrance via Berry's Canal; and,
- Impacts on over floor flooding of habitable floor levels.

The current trigger for the enactment of Council's EMP (2006) is based on actual flood levels being reached or flood levels being predicted from a BoM Flood Warning. A Flood Warning includes predicted flood levels at the Nowra bridge gauge which can be used to inform pre-emptive entrance management activities at Shoalhaven Heads. A review of the suitability of enacting the opening on a Flood Watch instead of a Flood Warning is also discussed.

These assessments are detailed below.

4.2. Limitations and Assumptions

In considering the outcomes of the assessments below, it is important to keep in mind the uncertainties and limitations in the modelling undertaken.

The TUFLOW model utilised in this assessment is considered a suitable tool for assessing the impacts of various trigger levels on peak flood levels. However, there are uncertainties associated with the model input data, and assumptions have been required to be made due to the complex nature of the Shoalhaven River entrance system.

With regard to input data, the key uncertainties relate to:

- Ground and floor level data – ground level data has been sourced from LiDAR data, with a vertical accuracy of +/- 0.15 m. Some locations have been surveyed by a surveying team. These locations have a vertical accuracy of +/-0.05 m;
- The scoured entrance shape – the scoured entrance profile was taken from the latest Lower Shoalhaven River Flood Study (2022), but not all assessed events had this data reported in the flood study. Interpolation between reported events was required. Furthermore, the scoured entrance shape is not fully dynamic over time but has been simplified for the purpose of this assessment;
- The scour time – the scour times incorporated into the model are based on the scour times reported in the Lower Shoalhaven River Flood Study (2022) with the entrance at 2 mAHD. Scour times have not been revised for various trigger levels. As such, a lower trigger level will result in a slower scour rate and potentially less flood benefits than modelled (as the scour time remains the same, but the scour depth is reduced), and higher trigger levels will result in a more rapid scour progression, and potentially less flood impacts than modelled;

- Local influence on flood levels of wind and waves;
- Entrance not opened on receding tide, as per Council's policy. Ocean tide is aligned so that the peak tide aligns with the peak catchment flow. This gives a conservative estimate of flooding.
- The assessment has been undertaken for a single, design scenario (see discussion immediately following). Changes to these assumptions would result in changes in modelled/simulated flood levels, and potentially changes in the outcomes of the assessments undertaken.

The TUFLOW model was constructed to determine peak flood levels in the Lower Shoalhaven River floodplain, in accordance with industry guidance and best practise.

As each flood and coastal event are different, a range of different outcomes will result from the manual opening of the entrance. To enable a comparative assessment, some assumptions needed to be made, noting these assumptions will not always occur.

The model has assumed:

- That the peak ocean level coincides with the peak flood level;
- A critical flood duration of 36 hours, which is the duration that results in the highest flood level in the Shoalhaven River;
- The adoption of a single rainfall temporal pattern, in accordance with Australian Rainfall and Runoff 2019 (ARR2019) guidelines; and,
- A representative rainfall over the entire Shoalhaven River catchment.

The Shoalhaven River entrance is a complex system, due to the interaction of the entrance berm, local catchment flows, and the ocean condition, coupled with the presence of the second outlet via Berry's Canal, which conveys most of the flow (except in large flood events, refer **Section 4.7**). The system presents a significant number of variables and modelling each combination of these is not feasible. As such, this assessment has been undertaken with best available information and is considered suitable for the purpose of providing an indication of flood impacts arising from the adoption of various trigger levels.

It is also noted the Shoalhaven River and Crookhaven River entrances are both subject to flooding from both catchment driven events (via rainfall) and ocean driven events (east coast lows). Under a scenario with an east coast low, and a small catchment rainfall, the opening of the entrance is likely to result in increased flood levels at Shoalhaven Heads, due to propagation inland of elevated ocean levels.

The focus of the assessment is on managing catchment driven flood events.

4.3. Impact of Trigger Levels on Peak Water Levels

A summary of peak water levels at Shoalhaven Heads and Greenwell Point from the various trigger level scenarios are presented in **Table 4-1**. The locations of the assessment are shown in **Figure 4-1**.

The results indicate that design flood levels are insensitive to reductions in the Shoalhaven Heads trigger level between 1.5m and 2m. Reductions in flood levels across the events assessed ranged from 0.01m to 0.07m at both Shoalhaven Heads and Greenwell Point, with the 10% AEP event being the most sensitive to reductions in the trigger level. These reductions are not considered significant given the underlying uncertainty of the model data (refer Section 4.2).

Figure 4-1 Reporting Locations

However, increasing the trigger level to 2.6 mAHD results in an increase in flood levels at Shoalhaven Heads in the 20% AEP and 1% AEP events of 0.15m and 0.26m respectively. The impacts on flood levels at Shoalhaven Heads, because of a 2.3 mAHD trigger level, in larger events were less significant with increases in the 20% AEP and 1% AEP events of 0.15 and 0.09m.

Impacts at Greenwell Point, whilst different, were of a similar scale to those at Shoalhaven Heads. Greenwell Point showed a similar sensitivity to the 2.6 mAHD trigger level with increases in the 20% and 1% AEP events of 0.05 m and 0.20 m respectively.

For the 2.6 mAHD scenario, where it is assumed that Council is unable to open the entrance and the berm is at the level of 2.6 mAHD, flood levels are 0.26 m higher at Shoalhaven Heads in a 1% AEP event compared to the existing case, where Council opens the entrance at 2 mAHD.

The modelling assumes the entrance is opened once the water level at Shoalhaven Heads reaches the trigger level (i.e. 2 mAHD under existing approach). In practice, Council opens the entrance on a Flood Warning for levels above 3.0 mAHD at Nowra Bridge (i.e. flood levels at Shoalhaven Heads have not yet reached 2 mAHD but are predicted to). The results are therefore conservative and assume that the entrance is only opened when the trigger level is reached upstream.

Table 4-1 Trigger Level Peak Water Level Summary

AEP	Trigger Level (mAHD) (Difference to 2.0 mAHD scenario (m))				
	1.5 mAHD	1.7 mAHD	2 mAHD (existing)	2.3 mAHD	2.6 mAHD (Council unable to open entrance)
Shoalhaven Heads					
20% AEP	2.11 (-0.02)	2.12 (-0.01)	2.13	2.28 (+0.15)	2.28 (+0.15)
10% AEP	2.41 (-0.07)	2.44 (-0.04)	2.48	2.54 (+0.06)	2.64 (+0.16)
5% AEP	2.82 (-0.04)	2.84 (-0.02)	2.86	2.92 (+0.06)	2.98 (+0.12)
1% AEP	2.85 (-0.06)	2.87 (-0.04)	2.91	3.00 (+0.09)	3.17 (+0.26)
Greenwell Point					
20% AEP	1.29 (-0.01)	1.29 (-0.01)	1.3	1.35 (+0.05)	1.35 (+0.05)
10% AEP	1.56 (-0.07)	1.58 (-0.05)	1.63	1.69 (+0.06)	1.80 (+0.17)
5% AEP	2.26 (-0.06)	2.27 (-0.05)	2.32	2.40 (+0.08)	2.47 (+0.15)
1% AEP	2.82 (-0.04)	2.84 (-0.02)	2.86	2.91 (+0.05)	3.06 (+0.20)

4.4. Impact of Trigger Level on Time to Inundation and Period of Inundation

A summary of the flood warning and period of inundation for habitable floor levels under the various trigger levels is summarised in **Table 4-2** and **Table 4-3** respectively. The times have been calculated based on the average floor level height of the lowest 20 properties at each location.

The results indicate that overall, the trigger level has a negligible impact on time to inundation and the period of inundation, and that lowering the trigger level does not significantly affect the period of inundation at Shoalhaven Heads. The notable exception was the period of inundation in the 20% AEP, for which the 2.3 m and 2.6 m trigger scenarios had an additional 6 and 6.5 hours of inundation respectively compared to the other trigger levels.

The reason for the outcomes can be seen in the water level time series plotted in **Figure 4-2**. The plot shows the water level time series for the 20% AEP at Shoalhaven Heads. Results for other AEP events, and at Greenwell Point all show a similar behaviour. The plot shows that:

- The water levels in all scenarios up to 1.5 mAHD are the same (as the entrance is closed for all scenarios up to this point);
- The 1.5, 1.7, and 2.0 mAHD scenarios show some minor differences, but overall behave very similarly;
- The 2.3 and 2.6 mAHD triggers in contrast, shows a more pronounced rising limb and a notably higher flood peak; and,
- Once the flood peak has passed and the entrance is fully open, the falling limbs of all scenarios are similar, regardless of whether the entrance is open or closed.

Table 4-2 Time to Inundation Summary

AEP	Trigger Level (mAHD) (Difference to 2.0 mAHD scenario (hours))				
	1.5	1.7	2	2.3	2.6
Shoalhaven Heads (average floor height of lowest 20 properties is 2.3 mAHD)					
20% AEP	71.5 (+0.5)	71 (0)	71	71 (0)	71 (0)
10% AEP	52.5 (0)	52.5 (0)	52.5	52.5 (0)	52.5 (0)
5% AEP	22 (0)	22 (0)	22	22 (0)	22 (0)
1% AEP	40.5 (+0.5)	40 (0)	40	40 (0)	40 (0)
Greenwell Point (average floor height of lowest 20 properties is 1.5 mAHD)					
20% AEP	Not flooded	Not flooded	Not flooded	Not flooded	Not flooded
10% AEP	65.5 (+0.5)	65 (0)	65	65 (0)	63.5 (-1.5)
5% AEP	28.5 (+0.5)	28.5 (+0.5)	28	27 (-1)	27 (-1)
1% AEP	40 (0)	40 (0)	40	40 (0)	40 (0)

Table 4-3 Period of Inundation Summary

AEP	Trigger Level (mAHD) (Difference to 2.0 mAHD scenario (hours))				
	1.5	1.7	2	2.3	2.6
Shoalhaven Heads (average floor height of lowest 20 properties is 2.3 mAHD)					
20% AEP	19.5 (-0.5)	20 (0)	20	26 (+6)	26.5 (+6.5)
10% AEP	30 (0)	30 (0)	30	30 (0)	30.5 (+0.5)
5% AEP	21.5 (-1)	22 (-0.5)	22.5	22.5 (+0.5)	22.5 (+0.5)
1% AEP	43 (-0.5)	43.5 (0)	43.5	43.5 (0)	43.5 (0)
Greenwell Point (average floor height of lowest 20 properties is 1.5 mAHD)					
20% AEP	Not flooded	Not flooded	Not flooded	Not flooded	Not flooded
10% AEP	4.5 (-1.5)	5.5 (-0.5)	6	7 (+1)	10.5 (+4.5)
5% AEP	15.5 (-0.5)	15.5 (-0.5)	16	17 (+1)	17 (+1)
1% AEP	42.5 (-1)	43 (-0.5)	43.5	43.5 (0)	48.5 (+5)

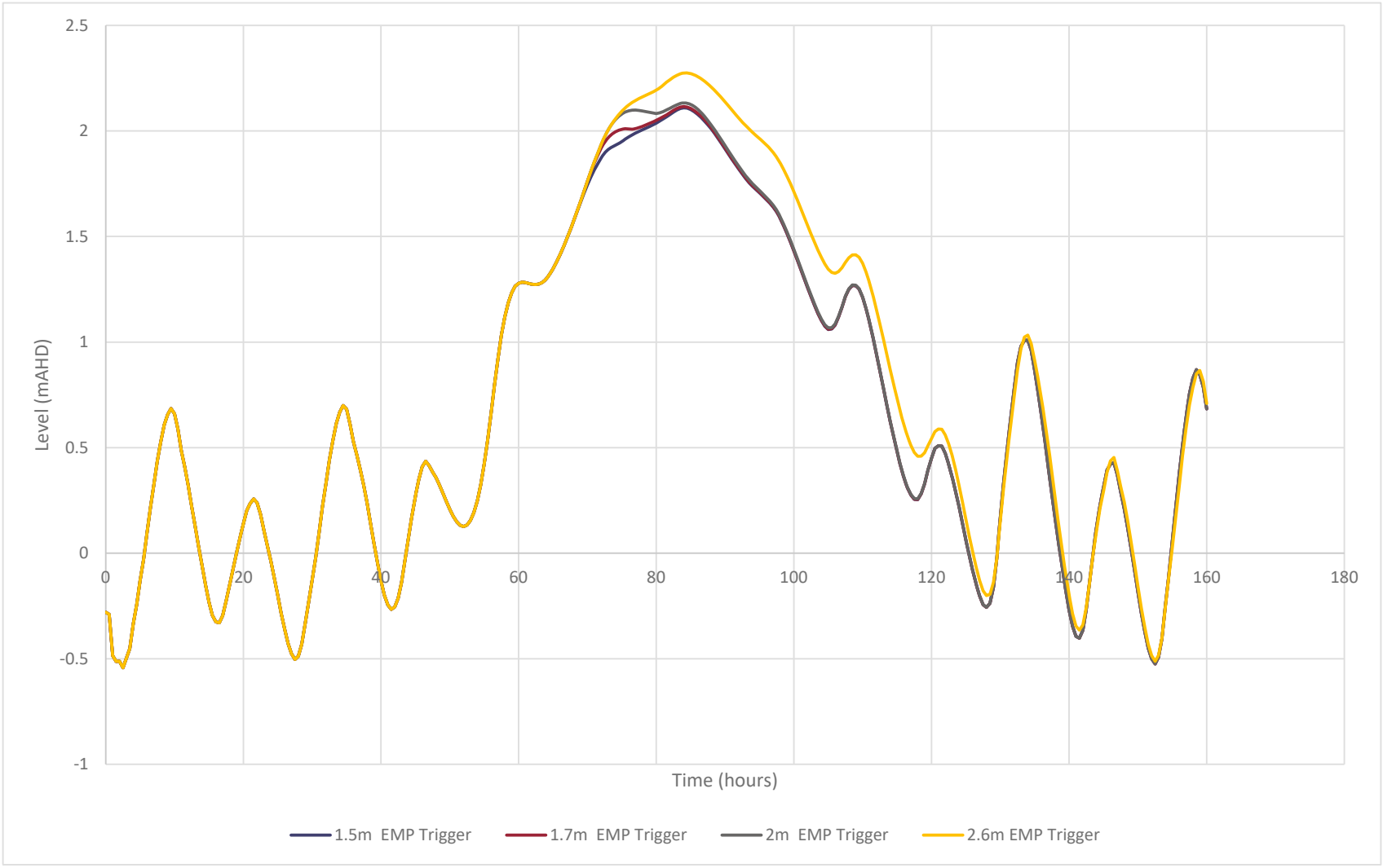

Figure 4-2 20% AEP Water Level Time Series at Shoalhaven Heads

4.5. Impacts on Over Floor Flooding

There are several properties in Shoalhaven Heads, Comerong Island, Greenwell Point, and Culburra Beach that can be impacted by flooding over the habitable floor level. As previously noted, from a planning perspective, there is no requirement for a minimal non-habitable floor level for non-habitable structures/buildings (i.e., they can basically be constructed at sea level). As such, it is unrealistic to implement flood mitigation actions to protect non-habitable structures when these can lawfully be constructed at extremely low levels at the property owner's own risk in accordance with the NSW Government planning framework.

A floor level survey was undertaken as part of the Shoalhaven LGA Floor Level Survey for Flood Planning (2024) investigation, to gain a better understanding of the exposure of existing residential properties to flooding.

In a relatively frequent event (e.g. the 20% AEP event), under current entrance opening arrangements (trigger level of 2 mAHD), over floor flooding in the downstream areas of the Shoalhaven River can impact approximately seven of the lowest lying properties. Depth of over floor flooding for these properties is between 0.1 and 0.4 meters.

Over floor flooding in a large and rare event (e.g. the 1% AEP event), under current opening arrangements, can impact more than 400 properties with flood depths over floor on average 0.9 metres.

As discussed above in **Section 4.3**, reductions in the trigger level have a minimal impact on peak flood levels (less than 0.02m in the 20% AEP event and less than 0.06m in the 1% AEP event). Consequently, it also has a minimal impact on flooding above habitable floor levels.

Conversely, modelling identified that increasing the trigger level would result in an increase of property affectation. Water level increases with a 2.6 mAHD trigger were 0.12 m to 0.26 m depending on the design flood event. These changes are enough to result in previously flood free habitable areas of properties becoming affected by over floor flooding.

As discussed in **Section 4.4**, reducing the trigger level did not result in a significant reduction in inundation durations.

4.6. Impact of Trigger Level on Road Access

The low point on Hay Avenue in Shoalhaven Heads is 1.37 mAHD, and the low point on Adelaide Street in Greenwell Point is 1.2 mAHD. As these levels are both below the lowest assessed trigger level at Shoalhaven Heads of 1.5 mAHD, the trigger level adopted has no impact on the warning time to road access being lost, i.e. it was the same under all trigger level scenarios.

The adopted trigger had a negligible impact on the period of inundation. Both these road levels are sufficiently low that once the falling limb of the flood event reaches this level, it is largely independent of the entrance trigger, due to the entrance having been fully scoured out some time before. All inundation periods were within 0.5 hours of each other, regardless of the entrance trigger level adopted.

4.7. Impact of Trigger Level on Flow Distribution between the Shoalhaven River entrance at Shoalhaven Heads and Crookhaven Heads entrance via Berry's Canal

A comparison of the flow through both the Shoalhaven River entrance at Shoalhaven Heads and Crookhaven Heads entrance via Berry's Canal was undertaken for each of the assessed events. The results are shown below in **Figure 4-3** to **Figure 4-6**.

The comparison shows that in smaller events, the bulk of the flow from the Shoalhaven River is conveyed by Berry's Canal to the Tasman Sea via the Crookhaven Heads entrance. As the flood event magnitude increases, the proportion of the flow conveyed through the Shoalhaven River entrance at Shoalhaven Heads increases. Once flooding reaches the 1% AEP (refer **Figure 4-6**), the Shoalhaven River entrance at Shoalhaven Heads becomes the primary outlet of the Shoalhaven River, conveying approximately 60% of the total flow.

The plots show the flow time series for the most extreme triggers assessed; 1.5 mAHD and 2.6 mAHD. Whilst the trigger level affects the time at which flow through the Shoalhaven River entrance at Shoalhaven Heads commences (lower triggers have an earlier flow) the flood peaks and falling limbs show little difference. The exception is the 20% AEP, where the 2.6mAHD trigger does not overtop the entrance berm during the event so no flow passes through the Shoalhaven River entrance at Shoalhaven Heads.

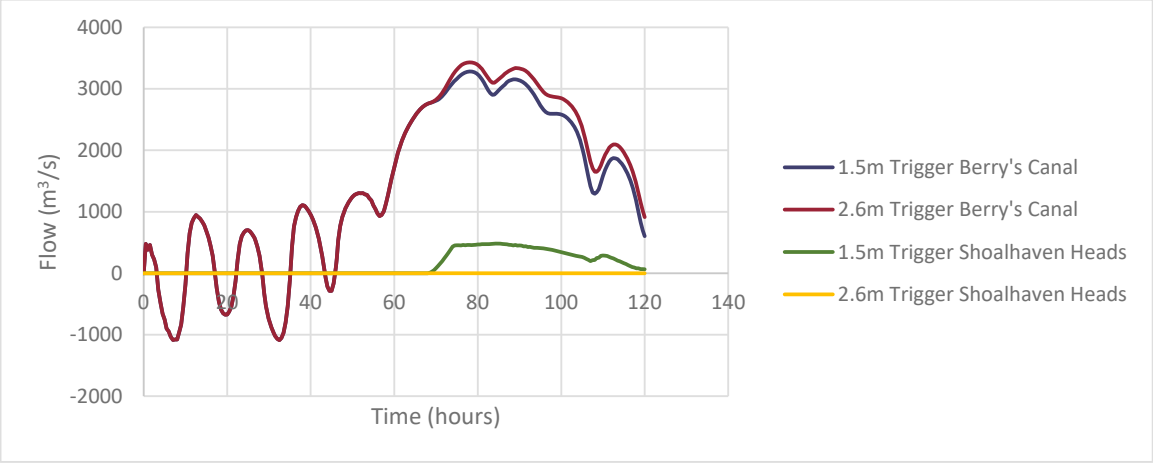

Figure 4-3 20% AEP Flow Comparison

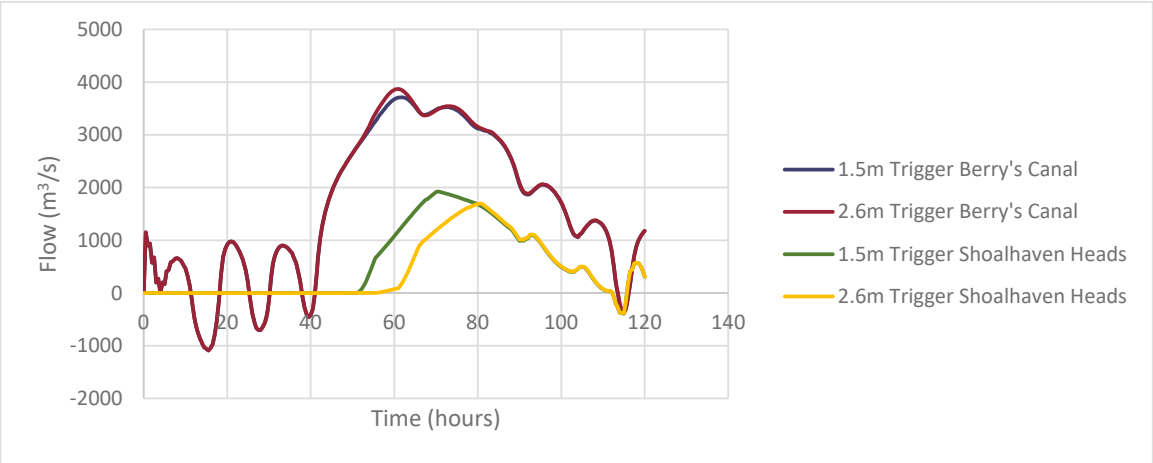

Figure 4-4 10% AEP Flow Comparison

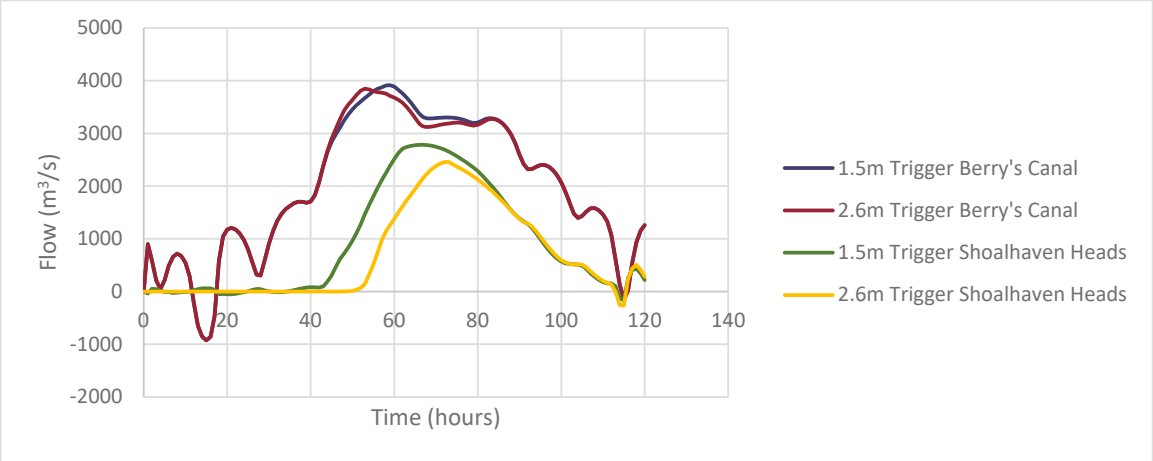

Figure 4-5 5% AEP Flow Comparison

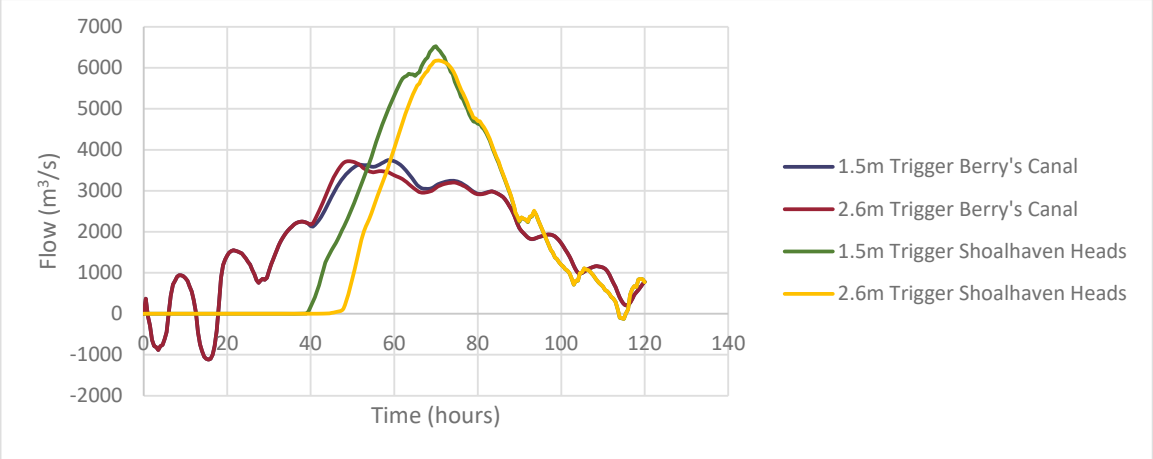

Figure 4-6 1% AEP Flow Comparison

4.8. Suitability of Opening on a Flood Watch

Council currently implements the entrance opening policy based on a Flood Warning level of 3 mAHD or higher at Nowra Bridge, or actual gauge levels of either:

- 3 mAHD at Nowra Bridge; or,
- 2 mAHD at Shoalhaven Heads.

An alternative would be to implement the opening policy at a Flood Watch instead of a Flood Warning.

The intent for the change would be to enable the cutting of the pilot channel through the entrance berm at an earlier stage and reduce the possibility that the entrance could not be opened prior to a flood peak arriving due to unsafe weather conditions.

There are some challenges with opening on a Flood Watch. A risk of early opening is that ocean washover will close up any pilot channel opening in advance of the floodwater arriving. From this perspective, the later the entrance is opened the better, as it limits the amount of sand that will be deposited in the pilot channel prior to the flood. Furthermore, to improve the effectiveness of an entrance opening (i.e., how effective the scour is and the time by which it stays open), the opening should occur with a significant hydraulic gradient between the river and the ocean (i.e., opening as late as possible and/or on a falling tide is beneficial from a hydraulic perspective).

Not all Flood Watches become Flood Warnings. As such, opening on a Flood watch would result in a significant increase in the number of openings, many of which will ultimately prove to be unnecessary. These additional openings would impose a financial burden on Council.

These unnecessary openings would also contribute to environmental impacts of entrance management (discussed in the Review of Environmental Factors), due to more frequent interference with the natural opening and closing regime of the entrance. When the entrance is closed, the sand berm is used by threatened shorebirds and migratory birds, typically between August and March, as a nesting site.

Furthermore, a Flood Watch will only say if a Minor, Moderate, or Major flood may occur. The high level of uncertainty at this point does not allow BoM to predict peak flood levels in the river, which they do for a Flood Warning. A Flood Watch may be issued for a wide range of possible scenarios, including minor flooding that would not reach the relevant trigger levels.

The only potential benefit of opening on a Flood Watch rather than a Flood Warning is that it provides Council with a longer window to undertake the works. The maintenance of the dry notch allows a pilot channel to be excavated much quicker. The assessments undertaken above have demonstrated that enacting the opening policy provides flood level reductions. There is a risk that if the opening trigger is reached at night, or conditions are too dangerous, then Council may not be able to open the entrance, leading to adverse flooding conditions if the entrance berm is high at the time.

However, given the risk of sand being deposited back due to ocean washover, and the negative environmental impacts, it is suggested that a program of entrance berm height management would be a better option to manage the risks of not being able to open the entrance. This is discussed further in **Section 4.9**.

Consequently, opening the Shoalhaven River entrance at Shoalhaven Heads on a Flood Watch is not recommended as it provides no entrance management benefits and could lead to unnecessary adverse environmental impacts and impose an unnecessary financial burden on Council.

A Flood Watch could be used to strategically deploy plant for a potential opening if required in line with a berm height management plan. Noting that Council already move plant to Shoalhaven Heads on a Flood Watch to ensure this can be quickly deployed for an opening when the EMP trigger levels have been met.

It is also noted that under BoM's service level specifications, they seek to provide a 6 hour warning time for flood levels greater than 2.3m AHD at Nowra and a 9 hour warning time for flood levels greater than 3.3 mAHD at Nowra. The Lower Shoalhaven River Flood Study (2022) identified that for a flood event resulting in 3m AHD at Nowra, the travel time from Nowra to Shoalhaven Heads is 1.5 hours, further increasing available lead time for Council to mechanically open the entrance based on a Flood Warning.

4.9. Berm Management

The trigger level assessment demonstrated that should Council be unable to open the entrance, and that the entrance berm is high (at 2.6mAHD), that this could lead to adverse flood impacts. It is worth noting that the 2.6 mAHD level is highly conservative, representing the highest recorded berm height over 23 years' worth of entrance survey data. Review of the available survey data (taken approximately 2 to 4 times a year between 2001 and 2024) identified that the entrance only exceeded 2.3 mAHD 20% of the time.

However, despite the low likelihood of the berm height reaching 2.6 mAHD, there remains a risk that if the berm level is high, and, Council is also unable to implement the opening policy, then flood conditions may be worsened.

It is noted that the management of the dry notch would work alongside berm management to address flood risks. As previously noted, the purpose of the dry notch is to:

- Reduce the burden of sand required to be removed at the time of a flood to enable efficient mechanical openings; and,
- Control the location of the entrance channel for the protection of the beach and nearby assets.

The presence of the dry notch means that opening the entrance requires the removal of the dune crest (entrance berm) only, and not a full excavation of the dune as would be required without the dry notch. This allows for a quicker and safer opening procedure.

A typical section through the entrance berm, also showing the dry notch maintained upstream, is shown in **Figure 4-7**.

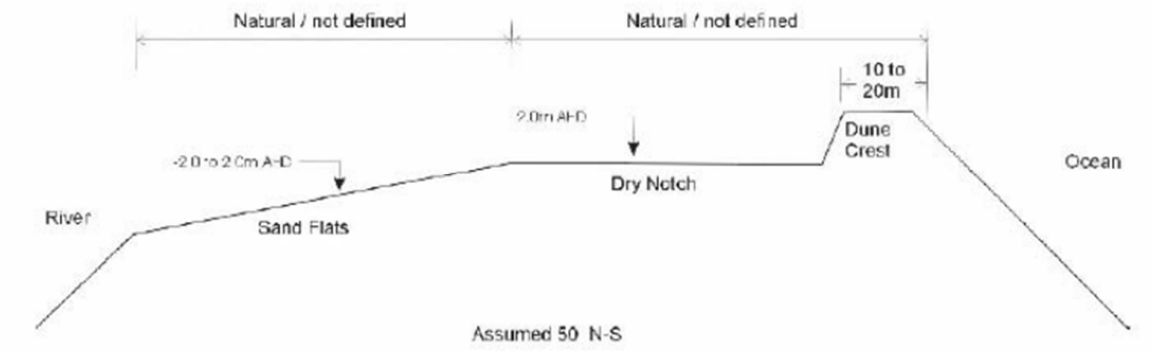

Figure 4-7 **Typical Section of Entrance (Shoalhaven River Entrance Management Plan for Flood Mitigation (2006)**

To manage this risk, it is recommended that an entrance berm height management policy be investigated as part of the REF. This would complement the opening policy, not replace it.

From a flooding perspective, it is recommended that the policy would allow Council to either:

- Maintain the entrance berm and prevent it rising higher than a set level; or,
- Reduce the entrance berm level, if required, in the event of a Flood Watch or Flood Warning. Berm lowering prior to a flood event allows the rising floodwater to overtop the entrance berm at a level which prevents any adverse flood impacts.

Maintaining the entrance berm constantly at a low level would likely be difficult due to the rapid infilling that occurs due to wind and wave action. The assessments showed that a trigger of 2.3 mAHD (representative of a 2.3 mAHD berm height) was sufficient to halve the impacts observed in the 2.6 mAHD scenario.

Such a policy would require consideration to be given to environmental concerns, including consideration of the best times to undertake berm maintenance (the presence of shorebirds for example would present challenges in undertaking entrance berm management). However, it is noted that based on the available survey data, the entrance only exceeded 2.3 mAHD 20% of the time, indicating that frequent maintenance works may not be required (a total of 14 times across the survey record).

It is noted that the berm need not be maintained constantly at a set level. To reduce the environmental and financial impacts, it is recommended that the berm is only lowered on a Flood Watch (assuming the berm height is higher than the applicable EMP trigger level).

Actively reducing the berm level in the event of a Flood Watch would seek to ensure that should a subsequent opening not be possible, then the potential flood impacts are managed. In addition, the works required to undertake an opening would likely be reduced due to the preparation work undertaken during the berm lowering.

It is noted that maintaining the entrance berm at a lower level (or lowering it via berm lowering such as on a Flood Watch) may increase the likelihood of washover, preventing further mechanical intervention from occurring (such as excavating a pilot channel). However, the lowered berm would prevent adverse flood impacts from occurring as it would allow the Shoalhaven River entrance at Shoalhaven Heads to naturally overtop at a level which avoids adverse flood impacts.

A Review of Environmental Factors (REF) would need to consider the likely frequency and the impact of the works on the beach and dune environment and shorebirds.

5. Summary of Outcomes

The assessment examined the impacts of Shoalhaven River entrance at Shoalhaven Heads trigger levels on flood behaviour.

The assessment examined the impacts of trigger levels set at:

- 1.5 mAHD;
- 1.7 mAHD;
- 2.0 mAHD;
- 2.3 mAHD; and,

- 2.6 mAHD.

The assessment found that lowering the trigger level from the existing level of 2.0 mAHD to either 1.5 or 1.7 mAHD did not provide significant flood benefits in flood events ranging from a 20% AEP to a 1% AEP event. Specifically, the reduction in trigger levels had:

- A minor reduction in peak flood levels (0.01 – 0.04 for a 1.7 mAHD trigger, 0.02 – 0.07 m for a 1.5 mAHD trigger);
- A negligible impact on flood warning;
- A negligible impact on period of inundation; and,
- A minor impact on flooding of habitable floors.

It is noted that lowering the trigger level would also be expected to have adverse environmental impacts, and would result in higher maintenance costs for Council (refer **Sections 4.8** and **4.9**).

With respect to Council maintenance costs a review of the historic record from 1990 to 2024, found that a slightly lower trigger of 1.7m AHD may not have resulted in an increase in the overall number of entrance openings (as anytime the levels reached 1.7m, they went on to reach 2.0m). This suggests that a lower trigger may not have a substantial impact on opening costs. However, a lower trigger also requires a lower dry notch to be maintained. A lower dry notch requires not only an increase in excavation depth, but also an increase in excavation area (as all the sand between 1.7mAHD and 2.0mAHD that was not previously excavated, would also require excavation). This would result in an increase to Council's maintenance costs for entrance management.

The additional area that would be required to be excavated would also further increase the environmental impacts of maintaining the dry notch.

Raising the trigger level to 2.3 mAHD was found to moderately increase flood levels and associated flood risk in the Shoalhaven Heads and Greenwell Point (up to 0.15m at Shoalhaven Heads and 0.08m at Greenwell Point).

The assessments also identified that a trigger level of 2.6 mAHD (effectively assessing the flood behaviour if the opening policy is not implemented and the berm height is at 2.6 mAHD) resulted in significantly higher flood levels and longer periods of inundation compared to the other trigger levels.

Whilst Council would seek to implement the policy in all instances, constraints due to time of day (warning issued at night) or unsafe conditions may prevent the opening taking place.

To mitigate this risk, a program of berm maintenance could be investigated, to allow Council to manage the berm heights. It is suggested that berm height management works could be limited to periods when a Flood Watch has been issued to allow for lower berm heights to be achieved, and to reduce the frequency of works to mitigate environmental impacts.

It is noted that the impacts of berm lowering would differ between the shorebird nesting and non-nesting seasons. Environmental impacts would be greater during nesting season and would likely require a threatened species permit to be obtained prior to undertaking any lowering works.

To manage this risk, it is recommended that Council undertake dry notch maintenance and berm lowering immediately prior to the commencement of the shorebird nesting season, if the entrance is closed at this time. This would reduce the risk of having to undertake berm maintenance during nesting season.

This review only examined the potential flood impacts arising from various trigger levels. The environmental impact of implementing an alternative trigger level would need to be fully assessed as part of a Review of Environmental Factors (REF). It is expected that lower trigger levels are likely to have higher environmental impacts.

6. Recommendations

Based on the above outcomes, it is recommended to keep the Shoalhaven River EMP trigger levels at the current level of 3mAHD at Nowra Bridge and 2mAHD at Shoalhaven Heads.

This recommendation is based on:

- The significant adverse flood impacts that arise if the trigger level is raised higher. These impacts occurred in both the 2.3 mAHD and 2.6 mAHD trigger level scenarios, with the impacts from the 2.6 mAHD trigger being particularly pronounced; and,
- The limited benefits that arose from lowering the trigger level. Lowering the trigger level had negligible impacts on flood warning and the period of inundation. Whilst some limited benefits in peak levels were observed for the lower trigger level scenarios, the changes in flood levels were minor compared to the uncertainties present in the assessment (refer **Section 4.2**).

What the assessment did indicate was that there would be no adverse impacts on flood behaviour with a lower trigger level. If environmental and financial impacts were comparable between the various trigger levels, then lowering the trigger to achieve a minor potential improvement in peak flood levels may be warranted. Noting that environmental impacts need to be investigated as part of an REF to support a NSW Crown Lands licence request.

However, a lower trigger level would require more frequent manual openings by Council which would increase both the environmental impacts of the entrance management policy, as well as imposing additional financial costs on Council. Given the significance of these impacts, and the minor flood benefits that would arise from a lower trigger level, this assessment does not recommend a lower trigger level with respect to managing flood behaviour.

The assessment has also recommended that:

- Opening the Shoalhaven River entrance at Shoalhaven Heads should not be undertaken on a Flood Watch as it provides no entrance management benefits and could lead to unnecessary adverse environmental impacts and impose an unnecessary financial burden on Council; and,
- An entrance berm height management policy be investigated as part of the REF (noting this would complement the opening policy, not replace it).

The most effective strategy to reduce flood risk to low-lying properties is to raise low-lying properties and assets to reduce their exposure to flood impacts. Potential flood mitigation options are being investigated as part of the Lower Shoalhaven River FRMSP. This will likely include a combination of property and planning measures, emergency response measures, and potentially structural measures to protect property, subject to viability.

It is also noted that the benefits of entrance management to assist with flood management will continue to reduce and become less effective as sea levels rise. Council's current sea level rise projections for planning purposes are based on a 2030 horizon of 100mm, a 2050 horizon of 230mm and 2100 horizon of 850mm.