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Tweed Sand Plant

Flood & Stormwater Assessment

Client: Hanson Construction Materials

Project No: BE190043

Document No: BE190043-RP-FSA-07

April 2024

Document Control Record

Prepared by:	Samuel Huddy
Position:	Senior Water & Civil Engineer
Signed:	
Date:	22/04/2023

Reviewed by:	Jonathan Cuell
Position:	Director - Urban
Signed:	
Date:	22/04/2023

Version No.	Description	Date	Prepared	Reviewed
00	Draft Submission	16/10/2020	SH	JC
01	Internal Submission	19/02/2021	SH	JC
02	EIS Submission	22/02/2021	SH	JC
03	Response to EIS Submission - Internal Submission	19/10/2021	SH	JC
04	Response to EIS Submission	26/10/2021	SH	JC
05	Peer Review Submission 1	19/09/2023	SH	JC
06	Peer Review Submission 2	01/12/2023	SH	JC
07	Response to Agency Advice Submission	22/04/2023	SH	JC

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Coote Burchills Engineering Pty Ltd ACN: 166 942 365

**Level 2, 26 Marine Parade SOUTHPORT QLD 4215
PO Box 3766, Australia Fair SOUTHPORT QLD 4215
Telephone: +61 7 5509 6400**

**Level 14, 167 Eagle Street BRISBANE QLD 4000
PO Box 83, BRISBANE QLD 4000
Telephone: +61 7 3606 0201**

**Level 1, 91 Landsborough Avenue SCARBOROUGH QLD 4020
PO Box 238, SCARBOROUGH QLD 4020
Telephone: +61 409 935 884**

**Level 3, 16 East Street IPSWICH QLD 4305
Telephone: +61 429 056 347**

Email: admin@burchills.com.au

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Executive Summary

Burchills Engineering Solutions have been engaged by Hanson Construction Materials Pty Ltd to prepare a Flood & Stormwater Assessment (FSA) for Hanson's Tweed Sand Plant which is located on Altona Road in Cudgen, NSW. The proposed development intends to expand the sand extraction area and increase operations from 500,000 tonnes/year to 950,000 tonnes/year over a period of 30 years.

In accordance with the requirements set out in the Planning Secretary's Environmental Assessment Requirements (SEARs) specific to this project, a scope was developed to assess the development's impact on stormwater and flooding. Version 02 of this report was submitted as part of the EIS, Version 4 of this report was submitted in relation to comments made by Tweed Shire Council and this version of the report address the further issues raised by Council. A peer review process was undertaken involving Martens & Associates Pty Lt ('Martens') Consulting Engineers who undertook a thorough review of the modelling practices and the response to Tweed Shire Council's RFI, this version of the report includes modelling alterations as discussed with Martens.

The assessment has focused on the local runoff from the subject site and its external catchments as well as the regional flooding at the site caused by the Tweed River.

The proposed expansion of the Sand Plant, including the proposed haulage route, introduces a significant change to the existing floodplain whereby agricultural land is converted into a pair of large, deep lakes. The hydraulic impacts caused by the development can be summarised as follows:

Changes in Peak Flood Level

This study has defined the allowable impacts (in consultation with Tweed Shire Council) on the surrounding land uses and has quantified the change to flooding as a result of the development. The changes to the flood behaviour for both the local and regional floods are within the acceptable limits as defined by this study due to a gain in flood storage caused by the introduction of the proposed lake system. The proposed Sand Plant expansion does not cause an adverse hydraulic outcome during times of flood.

Cumulative Development Scenario

The development has been assessed against the Tweed Shire Council's cumulative development scenario that was defined by BMT WBM in the 'Tweed Valley Floodplain Risk Management Study' (2014). It was found that with the introduction of the proposed Sand Plant expansion maintains the outcomes of the Management Study and is within the acceptable afflux range.

Changes In Peak Discharge at Critical Infrastructure

Two M1 culvert crossing have been assessed as part of this study, they are defined as the subject sites Legal Point of Discharge. As a result of the development there are no significant changes to peak flow at these culverts and there is no increase in flow rates in the development's ultimate form.



Changes in Inundation Time

Surrounding the proposed lakes are a number of existing low-lying agricultural landuses. It has been determined that the proposed Sand Plant expansion will not result in a change in time of inundation and that flood time remain generally consistent when comparing the existing and proposed development scenarios.

Based on the finding of this study it is not anticipated that the future Hanson Sand Plant Expansion will give rise to actionable damage or nuisance flooding.



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1. Introduction

1.1 Background

Burchills Engineering Solutions have been engaged by Hanson Construction Materials Pty Ltd to prepare a Flood & Stormwater Assessment (FSA) for Hanson's Tweed Sand Plant which is located on Altona Road in Cudgen, NSW. The proposed development intends to expand the sand extraction area and increase operations from 500,000 tonnes/year to 950,000 tonnes/year over a 30 year period.

The assessment has been commissioned to satisfy the provisions of the Tweed Local Environmental Plan and State Planning requirements with respect to the potential impact on local stormwater conditions and regional flood behaviour caused by the proposed expansion. Prior to the preparation of the FSA a scoping exercise was conducted with State and Local Authorities to define the required assessment level for the application.

This assessment will form part of an Environmental Impact Statement to be issued to the NSW state Government for assessment.

1.2 Objectives

The objectives of this assessment have been developed through consultation with local and state authorities, as outlined in the Planning Secretary's Environmental Assessment Requirements (SEARs) for state significant development. The following broad objectives relating to Flood and Stormwater have been identified as key to the assessment of this project:

- Determine the characteristics of local hydrology and detail any changes as a result of the development;
- Detail stormwater management measurements for the development across the life of the expansion;
- Determine the impacts on the flood regime caused by the development across the life of the expansion;
- Determine the developments impact on flood storage balance;
- Address the provisions of the NSW Floodplain Development Manual; and
- Address the provisions in the Tweed Valley Floodplain Risk Management Strategy.

1.3 Scope

To comply with the objectives defined by the SEARs response the following scope has been developed:

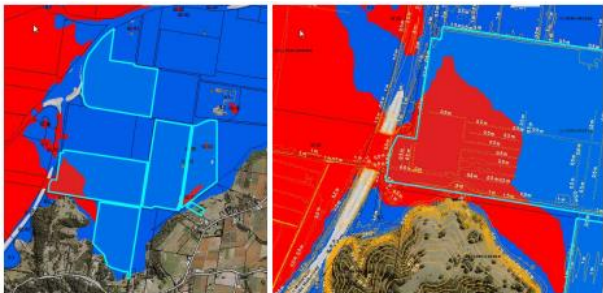
- Review the subject site and determine the existing local hydrologic/hydraulic conditions for the local and regional system;
- Assess the proposed plant expansion and determine changes to the hydrologic regime;
- Outline 'high-level' stormwater management measures for future development hydraulics of the plant; and
- Develop a two-dimensional hydraulic model to assess the changes in regional flood behaviour across the study area as a result of the plant expansion.



1.3.1 Endorsed Tweed Shire Council Comments

In addition to the above-mentioned scope the following items were raised by Tweed Shire Council dated 4 June 2021 with respect to stormwater and flooding on the subject site (Council Reference: DA21/0233 LN 41917). A table has been prepared that summarises Burchills' response to the items raised by Tweed Shire Council.

Table 1.1 Response to RFI – Tweed Shire Council DA21/0233 LN 41917 (1)

Information Request	Request Response
1. Flooding 1.1 High Flow Areas The majority of the site is classified as 'low flow' area. The exception to this is a small area in the south-west corner around the Pacific Motorway culvert/bridge (shown in red in Figure 1 below). In this area existing ground levels are as low as RL 0.5m AHD.  Figure 1 – Low flow (blue) / High flow (red) The proponent's FSA suggests that the proposed lake is to be bunded to RL 1.3m AHD. This will result in a bund approximately 0.8m high being placed directly downstream of the highway culverts. It should be noted this is a flow path of critical importance. It is the primary access to the wider Chinderah/Kingscliff flood storage. Any obstruction to flow here is likely to have significant impacts upstream. The proponent's flood impact assessment does not include the bunding of 'Lake 2' to RL 1.3m AHD. The FSA states that: <i>The proposed bunding at RL 1.3 m AHD has NOT been included as it is considered negligible due to its low level compared to the overall flood levels experienced at the site.</i> Council does not agree with the above statement. Whilst this may be valid for some areas of the proposed lake expansion (where existing topography is already around RL 1.3m AHD) it is not true of the critical high flow area adjacent to the Pacific Motorway culvert/bridge. An 800mm high bund in this area is likely to pose a significant barrier to flood waters entering the Chinderah/Kingscliff storage area and therefore have significant afflux upstream. It should be noted that DCP-A3 only permits changes to ground levels up to 300mm in high flow areas (for local drainage purposes). In this case, given the critical nature of the flow path, 300mm would not be automatically	The lake bunding configuration has been amended following a review of flood results with bunding at RL 1.3 m AHD. It is now proposed to set the lake bunding for 'Lake 2' (the southern lake) to RL 1.0 m AHD, this has been reflected in the modelling. Lake Bunding at RL 1.0 m AHD has been selected because it best represents the existing ground level in the area of the lakes. No bunding is proposed for 'Lake 1' (the northern lake), Lake 1 will overtop at RL 0.5 m AHD toward the LPD.



considered permissible and this would be subject to detailed flood modelling (with bunding included). Any significant bunding in this area is contrary to DCP-A3 and unlikely to be supported. This is a significant constraint for the proposal that has not been addressed and may have substantial implications as the ability to bund the lake to RL 1.3m AHD may not be possible. Refer to request for further information below (Item 8.1).	
1.2 Emergency Response Provisions The proposal does not include any habitable land uses. Therefore the Emergency Response Provisions (evacuation) of DCP-A3 do not apply. Nevertheless, the SEARs included similar assessment requirements and the proponent has adopted DCP-A3's framework and submitted a Flood Response Assessment Plan (FRAP). The FRAP identifies an evacuation approach to risk management, which is considered appropriate. It goes on to identify various flood action plan type measures, which is beyond the intended scope of a FRAP. The FRAP is noted.	No Response required.
1.3 Time of Inundation The FSA does not include any analysis of any changes in the time of inundation due to the proposal. This is particularly relevant to nearby agriculture and development/environmental areas. Prolonged inundation can kill crops, increase nuisance and change environmental values. The proposal will have significant changes to the low-flow drainage regime of the area and therefore may effect time of inundation of surrounding floodplain areas. Refer to request for further information below (Item 8.1).	Discussion on Time of Inundation has been included in Section 4.5 and 6.1.3 In summary, there are no significant times of inundation as a result of the development.
1.4 Reduction in Peak Flood Levels for Minor Events The FSA reports modelling results that predict: <i>For events lower than the 1% AEP, the development improves flooding in the area due to a large gain in flood storage.</i> Whilst the starting water level (at beginning of regional flood modelling event) for each model run is not explicitly stated in the FSA, section 4.7 suggests that the consultant may have adopted the dry weather standing (ground) water level. <i>Flood storage calculations taken from the DFL (3.23 m AHD) to the standing water level at site (0.3 m AHD).</i> The 2 x lakes are proposed to be bunded with overflow weirs at RL 1.0m AHD. Flooding in the Tweed Valley generally follows multiple days of heavy rain. A few hundred millimetres of rain falling over these bunded lakes in the lead up to a flood event would significantly reduce the 'large gain in flood storage'. These antecedent conditions are generally not included in flood model design event runs. Therefore, depending on the assumptions input to the model, the predicted improvements in flooding for events lower than 1% AEP may be invalid. The starting water levels and/or antecedent condition assumptions used for the flood assessment should be clarified to verify the validity of these predictions. Refer to request for further information below (Item 8.1).	The Assessment has adopted a lake full scenario for all hydraulic assessment, i.e. Lake Water levels are set as follows: • Lake 1 – 0.5 m AHD; and • Lake 2 – 0.7 m AHD.
1.5 Cumulative Development Scenario	



The proponent was advised at a pre-lodgement meeting with Council that “...the development must be assessed on an individual and cumulative development basis, consistent with the Tweed Valley Flood Study and Tweed Valley Floodplain Risk Management Study and Plan”. They were also advised that “...Given other significant floodplain developments in the West Kingscliff catchment, modelling of a cumulative development scenario for the 1% AEP and 1% climate change events is warranted. This includes expansion of the aquaculture farm, and sand mining and subdivision development by Gales Holdings. Gales Holdings is advancing their masterplanning and it is strongly advised that Hanson consults and consolidates the current technical studies if possible”. Section 4.6 of the FSA notes (part of) the Gales Kingscliff developments (Lot 21) but does not provide any further, cumulative analysis. This is not considered to be acceptable. The proposal’s impact on flooding in the area cannot be considered in isolation only. If co-operation from Gales Holdings, and their consultants, is not forthcoming the proponent can adopt the Tweed Valley Floodplain Risk Management Study 2014 cumulative development scenario and consult with Council to ensure any change since 2014 are included. A cumulative development scenario must be assessed otherwise the Flood Impact Assessment is not complete. Refer to request for further information below (Item 8.1).	The allowable cumulative development scenario described in the Tweed Valley Flood Study and Tweed Valley Floodplain Risk Management Study and Plan has been assessed with the inclusion of the proposed lakes. It has been determined that the hydraulic impact associated with the cumulative development scenario remains consistent with the Tweed Shire Development Control Plan including the proposed lakes. Additional discussion is provided in Sections 4.4.1, 4.7.2 and 6.2.4.
1.6 Acceptable Afflux Claims The FSA repeatedly claims that afflux as a result of the proposal “...is within the allowable limits as set by the Tweed Council”. It should be noted that these thresholds were adopted for the Tweed Valley Floodplain Risk Management Study cumulative development scenario which included all anticipated fill/development of the floodplain. They are not applicable to an individual development assessment and should not be deemed an acceptable target in isolation. Refer to request for further information below (Item 8.1).	The acceptable Afflux thresholds have been amended, refer to Section 4.7.
1.7 PMF Afflux Results The FSA makes a general conclusion: <i>The proposed lakes do allow flood waters to be conveyed across them with less resistance than the existing farm paddocks, creating a marginal change to the level of flooding in some areas of the model domain. This is specifically notable in extreme events including the 0.2% AEP and above events.</i> However, the PMF afflux maps depict the opposite result. A widespread reduction in peak water level to the east of the site and an area of increase to the south-east. This is inconsistent with the above commentary and the reason for it has not been explained. Refer to request for further information below (Item 8.1).	No response required.
2. Stormwater	
2.1 Predicted Afflux The FSA analyses local stormwater flooding and concludes that:	The method for local stormwater assessment has been updated to a Rain-



It is shown from the local flood assessment an increase in water level outside the allowable increase for rural properties (100mm) is anticipated at interrogation locations B, D, E and F in various events. An increase in flooding is due to loss in conveyance area caused by the proposed lake bunds. It then goes on to claim that, as local stormwater peak flood levels are far lower than the regional peak flood levels, this is acceptable. It is considered that this is an over simplification of the problem. It is not acceptable to dismiss increases in local stormwater flooding simply because regional flooding is worse. Local drainage efficiency and time of inundation is important for the nearby agricultural land uses, for the viability of nearby development areas and for the ecology of environmental areas. The proponent has not demonstrated that the increases in local stormwater flooding are acceptable. Refer to request for further information below (Item 8.1).	On-Grid modelling approach. As such the results and results discussion have been updated.
2.2 Drain Upgrades It is noted that FSA Appendix C contains a map that outlines various drainage channel realignments. The document states that: <i>If during the operation of the sand plant, channels are required to be reformed or realigned, required channel sizing has been indicated in Appendix C.</i> The document then goes on to state: <i>No channel upgrades are proposed under this EIS submission. Predevelopment channel sizing is matched in the proposed scenario and generally catchment areas draining to the channels have been maintained.</i> Further clarification is required in this regard. It appears the FSA local stormwater results conclude that local stormwater afflux is not acceptable, suggests drain upgrades to offset these impacts, but then declines to include them in the proposal. Refer to request for further information below (Item 8.1).	The development proposes to maintain the existing hydraulic regime of the floodplain as much as possible, this is achieved through the following: • Utilise existing channels wherever possible; • Maintain existing channel size parameters if realignment is required; • Maintain the general existing surface level in the area of the lakes during times of flood (i.e. RL 0.7 m AHD). Doing the above minimizes the changes to hydraulic condition, which is reflected in the hydraulic results.
2.3 Time of Inundation As per the abovementioned flood comments, the FSA does not include any analysis of any changes in the time of inundation due to the proposal. The changes to the southern drain result in a longer flow path for low flow drainage to take to reach the outlet. The stormwater analysis should include consideration of low flow drainage and time of inundation. Refer to request for further information below (Item 8.1).	Refer to Request Response Item 1.2.
2.4 Flow from Eastern Catchments Through direct experience and various assessments of development proposals east of the subject site it has been generally accepted that the Altona Road and Julius drains can flow in both directions depending on tail water levels, rainfall distribution and storage stages. The FSA selects a catchment divide that routes stormwater from the east of the site to the north. A sensitivity analysis should be considered where a suitable catchment east of the site are routed to the west, through and around the subject site. Refer to request for further information below (Item 8.1).	Stormwater flows from the eastern catchments have been considered as part of the updated Ran-On-Grid Assessment. Utilizing a Rain-On-Grid modelling approach ensures the complex flow behavior of the floodplain is modelled correctly.



2.5 Peak Discharges The FSA predicts significant increases in peak stormwater discharge at the catchment outlets in more frequent events (refer to tables 3.3 and 3.4). However, no justification as to why this is acceptable is provided by the proponent. It should be noted that, for natural (unsealed) drains, peak discharge increases in frequent events can be related to erosion and associated environmental problems. Avoiding these is the objective of the waterway stability control in Development Design Specification D7 – Stormwater Quality. The proponent should either provide justification as to why these increases will not have any detrimental impact or propose mitigation measures. Refer to request for further information below (Item 8.1).	The updated Rain-On-Grid assessment has resulted in changed results for the local assessment. Changes in peak flows are considered acceptable. Refer to section 6.1.1 for further reference.
8. Request For Further Information	
8.1 Flooding and Stormwater	
a. The proposed Southern lake is to be bunded to RL 1.3m AHD. The proponent's Flooding and Stormwater Assessment does not include this bunding in its flood model as it 'is considered negligible due to its low level compared to the overall flood levels experienced at the site'. The proposal will result in a bund approximately 0.8m high being placed directly downstream of the Pacific Highway Bridge which is a critical flow path for water entering the Chinderah/Kingscliff floodplain storage. Any obstruction to flow here is likely to have significant impacts upstream. It should also be noted that the area near the Pacific Highway Bridge is classified as "High Flow". Tweed Shire Development Control Plan section A3 – Development of Flood Liable Land strictly limits changes to ground levels in high flow areas in order to maintain flood conveyance in critical areas. Any significant bunding in this area is contrary to DCP-A3 and unlikely to be supported. This constraint has not been addressed and a proper assessment may reveal unacceptable flood impacts upstream that could have substantial implications for the proposal.	Refer to Request Response Item 1.1.
b. The Flooding and Stormwater Assessment does not include any analysis of changes in the time of inundation in the surrounding floodplain due to the proposal. This is particularly relevant to nearby agriculture, development and environmental areas. Prolonged inundation can kill crops, increase nuisance and change environmental values. The proposal will have significant changes to the low-flow drainage regime of the area and therefore may effect time of inundation of surrounding floodplain areas. This should be evaluated.	Refer to Request Response Item 1.2.
c. The Flooding and Stormwater Assessment predicts that 'for events lower than the 1% AEP, the development improves flooding in the area due to a large gain in flood storage'. These results are likely to be heavily dependent on the starting water level of the lakes input into the flood model runs, which are not defined in the Flooding and Stormwater Assessment. Flooding in the Tweed Valley generally follows multiple days of heavy rain, while the 2 x lakes are proposed to be bunded with overflow weirs at RL 1.0m AHD. It is likely that a large portion of the "gain in flood storage" would be consumed by this trapped 'pre-flood' rainfall.	Refer to Request Response Item 1.4.



The proponent should define the starting water level and/or antecedent conditions applied to each flood model run so that the validity of this result can be assessed.	
d. The Flooding and Stormwater Assessment analyses the proposals impact on flooding in isolation but does not consider a cumulative development scenario. This not acceptable and a comprehensive cumulative development scenario must be investigated. If the latest plans for surrounding development cannot be sourced from the relevant landowners and their consultants the proponent can adopt the Tweed Valley Floodplain Risk Management Study 2014 cumulative development scenario and consult with Council to ensure any changes since 2014 are included.	Refer to Request Response Item 1.5.
e. The Flooding and Stormwater Assessment repeatedly claims that afflux as a result of the proposal 'is within the allowable limits as set by the Tweed Council'. It should be noted that these thresholds were adopted for the Tweed Valley Floodplain Risk Management Study cumulative development scenario which included all anticipated fill/development of the floodplain. They are not applicable to an individual development assessment considered in isolation only. These precedents can only be considered relevant if a comprehensive cumulative development scenario is undertaken.	Refer to Request Response Item 1.6.
f. The Flooding and Stormwater Assessment makes a general conclusion that 'the proposed lakes do allow flood waters to be conveyed across them with less resistance than the existing farm paddocks, creating a marginal change to the level of flooding in some areas of the model domain. This is specifically notable in extreme events including the 0.2% AEP and above events'. However, the PMF afflux maps depict the opposite result - a widespread reduction in peak water level to the east of the site and an area of increase to the southeast. This is inconsistent with the above commentary and the reason for it should be explained.	Refer to Request Response Item 1.7.
g. The Flooding and Stormwater Assessment analyses local stormwater flooding and concludes that: 'an increase in water level outside the allowable increase for rural properties (100mm) is anticipated at interrogation locations B, D, E and F in various events. An increase in flooding is due to loss in conveyance area caused by the proposed lake bunds. It then goes on to claim that, as local stormwater peak flood levels are far lower than the regional peak flood levels, this is OK. It is not acceptable to dismiss increases in local stormwater flooding simply because regional flooding is worse. Local drainage efficiency and time of inundation is important for the nearby agricultural land uses, for the viability of nearby development areas and for the ecology of environmental areas. The proponent has not demonstrated that the expected increases in local stormwater flooding are acceptable.	Refer to Request Response Item 2.1.
h. The Flooding and Stormwater Assessment predicts some significant changes to peak discharge and peak water level in local stormwater flooding scenarios. It does not propose any mitigation measures to manage these impacts. It is noted that Appendix C contains a map that outlines various drainage channel realignments/upgrades and the document text states	Refer to Request Response Item 2.2.



that: 'If during the operation of the sand plant, channels are required to be reformed or realigned, required channel sizing has been indicated in Appendix C '. However, the document then goes on to state that 'no channel upgrades are proposed under this EIS submission. Pre-development channel sizing is matched in the proposed scenario and generally catchment areas draining to the channels have been maintained'. It appears the Flooding and Stormwater Assessment concludes that local stormwater afflux is not acceptable, suggests drain upgrades to offset these impacts, but then declines to include them in the proposal. This requires clarification.	
i. The Flooding and Stormwater Assessment local stormwater analysis does not include any assessment of changes in the time of inundation due to the proposal. The changes to the southern drain result in a longer flow path for low flow drainage to take to reach the outlet. The stormwater analysis should include consideration of low flow drainage and time of inundation.	Refer to Request Response Item 2.3.
j. The Altona Road and Julius (at the foot of Cudgen ridge) drains are known to flow in both directions depending on tail water levels, rainfall distribution and storage stages. The Flooding and Stormwater Assessment selects a catchment divide that routes stormwater from the east of the site to the north. A sensitivity analysis should be considered where a reasonable area of catchment east of the site is routed to the west, through and around the subject site.	Refer to Request Response Item 2.4.
k. The Flooding and Stormwater Assessment predicts significant increase in peak discharge at the catchment outlets in more frequent events (tables 3.3 and 3.4). However, no justification as to why this is acceptable is provided. It should be noted that, for natural (unsealed) drains, peak discharge increases in frequent events can be related to erosion and related environmental problems (see Development Design Specification D7 – Stormwater Quality waterway stability objective). The proponent should either provide justification as to why these increases will not have any detrimental impact or propose mitigation measures	Refer to Request Response Item 2.5.
l. Table 3.3 of the Flooding and Stormwater Assessment contains typographical errors that should be corrected.	Amended.

1.3.2 Tweed Shire Council Submission – Hanson Tweed Sand Plant Expansion - State Significant Development (SSD-10398)

Additional comments were received from Council dated 6 December 2021 (Council Reference: DA21/0233 LN 41917). A table has been prepared that summarises Burchills' response to the further items raised by Tweed Shire Council.

Table 1.2 Response to RFI – Tweed Shire Council DA21/0233 LN 41917 (2)

Further Council Comments	Response
1. Flooding 1.1 High Flow Areas In response to Council's initial review of the SSD, the proponent has reconfigured the proposed bunding of the lakes. It is now proposed to "...set	Bunding of Lake 2 remains at RL 1m AHD for the majority of the lake



the lake bunding for 'Lake 2' (the southern lake) to RL 1.0 m AHD, this has been reflected in the modelling. Lake Bunding at RL 1.0 m AHD has been selected because it best represents the existing ground level in the area of the lakes. No bunding is proposed for 'Lake 1' (the northern lake), Lake 1 will overtop at RL 0.5 m AHD toward the LPD". Whilst no detail of the proposed bund in the area of concern (highway culverts high flow area) is provided, it is anticipated that this will result in a bund of approximately 500mm across the high flow area and critical flowpath. The model results do not predict any upstream afflux in any regional events analysed, which is unexpected. A 500mm bund through the high flow classified area is still non-compliant with DCP-A3 High Flow Areas controls, which limits fill / obstructions to no greater than 300mm above natural ground. Concern remains with respect to the proposal's intention to place a bund across this critical flow path. The proponent's flood modelling does not predict any upstream afflux as a result of this (which is itself raises concerns with respect to the efficacy of the proponent's modelling) the placement of any bund / fill greater than 300mm in this area is still contrary to DCP-A3 High Flow Areas controls. Proposed cut/fill details of this area should be defined by the proponent and further information provided on how this has been represented in the flood model and by what hydraulic mechanism/behaviour this results in zero upstream afflux. Further information is required in this regard.	perimeter. Lake 2 water level will be controlled by setting bunding to RL 0.7m AHD. The location of this lower bunding will be in the DCP-A3 High Flow Area and therefore complies with the control as bunding will be approximately 200mm high. Concept sketches of the lake bunding and outlet control structures has been included in Appendix B. As demonstrated by the revised flood modelling the proposed Sand Plant expansion does not result in adverse hydraulic impacts.
1.2 Time of Inundation Time of inundation, for local stormwater flooding only, is now included in the proponent's revised Flooding & Stormwater Assessment (FSA). The results are provided in hydrograph format only (no maps) and pose some significant concerns. The FSA concludes that: "It has been determined that alteration of the floodplain in the area of Lake 2 has changed the volume of runoff that drains to western cane farms located between the M1 and Tweed Valley Way. The increased volume of water in this area results in a longer drainage time for the farms. It is anticipated that these downstream properties will remain flooded for a longer period of time than experienced in the existing condition". No mitigation measures or justification as to why this is acceptable is provided by the proponent's RTS. The areas to the south-west of the site, where the results suggest impacts of up to 20+ hours additional inundation in a 0.5EY event (see hydrographs for Lots 721 and 111), are some of the lowest set (sensitive) agriculture areas of the Tweed Valley. "Byrne's Bend", on Tweed Valley Way, is also nearby to this area and known to be subject to flooding in only minor events. This is a major arterial road for the shire – any increase to the duration of	The Time of inundation assessment has been expanded to include regional flood assessment in addition to the local flood assessment. The results of the assessment have concluded that there is no significant change in time of inundation for the low-lying agricultural properties within the extent of the model, including the properties around the 'Byrnes Bend' area.



flooding here is extremely concerning. Further information is required in this regard. It is noted that the proponent's truncated flood model does not extend far enough upstream / south to cover "Byrne's Bend". But the results shown for Lots 721 and 111 suggest similar, negative, impacts here. Time of inundation results should also be analysed for regional flooding scenarios. Further information is required in this regard.	
1.3 Reduction in Peak Flood Levels for Minor Events The proponent's revised FSA defines model run start parameters with the lake water levels set to full. That is, Lake 1 = 0.5m AHD; and Lake 2 = 1.0m AHD. The proponent's initial conclusion that "...for events lower than the 1% AEP, the development improves flooding in the area due to a large gain in flood storage" has now been abandoned and the most significant afflux results are for events less than 1% AEP. Further discussion on the predicted afflux is provided in below sections.	No Response required.
1.4 Cumulative Development Scenario A Cumulative Development Scenario is now included in the proponent's revised FSA. It has adopted Council's TVFRMS&P 2014 fill / development scenario combined with the proposed lakes. It is noted that no consultation was undertaken with Council, as suggested, to incorporate any changes since 2014. It appears that the proponent may have misunderstood the configuration of the Cumulative Development scenario. The FSA notes that: "Industrial development in Chinderah (filled to 2.2m AHD, to represent 65% site coverage for flow obstructions above 2.2m AHD)". It is unclear whether this is a typo, but it appears that the FSA only included fill to 2.2m AHD in these areas. It should be fill to 2.2m AHD WITH 65% site coverage (blockage) above this level. If this has not been applied to the model correctly this may significantly influence the results. Further information is required in this regard.	The cumulative development scenario assessment has been updated in consultation with Council. Representation of cumulative development now 65% blockage for all area above RL 2.2m AHD.
1.5 Acceptable Afflux The proponent has researched "acceptable afflux" thresholds that have been applied to other developments (in isolation - not cumulative) and proposed some thresholds to be applied to this application. Essentially, the revised FSA proposes: 10mm maximum on existing buildings, 50mm maximum in residential areas (non-buildings), 100mm maximum in rural areas. No judgement of the appropriateness of these thresholds is made. However, it is noted they are somewhat similar to those accepted in the Tweed Valley FRMS&P. The FSA results then go on to exceed these self-imposed thresholds (see Table 6.7). The only justification offered as to why this might be acceptable is that it occurs only in one of the 3 phases (Phase 9) modelled and disappears in the ultimate configuration. "Phase 9" is scheduled to last for 3 years. The modelled scenarios do not enable Council to determine if the	Flood afflux thresholds have been discussed with Council and are noted as a guide for acceptable flood impacts. Revised flood modelling demonstrates that the proposed Sand Plant Expansion ensures flood impacts are within the proposed afflux limits. The flood impacts in the regional flood events are considered to be acceptable and do not cause an adverse hydraulic outcome. Differences in the Cumulative Development Assessment and the



similar, adjacent, phases will have similar impact. This is not an acceptable justification. No efforts to ameliorate this afflux appears to have been made. Further information is required in this regard. The Cumulative Development Scenario adopts the TVFRMS&P 2014 precedent afflux thresholds. The modelled afflux results are depicted in Figure F27 and show a reduction in peak 1% AEP levels in Chinderah in the order of 50 – 100mm. These results are not actionable; however this is not consistent with the TVFRMS results, which is slightly concerning.	assessment completed in the TVFRMS are likely caused by updates to the TUFLOW modelling methodology. TVFRMS was completed in 2009 and relied on a 40m grid U. This assessment has refined the grid size to 8m. It is noted that the updated modelling achieves reasonable calibration with the 1% AEP flood result.
1.6 PMF Afflux No response is provided by the proponent to this item. Modelled flood events now only go up to 0.2% AEP. Although Figure F18 shows a 0.0005% AEP (EXT) afflux results that follow a similar pattern.	Afflux assessment considers events up to the 1% AEP flood + Climate Change. Afflux assessment above the 1% AEP + CC is not required as agreed with Council. Flood assessment extends to the 0.0005% event.
2. Stormwater 2.1 Predicted Afflux The proponent's FSA has been updated to a "Rain-on-Grid" model. Section 6.1.1 of the FSA provides a peak flow assessment and concludes that: "...Generally peak flows at the site's LPDs are maintained in the post-developed scenario. A maximum increase 0.57 m³/s is experienced at the Southern M1 Culverts in the 2% AEP. This equates to a 4% increase in flows and it is not anticipated that this will cause adverse hydraulic impacts or give rise to nuisance in the downstream floodplain". This statement is not concurred with. The results for 0.5EY in Table 6.2 represent a 20% increase in peak flow to the Southern point of discharge. Further information is required in this regard. This is also reflected in the time of inundation results discussed below. The time of inundation conclusions in the proceeding section give a conflicting conclusion: "...It has been determined that alteration of the floodplain in the area of Lake 2 has changed the volume of runoff that drains to western cane farms located between the M1 and Tweed Valley Way". Table 6.3 also shows 'notable afflux' which depicts up to 30mm increase in the area around Melaleuca Station and the adjacent servo. Whilst this may be within the thresholds of the proponent's self-imposed limits, it is concerning. No attempt to ameliorate this has been made. Further information is required in this regard.	Revised modelling indicates that peak flow rates at each of the Lawful Points of Discharge is generally less in the proposed scenario then compared with the existing scenario. The proposed Sand Plant expansion stores runoff during flood events and thus peak flows are detained. It is noted that there are some events where a very small increase in peak flow is observed, these increases are generally limited to 2%. For all events there is a decrease in the ultimate development scenario. The proposed Sand Plant Expansion does not significantly impact inundation times as is demonstrated in the results. Lowering of the lake water level and inclusion of the many smaller drainage structures throughout the flood plain has assisted in achieving acceptable afflux results.
2.2 Drain Upgrades The proponent's revised FSA clarifies that no drain upgrades are proposed	No response required.



2.3 Time of Inundation Results are unacceptable – refer to time of inundation comments above	Discussed above.
2.4 Flow from Eastern Catchments The proponent has adopted a “Rain-on-Grid” model to represent complex catchment conditions. This is considered to be acceptable.	No response required
2.5 Peak Discharges As noted, the proponent has adopted a “Rain-on-Grid” model to represent complex catchment conditions. The revised FSA concludes that: “...the updated Rain-On-Grid assessment has resulted in changed results for the local assessment. Changes in peak flows are considered acceptable”. Council does not agree with this conclusion. The changes in peak flows are not considered to be acceptable. No comment on waterway stability has been provided in the context of the increased flow rates / volumes in frequent events. Refer to comments above on peak flow and time of inundation.	Revised modelling indicates that peak flow rates at each of the Lawful Points of Discharge is generally less in the proposed scenario then compared with the existing scenario. The proposed Sand Plant expansion stores runoff during flood events and thus peak flows are detained. It is noted that there are some events where a very small increase in peak flow is observed, these increases are generally limited to 2%. For all events there is a decrease in the ultimate development scenario.
3. Additional Flooding / Stormwater Issues 3.1 Regional Flood Afflux (in isolation) The proponent’s revised FSA provides regional catchment flooding afflux predictions for various modelled scenarios of the development in isolation (not cumulative). Whilst the proponent has suggested ‘acceptable afflux’ thresholds, it is beyond the authority of a Council officer to endorse what external impact is “acceptable”. Nevertheless, the following results are considered concerning: ☐ Phase 11 – 20% AEP (Fig F13); ☐ Phase 9 – 20% AEP (Fig F19); ☐ Phase 9 – 5% AEP (Fig F20); and ☐ Phase 7 – 20% AEP (Fig F23).	Afflux in the identified problem areas has been resolved. Afflux in the regional flood events is generally in accordance with the acceptable afflux criteria.
3.2 Local Flood Afflux (in isolation) The proponent’s revised FSA provides local stormwater flooding afflux predictions for various modelled scenarios of the development in isolation (not cumulative). Whilst the proponent has suggested ‘acceptable afflux’ thresholds, it is beyond the authority of a Council officer to endorse what external impact is “acceptable”. Nevertheless, the following results are considered concerning:	Afflux in the identified problem areas has been resolved. Afflux in the local flood events is generally in accordance with the acceptable afflux criteria.



☐ Phase 11 – 20% AEP (Fig F13); ☐ Phase 9 – 20% AEP (Fig F19); ☐ Phase 9 – 5% AEP (Fig F20); and ☐ Phase 7 – 20% AEP (Fig F23).	
3.3 Afflux Map Gradation Some of the afflux maps show substantial changes to peak levels in an area and zero change adjacent. For example, Table 6.7 (second graphic) shows 56mm of afflux and immediately zero in the adjacent area. It is questioned as to why there isn't a graded afflux? (say 40mm in the next cell, then 20, then 10). 	Afflux mapping has been updated to include wet-dry mapping that was previously excluded. Given that the local flood assessment has been completed with Rain-On-Grid, afflux gradation is somewhat different given the entire model domain is 'wet'. It is important to note that the afflux issues have been resolved in the above-mentioned locations.
3.4 0.005% AEP (EXT) Results There are some very strange results depicted for the 0.005% AEP (EXT) scenario (Figure F11). Downstream water levels are shown as >7m AHD whereas upstream levels are in the order of 6m AHD (a reverse gradient). This does not match the results of the Tweed Valley Flood Study 2009.	Revised flood modelling has resolved erroneous data previously presented for the 0.0005% AEP.

1.3.3 Gales-Kingscliff - Submission for Proposed Hanson Tweed Sand Plant Expansion (SSD-10398)

A submission made by Gales-Kingscliff on 19 May, 2021 requested updates to the hydraulic modelling within the FSA. A summary of the requests and the Burchills responses have been included in the below table.

Table 1.3 Response to RFI – Public Submission

Information Request	Request Response
B. Stormwater / Agricultural System	
We believe that the depiction of the stormwater and agricultural drainage system within the EIS and supporting Flood & Stormwater Report (Burchills, 2021) is erroneous. Specifically on Figures 3.2 and 3.3 of	Catchment Mapping provided in Figure 3.2 and Figure 3.3 is indicative for the immediate local catchments and does not



Burchills (2021) report the drain along the south-east part of the existing Quarry lake is not shown as a drain and Catchment 10 shows flow from Cudgen Plateau draining towards the east and north across bunded areas of CLSQ rather than to this unmarked drain. This is incorrect and is inconsistent with previous correspondence between Hanson and Gales regarding inundation of Gales lands caused by blockage in the agricultural drainage system impeding drainage from CLSQ to the west and contributing to wetting up of Gales land to the east of the blockage. It is acknowledged and appreciated that, in response to Gales raising this matter, Hanson commissioned Gilbert & Sutherland to investigate and provide reporting on this matter. Whilst the drainage lines and blockage appears to be on land immediately south of the Hanson operation (and where not owned by Hanson not a Hanson responsibility), the G&S report correctly depicts a portion of the drainage line south of the Hanson Tweed Sand Plant and indicates that this is tidal to the west by presence of salt tolerant aquatic vegetation. This is not reflected within the Burchill (2021) report. Whilst Gales continues to consult with Council, EPA and relevant land owners regarding removal of blockage to the drainage, it is requested that the Flood & Stormwater Report be revised to account for the correct drainage. This is of particular relevance given that Hanson's proposed expansion would remove the tidal connection of this area to the west and north to the Tweed River and as such should account for and consider the correct catchments on the basis of the properly functioning drainage system. The Burchill (2021) report appears to omit the existing drainage channel along the south-east part of the Hanson lake and to substantially underestimate the catchment area that would drain into the Hanson extraction pond. Given that the Hanson proposed expansion would permanently change the local drainage, proper assessment of this matter is essential. In addition to the above, in the drainage schematics shown in Appendix C of Burchill (2021) it is noted that the drainage direction for the existing drain adjacent Altona Road is incorrectly depicted as flowing from west to east. This drain cannot drain towards the east but drains westwards (towards the Tweed River). Gales is extremely concerned about the local drainage. CLSQ and Gales land beyond has become wetted up and Gales is currently in discussions with Council, local landowners and the EPA to determine to causes of the wetting up and blockages to drainage west. It is requested that the Burchill (2021) Flood & Stormwater Report be revised to account for the correct existing drainage, the blocked drains preventing flow west, and the impact of Hanson's proposed changes.	include regional external catchments that may or may not affect flows at the site depending on hydraulic grade. The catchment maps only pick the main flow paths of each catchment and do not pick up minor flow paths that feed to these main lines. Drainage lines along the south-east of the subject site are free from blockage as determined by a site inspection in February of 2021. Regardless of the nature in which drainage occurs around the site, a Rain-on-Grid model has been developed that accurately simulates the complex flow behaviour around the subject site. As rainfall has been applied to the entire model domain, all drainage paths (no matter the significance) have been modelled and the results of the proposed development on the local flood regime are discussed in Section 6.1.
C. Flood Assessment The assessment has not properly defined the external catchment influencing flood levels at the site (Figure 3.2). A local catchment flood assessment of the broader area undertaken for Gales by Venant Solutions established that during a 1% AEP event the drain along Altona	As discussed above, the flood assessment has been updated to utilise Rain-On-Grid Modelling that accurately simulates the



Road flows from east to west towards the Hanson site. Further, this drain receives runoff from the catchment to the east of Tweed Coast Road.	complex flow behaviour around the subject site.
There is no reporting of flood levels under existing and developed conditions at the eastern end of the site (western edge of Gales land) to demonstrate non-worsening.	Results discussion regarding hydraulic impact caused by the development is provided in Section 6.1 and 6.2 . Flood mapping has been provided in Appendix F .
For the regional flood assessment, the afflux limits in Section 4.1.1 of Burchill (2021) are taken from the BMT WBM report prepared for Tweed Shire Council's cumulative fill assessment. Hence these are limits for the cumulative fill scenario, not an individual assessment. To use these limits, the proposed Hanson development should have been tested in combination with Council's cumulative fill scenario and assessed against a no fill scenario.	Acceptable afflux limits have been amended, please refer to Section 4.5 and 4.7 . Cumulative development including the development has been assessed, please refer to Section 4.4.1 and 6.2.4.
The modelling did not include the proposed bund walls at 1.3 m AHD and 1.75 m AHD. A statement is made in Burchill (2021) that the bund walls were not included because they would have negligible effect, but the purposes of the modelling should have been to demonstrate that this is the case. If the bunds are included and the lakes are at 1.0 m AHD (the level of the weir outlet) when the main river flooding arrives this will represent a loss of flood storage which has not been included in Council's cumulative fill scenario as noted above. It is plausible that the lakes would be at 1.0 m AHD because of rainfall falling locally over the lakes prior to the main river flood arriving.	Flood modelling has been updated to include the proposed bunding associated with the subject site.

1.4 Peer Review Process

The hydraulic modelling completed for this assessment has undergone a thorough peer review process with Martens. A number of changes have been made to both the modelling inputs and methodology. These are summarised as follows:

- Revision on the regional flood inflow application (refer to Section 5.1.2);
- Rectifying the drain thalweg issue beneath the Pacific Highway Bridge;
- Revision of soil loss parameters to be consistent with the Tweed River Flood Model as per ARR2019 guidance (refer to Section 5.1 and Table 5.1);
- Assessment of a larger range of durations to determine the appropriate design event (refer to Section 4.3);
- Revision of the Mannings coefficient within urban areas (refer to Table 5.1);
- Use of Quad-Tree to refine the model resolutions in the agricultural drains for the local flood assessment (refer to Section 5.1.1);
- Excluding of Aerial Reduction Factors for the rainfall inputs in the local flood assessment;
- Modification to the terrain used in the regional and local models to reflect recently approved residential and commercial developments in the vicinity of Spoonbill Lane, Cudgen and southwest of Peal Street between Turnock and Boomerang Streets;
- Updating the roughness parameters (Manning's coefficients) according to the latest aerial imagery for the regional model (refer to Section 5.1.3); and
- Addressing styling issues in the flood impact mapping thresholds.



1.5 Data Collection

A variety of data was collected and used as part of this assessment. The data and sources adopted include:

- Data contained within Tweed Shire Council's Tweed Valley Flood Study 2009 (Tweed Shire Council, 2009);
- 1m LiDAR (NSW Government Spatial Services, 2013);
- Survey of Culverts (Landsurv Pty Ltd, 2020);
- Additional Survey of Culverts (Shapr Spatial Services, 2023)
- Council GIS data (Tweed Shire Council, 2020), including:
 - DCDB;
 - Zoning data; and
 - Stormwater Network data.



2. Site Details

The subject site is located on Altona Road, Cudgen, NSW and comprises the following parcels of land:

- Lot 22 DP1082435;
- Lot 23 DP1077509;
- Lot 494 DP720450;
- Lot 1 DP1250570;
- Lot 2 DP1192506;
- Lot 3 DP1243752;
- Lot 51 DP1166990; and
- Lot 50 DP1056966.

2.1 Land Use and Vegetation

Part of the subject site has been operating as a sand extraction plant since 1982 with Hanson taking over in 2007. Much of the site is currently vacant land with low ground cover (grass and sedges), prior landuses of the site have resulted in agricultural drainage lines throughout.

The site is surrounded by the following land uses/receptors:

- North – Tweed Shire Council's wastewater treatment facility; the proposed Carbrook Sands Plant isolated residential receptors; agricultural land (cane, grazing); Pacific Motorway and township of Chinderah in the distance (approximately 2 km);
- East – Cudgen Lake Sand Plant (Cudgen Lakes); township of Cudgen (approximately 1 km); Township of Kingscliff in the distance (approximately 3 km);
- South – Rural Residential receptors located along Cudgen Road ridge; Farm & Co Kingscliff; and
- West – Australian Bay Lobster Producers Pty Ltd; Melaleuca Station Memorial Gardens and Crematorium; Pacific Motorway; agricultural land (cane, grazing).

An aerial photograph of the site in its current state is shown below in Figure 2.1.





Figure 2.1 Site Aerial Photograph January 2024 (Nearmap)

2.2 Topography

The subject site is located within the Tweed Valley flood plain with the Tweed River approximately 3 km to the west. The subject site is generally flat with the average level of the site at relative level (RL) 1 m AHD.

There are many agricultural drainage channels present on the site these drain to main drainage lines that discharge flow at the M1.

2.3 Proposed Development

The Hanson Tweed Sand Plant Expansion involves an increase of extraction and processing of up to 950,000 tonnes of sand per annum for up to 30 years and the construction of a new building and wash plant. The project will also involve the transport of material off-site by public roads and progressive rehabilitation of the site this will involve the addition of a new haulage route in and out of the site.

The proposed phasing plan for the sand plant has been provided in Figure 2.2. A concept development / extraction phasing plan for the expansion can be found in Appendix A.



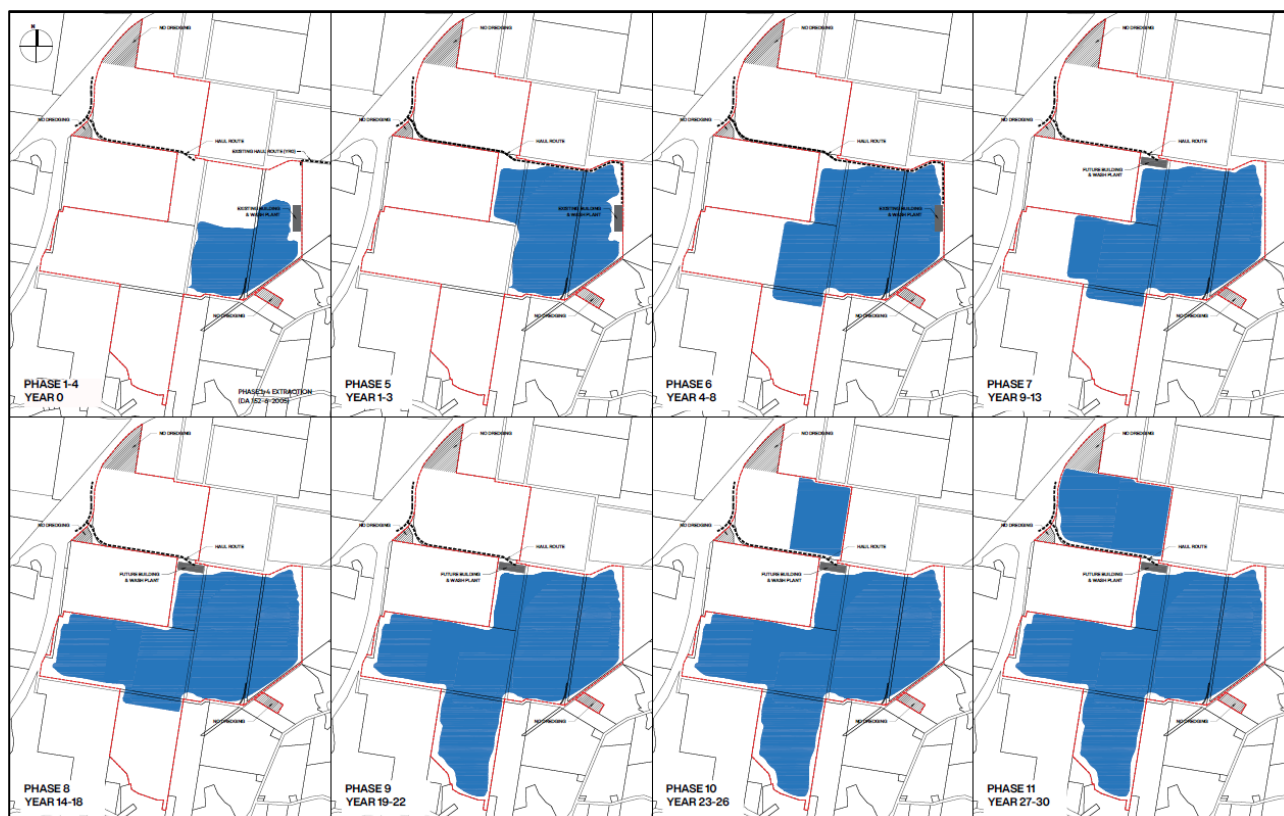


Figure 2.2 Proposed Site Phasing Layout (Zone, 2021)



3. Flooding and Stormwater Overview

3.1 Stormwater Management

The expansion of the sand plant production activities will result in the creation of large lakes, runoff produced over the lakes will be captured in the lakes and overtop once the lakes reach their limit. The lake bunding and overflow parameters are presented in the following table.

Table 3.1 Lake Stormwater Management Parameters

Lake	Lake Bunding Invert Level	Lake Overflow Invert Level	Lake Standing Water Level
Lake 1	No bunding proposed, lake level controlled by outlet set at RL 0.5 m AHD	0.5 m AHD	0.5 m AHD*
Lake 2	Minimum bunding to RL 1.0 m AHD, set to match existing floodplain surface level	0.7 m AHD	0.7 m AHD*

* Stormwater Modelling has considered the lake water level as a 'full condition', it is noted that lake levels vary significantly as document in the Gilbert and Sutherland Water Balance Assessment (ref: 12035_WB_RAF1Fr).

The ground level in the location of Lake 1 sits at approximately RL 1.0 m AHD. As Lake 1 water level will be controlled at the outlet of the lake to RL 0.5 m AHD, no specific bunding will be required around the perimeter of the lake.

Lake 2 water level will be controlled with a weir at RL 0.7 m AHD in the far west of the site near the M1. General bunding at RL 1.0 m AHD around the remained of the lake permitter is proposed to maintain the discharge location at the Lawful Point of Discharge.

In the proposed condition the general conveyance of external catchments is to be maintained using the existing drainage lines. Any realignment of existing channels will be minor in nature and ensure existing discharge locations are maintained. Once channels reach their hydraulic capacity, overtopping into the adjacent floodplains and Lakes is permitted as per the existing condition. Catchments to the south-east of the site (catchment 2 and 3 in [Figure 3.3](#)) will be permitted to enter the proposed lake via proposed culverts (4 x 600mm RCP).

If channel realignment is required to suit the proposed lake expansion, channel sizing has been indicated in Appendix B. It is important to note that no channel upgrades are proposed under this EIS submission. Pre-development channel sizing is matched in the proposed scenario and generally catchment areas draining to the channels have been maintained.

A new haulage route is proposed from the future washdown facility to the M1. The haulage route is proposed to be located at RL 1.35 m AHD (existing haulage route immunity), a culvert bank of 7 x 1500mm x 750mm RCBC is proposed at the existing channel location.

A conceptual drainage schematic for each of the proposed plant's expansions has been prepared in Figure 3.1, detailing the proposed channel realignments, bunding, hydraulic structures, control weir and washdown facility location at the subject site. Figure 3.2 and Figure 3.3 identify the site's local



catchments and associated flow paths. Refer to Appendix B for reference to stormwater management through the development phases.

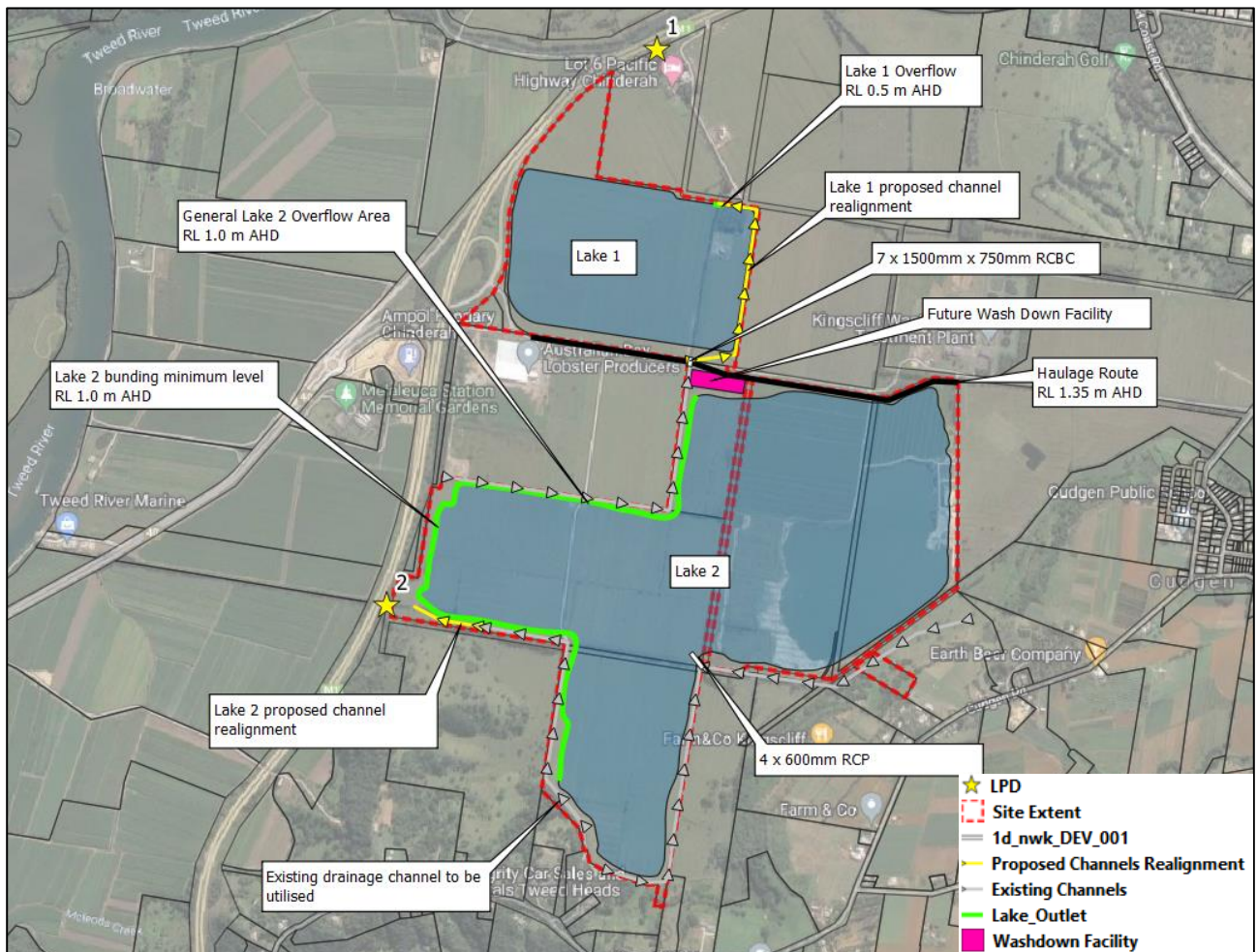
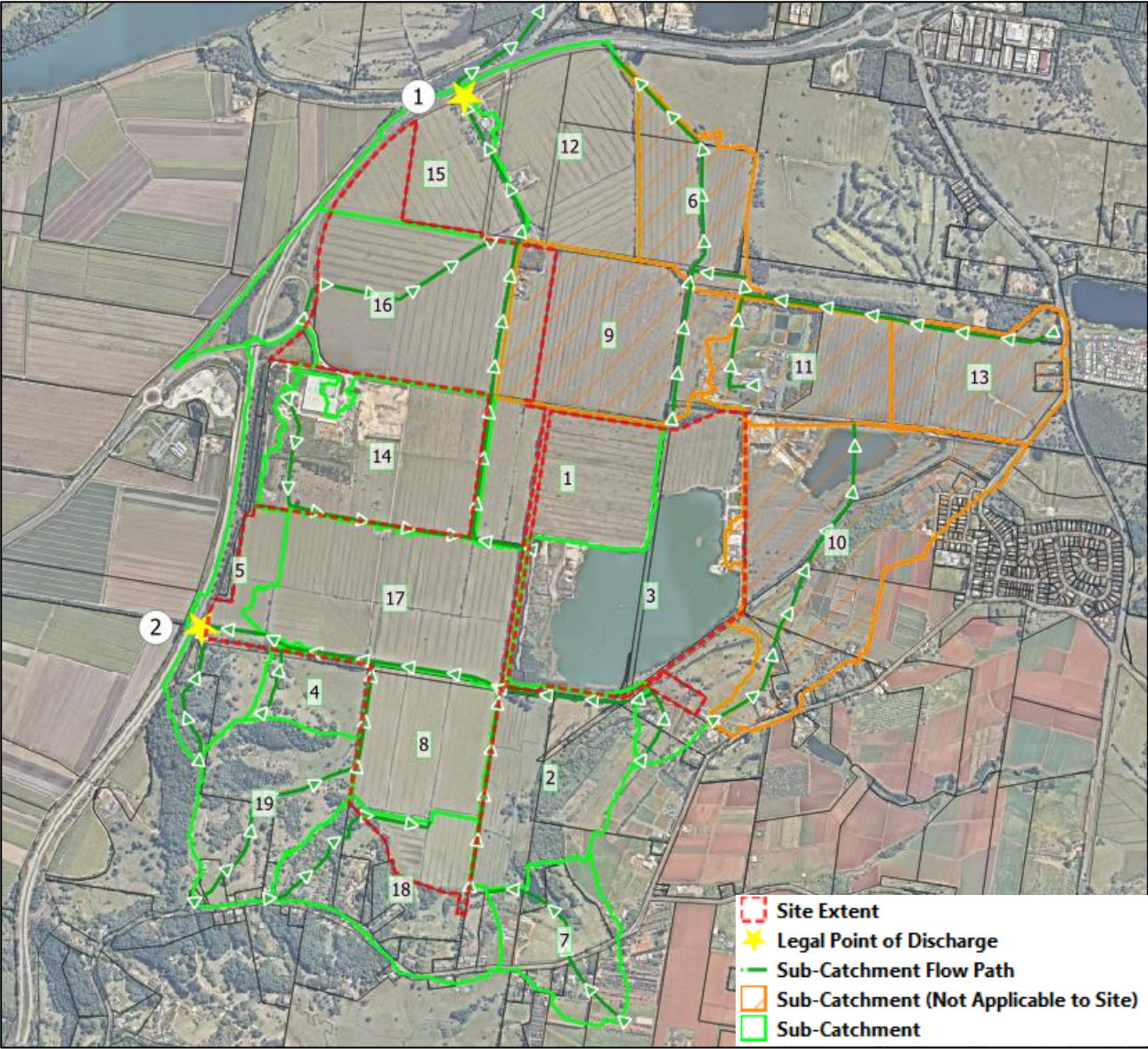


Figure 3.1 Conceptual Stormwater Management Schematic



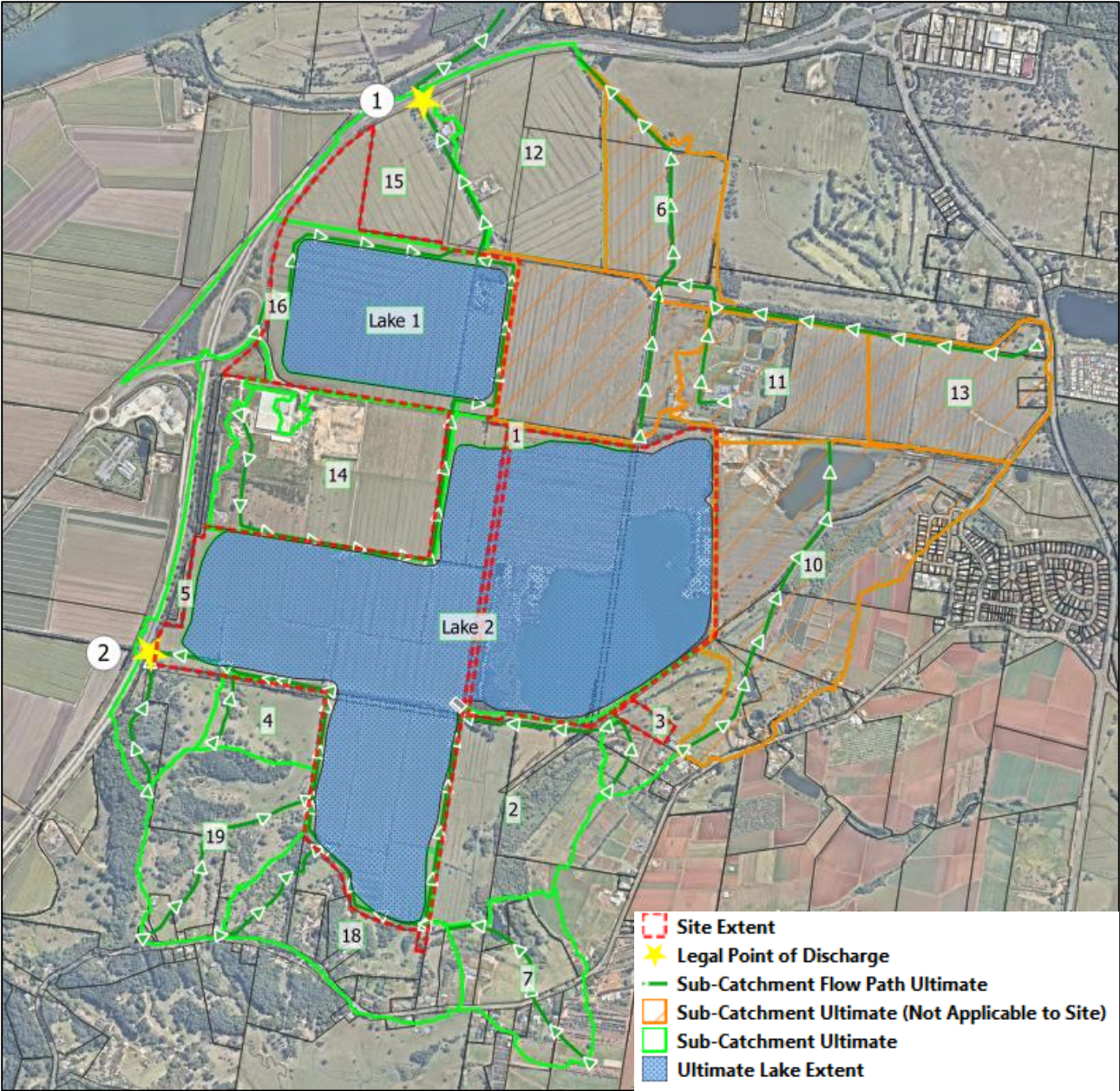


Figure 3.3 Local Catchment Map and Flow Paths – Ultimate Case (Phase 11)



3.2 Proposed Site Office and New Sand Washing Plant

A new building and sand washing plant has been proposed for later stages of the expansion (Phase 7). The layout of the proposed facility is to be confirmed at a later date, as such a Stormwater Management Plan (SMP) for the new facility will be prepared as this time.

The future SMP will need to consider the following:

- The management of runoff from the site, ensuring the proposed sand washing plant does not cause any adverse conditions to downstream properties.
- The management of stormwater quality, ensuring that the Water Quality Objectives of the local authority is achieved.

Runoff from the new sand washing plant will discharge back to the dredging lakes. This will ensure runoff and pollutants are captured on site and do not discharge externally to the site.

3.3 On-Going Maintenance Requirements

Hanson will conduct all necessary works during operation to maintain the proposed drainage regime. This will include the following works:

- On-Going scour protection remediation wherever erosion occurs at the lake outflow locations; and
- Ensure channels on site are free of debris and remain unblocked.

3.4 Regional Flooding

The existing site is located within the Tweed River Floodplain and is subject to regular inundation during high rainfall events. The majority of the flood inflow enters through the culverts that run beneath the M1 to the west of the TSP. Flood waters generally drain from the site through said culverts and to rural areas to the east. Typical flood depths within the site for a 1 in 100 AEP event prior to development is 2.0 – 2.1m with flood velocities of 0.1 m/s. The proposed haulage routes are set at RL 1.35m with a flood immunity that corresponds to approximately a 10% AEP local flood event. The existing washdown facility is at RL 3m with a flood immunity that corresponds to a 1% AEP event.



4. Flood Assessment Methodology

4.1 Overview

To assess the impact of the proposed development on the hydraulic regime, two-dimensional hydraulic modelling has been utilised that maps the flooding within the study area in both scenarios. TUFLOW hydraulic modelling software is the chosen platform. This assessment focuses on regional flooding at the site and investigates the potential for the proposed development to cause damage or nuisance to external properties.

4.2 Flood Assessment Scope

To assess the impact the proposal will have on the existing flood regime the following scope has been prepared:

- Data Collection:
 - Review and assessment of data completeness for use in the development hydraulic assessment.
 - Review existing Tweed Shire Council flood mapping, Flood Studies and Flood Policy.
- Hydraulic modelling:
 - Utilise Council's regional model, subdivide a smaller TUFLOW model with refined cell size, 1D elements, Manning's roughness values, and topography to represent the Tweed River floodplain;
 - Calibration of the refined TUFLOW model to Council's Designated Flood Level result (1% AEP);
 - Simulation of the regional flood event using the calibrated model;
 - Simulation of the local flood event utilising Rain-On-Grid Methodology.
 - Review of modelling results and identification of critical flood events for each AEP.
 - Review of modelling results including water level impacts, velocity impacts, hazards, and modelling inefficiencies; and
 - Refinement of proposed development to minimise flood impacts external to the subject site.
- Report and Mapping
 - Presentation of flood afflux maps for water surface level;
 - Impact assessment;
 - Review of any impacts resulting from the proposal in the context of whether such afflux may give rise to potential actionable damage to surrounding properties; and
 - Review of flood results in relation to the development conditions.

4.3 Local Flood Assessment

Local flooding within the study area has been assessed using a Rain-On-Grid method. Rain-On-Grid was adopted to accurately simulate the floodplain that is understood to flow in different directions depending on hydraulic grade within the system. In accordance with AR&R 2019 guidance the following statistical ensemble assessment method was used for the Local Flood Assessment.



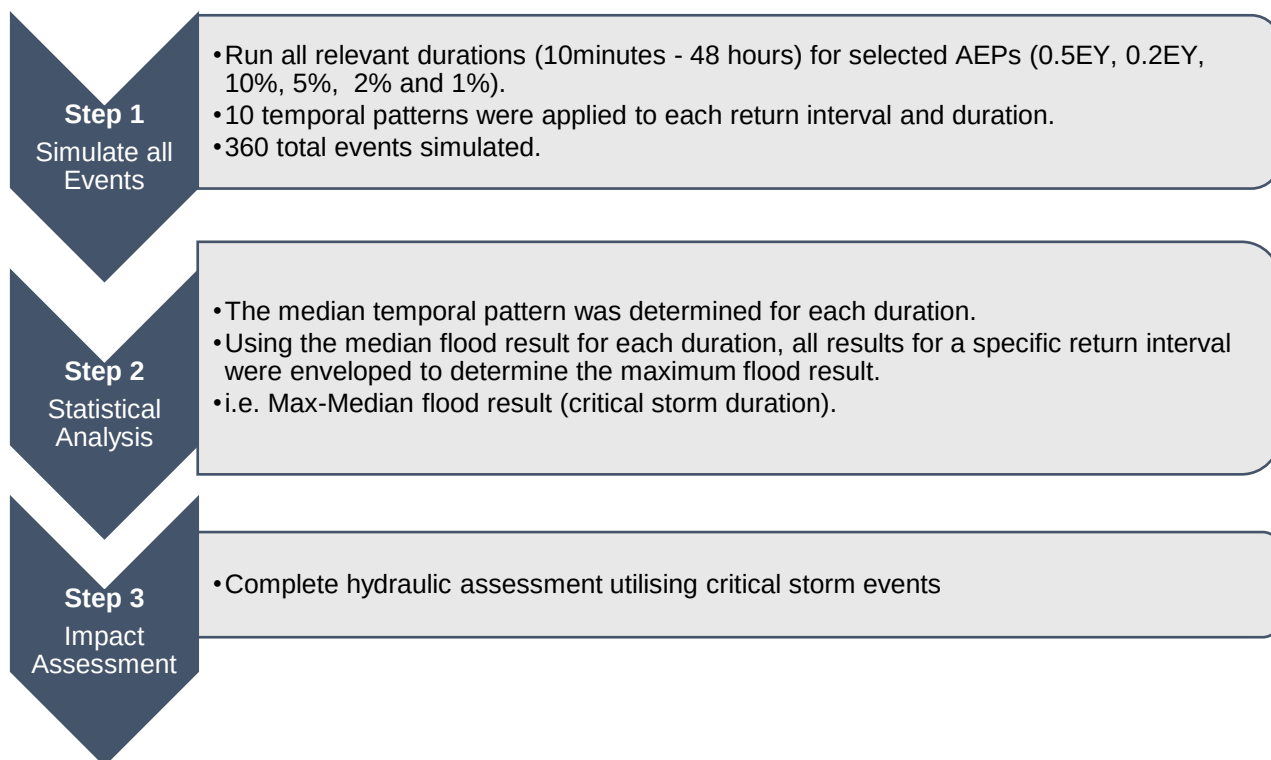


Figure 4.1 Local Flood Assessment Methodology Summary

4.3.1 Statistical Analysis

Based on the statistical analysis discussed above, critical storm durations could be identified for the Lower Tweed Valley Floodplain. Refer to Figure 4.2, Figure 4.3 and Figure 4.4 for the spatial distribution maps that indicate the median local flood event duration adopted. The following critical storms were determined.

Table 4.1 Critical Storm Duration Lower Tweed Valley Floodplain

AEP	Critical Storm Duration (Max-Median)
1%	36hr Temporal Pattern 6
2%	24hr Temporal Pattern 1
5%	18hr Temporal Pattern 6
10%	18hr Temporal Pattern 6
18%	18hr Temporal Pattern 3
39%	18hr Temporal Pattern 7



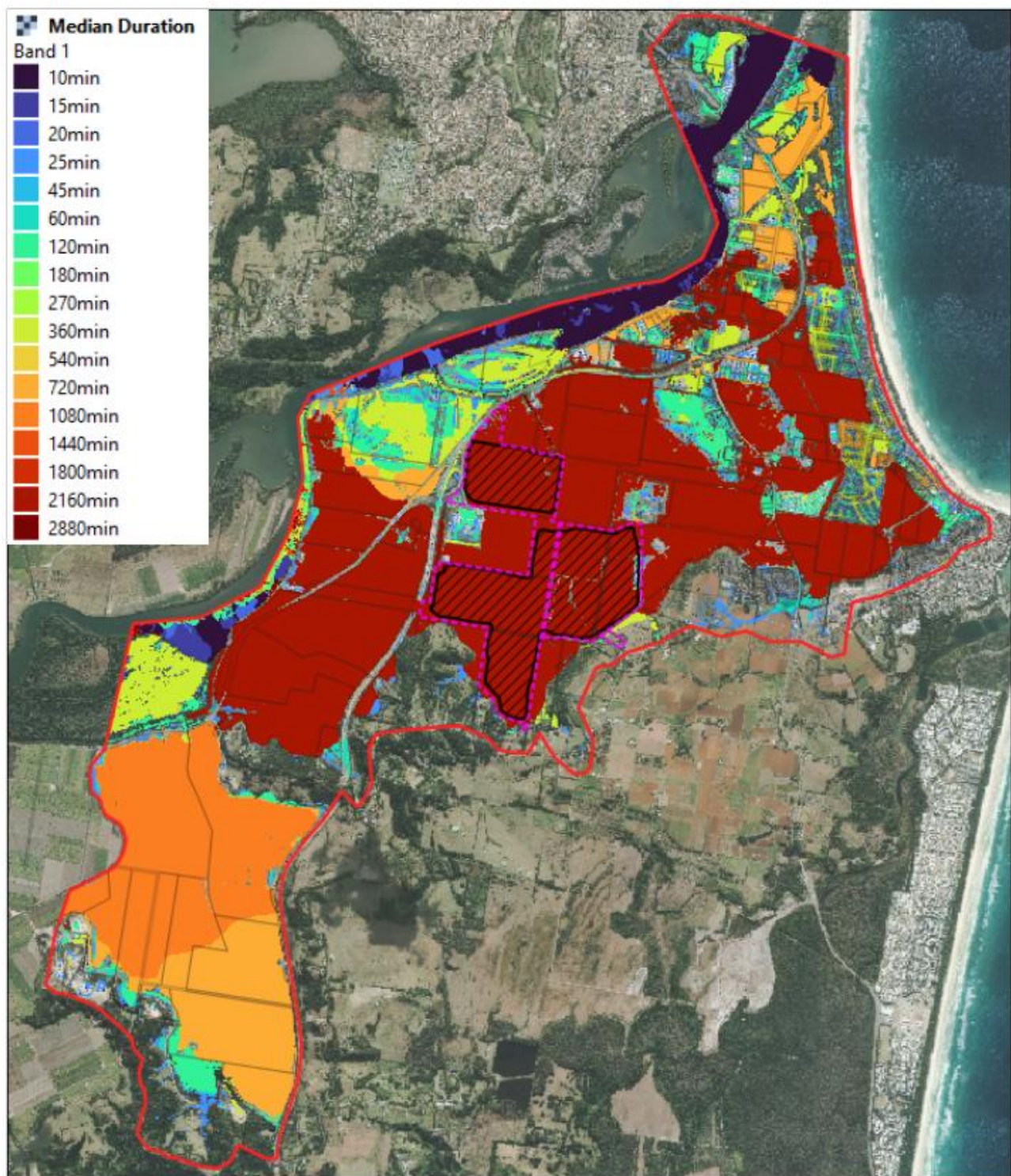


Figure 4.2 1% AEP Local Flood Model Spatial Distribution Median Duration



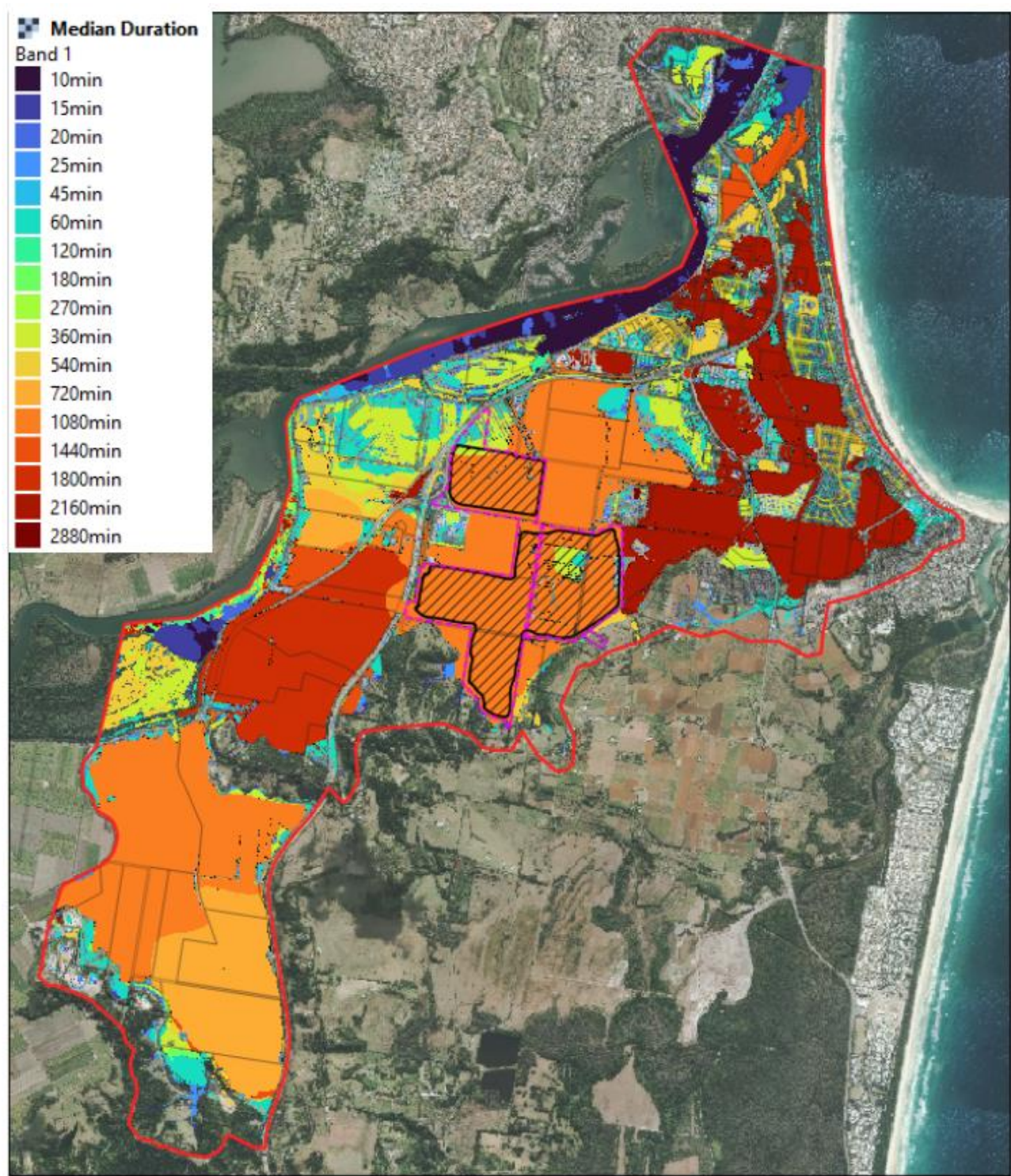


Figure 4.3 5% AEP Local Flood Model Spatial Distribution Median Duration



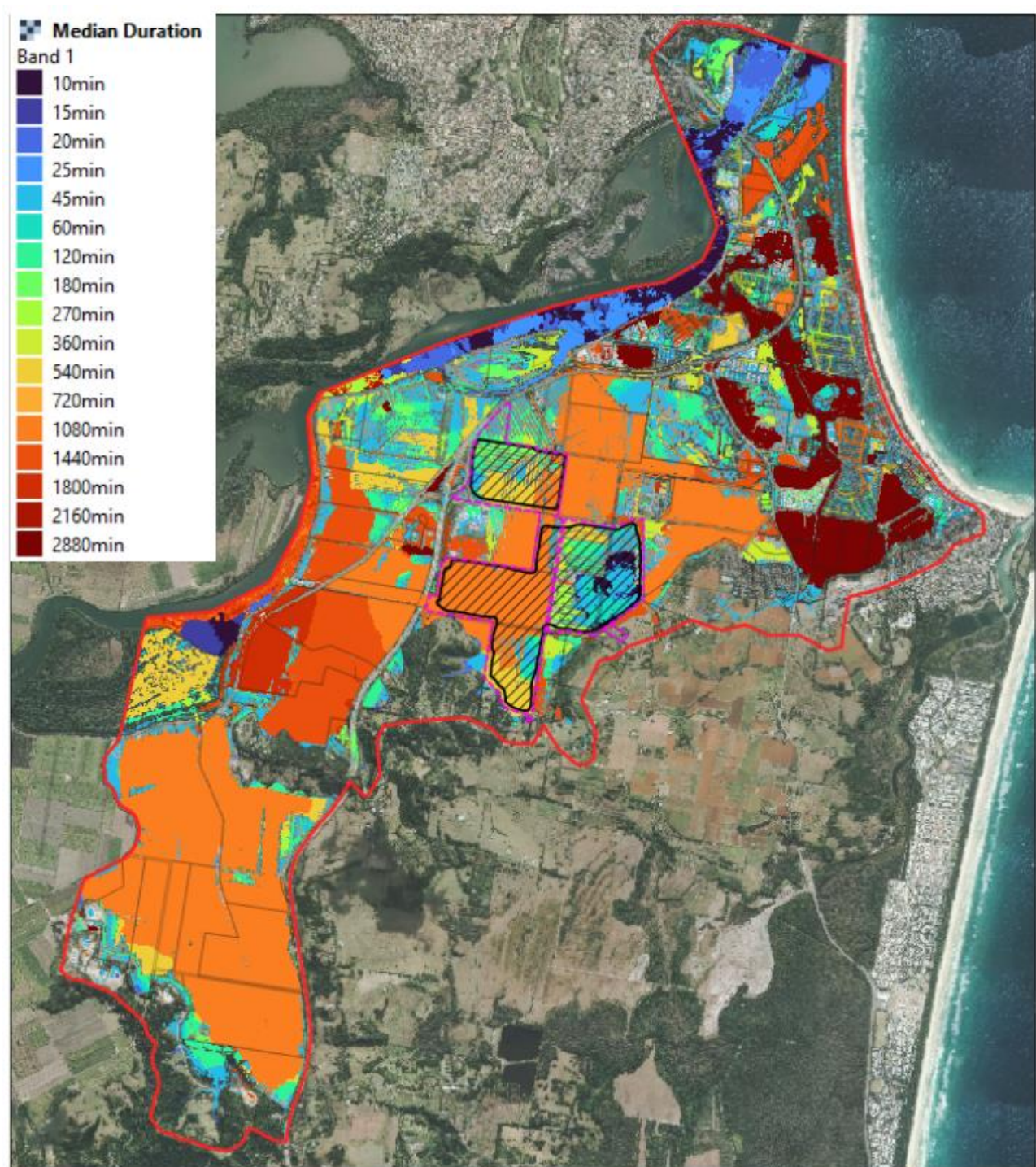


Figure 4.4 0.5EY Local Flood Model Spatial Distribution Median Duration



4.4 Regional Flood Assessment

Regional flooding has been assessed in accordance with the Tweed Shire Development Control Plan. The Regional Council model was adopted, and the design events proposed by the endorsed model were utilised for the assessment. The proposed development has been assessed for flooding at different stages within its operational life, those being:

- Existing Scenario;
- Phase 7 (year 9-13);
- Phase 9 (year 19-22); and
- Phase 11 (year 27-30).

4.4.1 Cumulative Development Assessment

In accordance with Tweed Shire Council's 'Tweed Valley Floodplain Risk Management Study (BMT WBM, 2014), a cumulative development scenario was assessed that considered future development within the lower Tweed River Catchment. Future Development proposed under the Floodplain Risk Management Study included the recommended allowable development outlined as Scenario 3 in Section 8.4.2.3 of the report. The cumulative development is summarised below:

- Residential development and infill in Kingscliff (minimum 1% AEP flood immunity);
- Industrial development in Chinderah (filled to 2.2 mAHD, with a 65% blockage factor on top to represent flow obstructions above 2.2 mAHD); and
- Other approved development, including;
 - Aquaculture development (bundled to 1% AEP flood level); and
 - Sewage treatment plant (1% AEP flood immunity).

A figure of the cumulative development modelled within this assessment is included in Figure 4.5.



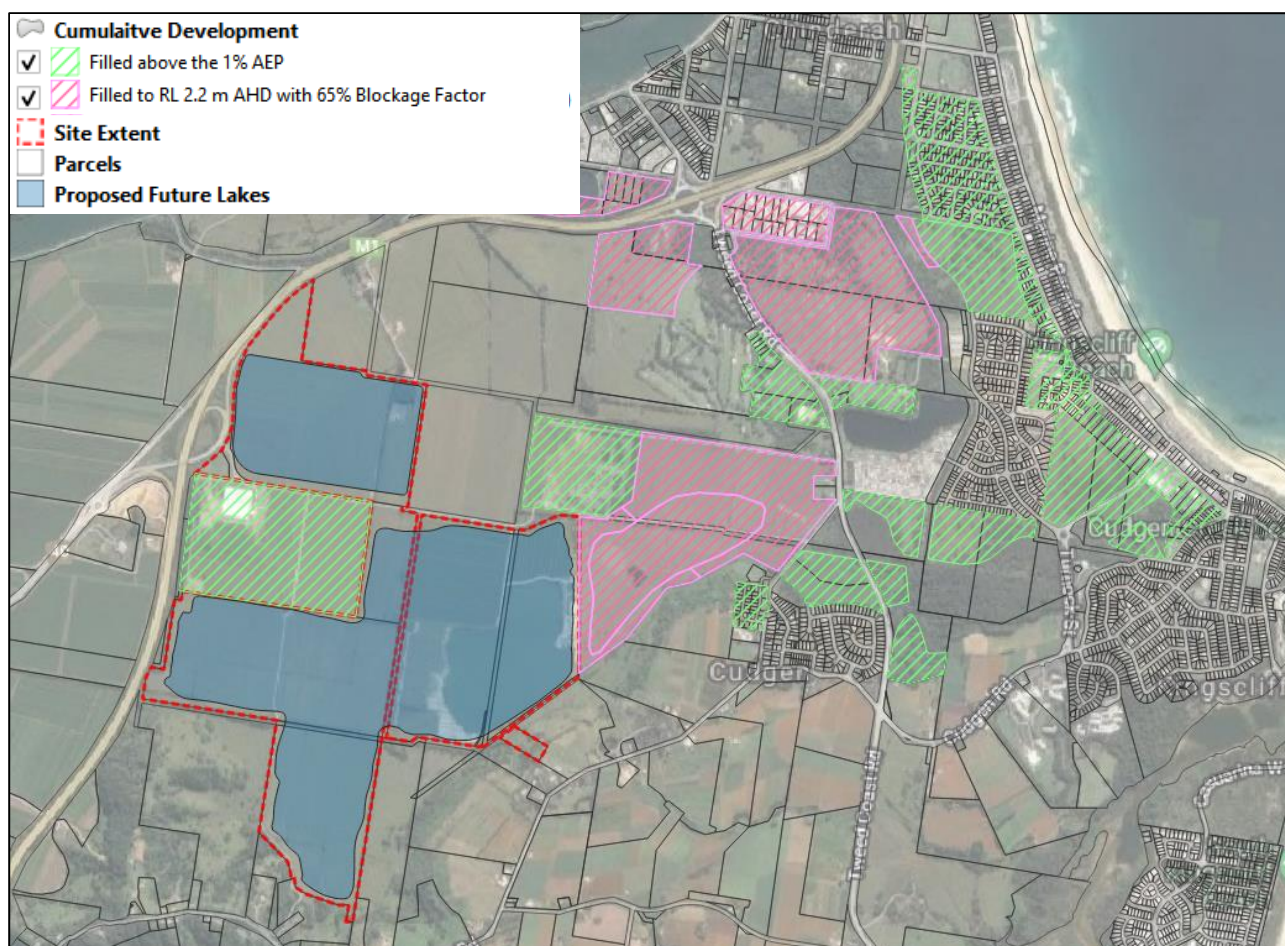


Figure 4.5 Cumulative Development Scenario

4.5 Time of Inundation Assessment

A time of inundation assessment was completed utilizing both the local and regional model results. This assessment involved a review of the depth of local flooding on the surrounding agricultural properties for the existing and proposed development scenarios. A significant change in the shape or magnitude of the depth-time plot would indicate a change in inundation time, no significant change of flood behaviour was considered to indicate a negligible change to inundation time.

Low-lying areas more susceptible to flooding were selected on each property to assess time of inundation to ensure the worst-case time of inundation could be selected. No interrogation was conducted in existing drains/waterbodies.

4.6 Impact Assessment Thresholds

Some documentation and guidance around practical hydraulic impact noise thresholds is available online. A presentation from the Hydrology and Water Resources Symposium, *Defining Acceptable Impacts for Flood Impact Assessments* (Retallick & Babister, 2018) which was published by Engineers Australia, recommends 10mm as a threshold for residential impact assessments. TUFLOW online support forums recommend 10mm generally (5mm under certain circumstances)



with further judgement required (recommendation made by TUFLOW representatives) (TUFLOW, 2010).

4.6.1 Literature Review – Afflux Thresholds and Acceptable Afflux

A review of other LGA's and infrastructure projects around Australia has highlighted model thresholds. Of the reviewed reports listed below +/-10mm appears to be the standard.

- Chapter 13 – Surface Water and Hydrology – Calvert to Kagaru EIS (ARTC, 2021).
 - *Existing habitable and/or commercial and industrial buildings/premises – 10mm.*
 - *Residential or commercial/industrial properties/lots where flooding does not impact dwelling/buildings – 50mm.*
 - *Existing non-habitable structures – 100mm.*
 - *Roadways – 100mm.*
 - *Agricultural and grazing land/forest areas and other non-agricultural land – 200-400mm.*
- Sunshine Coast Airport Expansion Project Environmental Impact Statement – Chapter B5 Airport and Surrounds Flooding (Sunshine Coast Council, Sunshine Coast Airport, 2014)
 - The Flood Impact Assessment undertaken for the Sunshine Coast Airport Expansion Project identified that the proposed development would result in afflux during the 1% AEP event which would result in overflow potentially flooding fifteen (15) houses on fourteen (14) properties.
 - In all current day modelled events, except the 100-year ARI event, the modelling indicates there would be a negligible increase in peak flood levels (less than 10 mm);
 - Up to 15 houses on 14 properties within the affected area have existing floor levels that may be affected by the increase in depth of up to 18.5 mm in the 100-year ARI event. The owners of the affected properties would be contacted during the public notification for the EiS to conduct detailed surveys to confirm the potential impact and determine the need for property-scale mitigation
 - In the 100-year ARI event, the modelling indicates that an area of Marcoola north of RWY 18/36 would experience a small increase in peak flood levels of less than 18.5 mm. This area currently experiences flood depths of 0.25 to 0.8 m during the 100-year ARI event
- Mordialloc Bypass – Surface Water Impact Assessment (WSP, 2018)



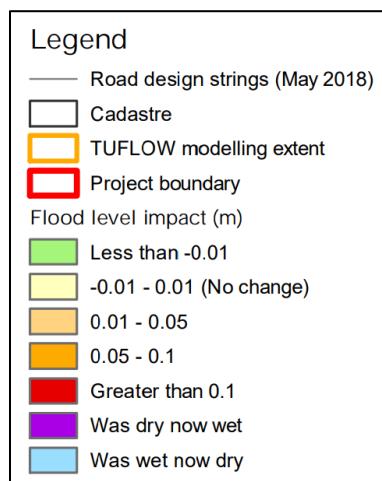


Figure 4.6 Flood Impact Mapping Legend - Mordialloc Bypass (WSP, 2018)

- Parramatta Light Rail – Flooding Technical Paper (ARUP, 2017)
 - Differences in peak flood levels of less than or equal to 0.01 metres (one centimetre or 10 millimetres) are considered to be within the accuracy of the hydraulic model. The project is therefore considered to have a negligible effect on flood behaviour in areas where an afflux of ± 0.01 metres is shown to be present.
- Suncoast Power Project (Suncoast Overhead Feeder Development, Eudlo Creek) (SMEC, 2017).
 - DESIGN IMPACT – The project is to achieve a no worsening on private owned land with a maximum allowable afflux of less than 10mm in peak water levels; and
 - Affluxes greater than 10mm may be achieved where occurring on council owned land subject to Councils consent.
- Kenmore Bypass Environmental Assessment Report – Chapter 5: Hydrology and Hydraulics (AECOM, 2009)
 - The results show that the afflux attributable to the preferred KBP option due to regional flooding is less than 0.02 metres in the Moggill Creek channel compared to the regional flood base case and is considered negligible.

4.6.2 Afflux Analysis

TUFLOW modelling is not an exact science, and as such engineering judgement is required to establish whether results are representative of what may occur in reality. Modelling limitations should be considered when completing any hydraulic impact assessment.

The following partial extract, from ARR Revision Project 15: Two Dimensional Modelling in Urban and Rural Floodplains summarises as fundamental advice (Australian Rainfall and Runoff, 2012):



- All models are coarse simplifications of very complex processes. No model can therefore be perfect, and no model can represent all of the important processes accurately.
- Model accuracy and reliability will always be limited by the accuracy of the terrain and other input data.
- Model accuracy and reliability will always be limited by the reliability/uncertainty of the inflow data.
- A poorly constructed model can usually be calibrated to the observed data but will perform poorly in events both larger and smaller than the calibration data set.
- No model is 'correct' therefore the results require interpretation.
- A model developed for a specific purpose is probably unsuitable for another purpose without modification, adjustment, and recalibration. The responsibility must always remain with the modeller to determine whether the model is suitable for a given problem (task).

There are also a number of common problems that occur in hydraulic models that may give rise to unrealistic impact representation or impacts that require further assessment of likelihood. These can be summarised as follows:

- Poor topographic data:
 - The quality of the input data can cause model noise, particularly with un-realistic indentations or low sections within the model that are poor draining. Significant changes to elevation between cells can result in instability or high error in results, which in turn can cause un-realistic afflux (due to error in result).
- Low points:
 - Low points such as basins, driveways in high rises, parks, drainage channels etc can result in afflux that requires further assessment of likelihood, particularly if the drainage system is not included within the model (which it typically is not for regional impact assessments). Care should be taken in assessing whether impacts in these areas are realistic, with consideration given to the input data and circumstances of the event modelled. One method of assessing the accuracy is by interrogating the peak water level within the low point. If the water level within the low point is significantly lower than the surrounding flood levels then this could indicate the result is unreliable (typically due to cell size, lack of drainage model, or poor DEM). These low points should also be interrogated to establish whether the type of flooding scenario simulated is critical for that location i.e. are other local frequent events likely to cause more flooding?
- Missing drainage data:
 - As stated above most regional hydraulic impact assessment models do not include minor drainage network data, which can result in poorly represented flood levels, particularly in drainage channels, basins, and trap sags. This can lead to poor representation of impact results due to low points not being able to drain leading up to the flood peak.

4.7 Flood Impact Objectives

Tweed Shire Council has adopted general development guidelines as part of their floodplain management strategy. These guidelines are based on the works undertaken by BMT WBM as part



of their original investigations into flooding along the Tweed River and acceptable limits of hydraulic impacts on the floodplain.

4.7.1 Acceptable Afflux

Afflux limits within the Tweed Shire Council LGA are assessed on a case-by-case basis. The following allowable afflux limits have been adopted as a guide for the development, justification for the limits has been provided in [Section 4.5](#).

- A 'no change' modelling tolerance of 10 mm;
- Increase of peak flood levels up to 10 mm limit on residential dwellings;
- Increase of peak flood levels up to 10-50 mm limit for existing urban areas (depending on location); and
- Increase of peak flood levels up to 100 mm limit for existing rural zoned areas in the floodplain.

4.7.2 Cumulative Development Acceptable Afflux

The allowable afflux limits for development within the cumulative development scenario have been adopted from the 'Tweed Valley Floodplain Risk Management Study (BMT WBM, 2014) and are summarised as follows:

- A 'no change' modelling tolerance of 30 mm;
- Increase of peak flood levels of up to 35 mm limit for existing residential zoned areas; and
- Increase of peak flood levels of up to 100 mm limit for existing rural zoned areas in the floodplain.



5. Flood Model

5.1 Hydraulic Model Representation

The study area is approximately 2600 ha and extends 8.5km along the Tweed River encompassing the floodplain area to the east around the Kingscliff/Chinderah township areas. The model used for this study is a refined version of the Council Tweed River Flood Model, with greater resolution (8m grid cell size) and additional hydraulic elements including culverts and channels.

The TUFLOW model used for the preliminary assessment was based primarily off information sourced from Council's 2009 Tweed River TUFLOW Flood model. A summary of the model features has been provided in the following table. Model Features maps are included in Appendix C.

Table 5.1 Hydraulic Model Schematisation

Parameters	Details
Scenarios	- Existing; - Phase 7; - Phase 9; and - Phase 11, ultimate development scenario.
Design Events	- Regional Events sourced from Council's Tweed River Flood Model. 20% AEP rainfall with 20% AEP Storm Surge; 20% AEP rainfall with 1% AEP Storm Surge; 5% AEP rainfall with 5% AEP Storm Surge; 1% AEP rainfall with 5% AEP Storm Surge; 1% AEP rainfall with 5% AEP Storm Surge + Climate Change factors; 0.2% AEP rainfall with 1% AEP Storm Surge; and - EXT (0.0002% AEP) rainfall with 1% AEP Storm Surge. - Local Events 0.5EY AEP rainfall with MHWS tailwater; 0.2EY AEP rainfall with MHWS tailwater; 10% AEP rainfall with MHWS tailwater; 5% AEP rainfall with MHWS tailwater; 2% AEP rainfall with MHWS tailwater; and 1% AEP rainfall with MHWS tailwater.
Topography	1m Lidar - NSW Government Spatial Services. - Culvert level survey – Landsurv Pty Ltd. - Culvert level survey – Sharp Spatial Services. - Local farmers drains were reinforced using z-shapes (topography modifications). - All topography modification utilised in the Tweed River Flood Model have been adopted in this assessment (M1, Tweed Valley Way, Levee). - Channel realignment represented with z-shapes. - Proposed lake bunding of Lake 2 represented at RL 1.0 m AHD with z-shapes.



Parameters	Details
	- Proposed lake outlet bunding of Lake 2 represented at RL 0.7 m AHD with z-shapes. - Proposed haulage route at RL 1.35 m AHD represented with z-shapes. - Cumulative development pads as per Figure 4.5.
2D Resolution	- Regional Model - 8m grid. - Local Model - Quad Tree form 8m to 2m grid.
Timestep	Adaptive timestep (HPC)
Inflows	- Regional assessment Inflows represented as 2D boundary conditions - One (1) inflow represented as water level-time boundary conditions – extracted from Council's Regional Tweed River Flood model results. - Five (5) inflows across the model domain represented as source area inflows – Adopted from Council's Regional Tweed River Flood model. - One SA polygon extent was split into three, as the polygon included two lakes. The model was placing the rain in the two wet lakes, and not proportionally across the entire polygon. Therefore, splitting the polygon into two ensures consistent inflow locations between development scenarios. - All boundary conditions were sampled from consistent Council TUFLOW Flood event results. - Local flood model adopted rain-on-grid modelling. Refer to Section 4.3 for further detail on rainfall selection.
Downstream Boundary Condition	- Regional assessment water level represented as 2D boundary conditions - One (1) location for water level-time boundary condition – taken from Council's TUFLOW Flood model. - Local flood assessment adopted a: - Stage-Discharge (HQ) outflow boundary condition along model domain perimeter with prescribed water surface slope of 1%. - Static tailwater (HT) of 0.6 m AHD within the Tweed River.
Lake Initial Water Level	- Regional and Local Assessment has considered lake full conditions for all events: - Existing Lake – RL 1.0 m AHD - Lake 1 – RL 0.5m AHD - Lake 2 – RL 0.7m AHD
Surface Roughness (reflected as Manning's 'n')	- Please refer to Appendix C for Manning's roughness maps used within the TUFLOW model. The following roughness values have been applied depending land use: - n = 0.022 – Water body - n = 0.030 – Riverbed - n = 0.125 – Riverbanks - n = 0.060 – Floodplain - n = 0.013 – Culverts - n = 0.030 – River / waterways



Parameters	Details
	○ $n = 0.026$ – Tidal waterways ○ $n = 0.090$ – Riverbanks ○ $n = 0.100$ – Dense vegetation ○ $n = 0.080$ – Vegetated islands in river ○ $n = 0.060$ – Cleared / grazing / bare land ○ $n = 0.040$ – Parks ○ $n = 0.150$ – Sugarcane ○ $n = 1.000$ – urban (regional) ○ $n = 0.150$ – urban (local) ○ $n = 0.025$ – highway / roads
Soil Infiltration	• In accordance with ARR2019 soil losses have been adopted from the Tweed River Flood Study 2008. That is: ○ No Soil Loss (1D river bed, 1D river banks, 1D floodplain, 2D river / waterways, 2D tidal waterways) ○ Initial Loss = 0; Continuing Loss = 2.5 (2D river banks, 2D dense forest, 2D vegetated island in river, 2D cleared / grazing / bare land, 2D parks, 2D sugarcane) ○ Initial Loss = 1; Continuing Loss = 0 (2D urban, 2D highway / roads)
1D Hydraulic Structures	• Various hydraulic structures were represented across the model domain. Primarily these structures are large regional culverts and bridges. For further information on the structures modeled, please refer to Survey of Culverts Drawing in Appendix G. • Street drainage and small local drainage networks have not been represented within the model.

5.1.1 Quad-Tree Grid Set-Up

Quad-Tree has been utilised in the local flood assessment to more accurately represent the various agricultural drains across the model domain by increasing the model cell resolution. In the agricultural drains, the cell size has been reduced from 8m to 2m. The following figure indicates the extent of the grid refinement.



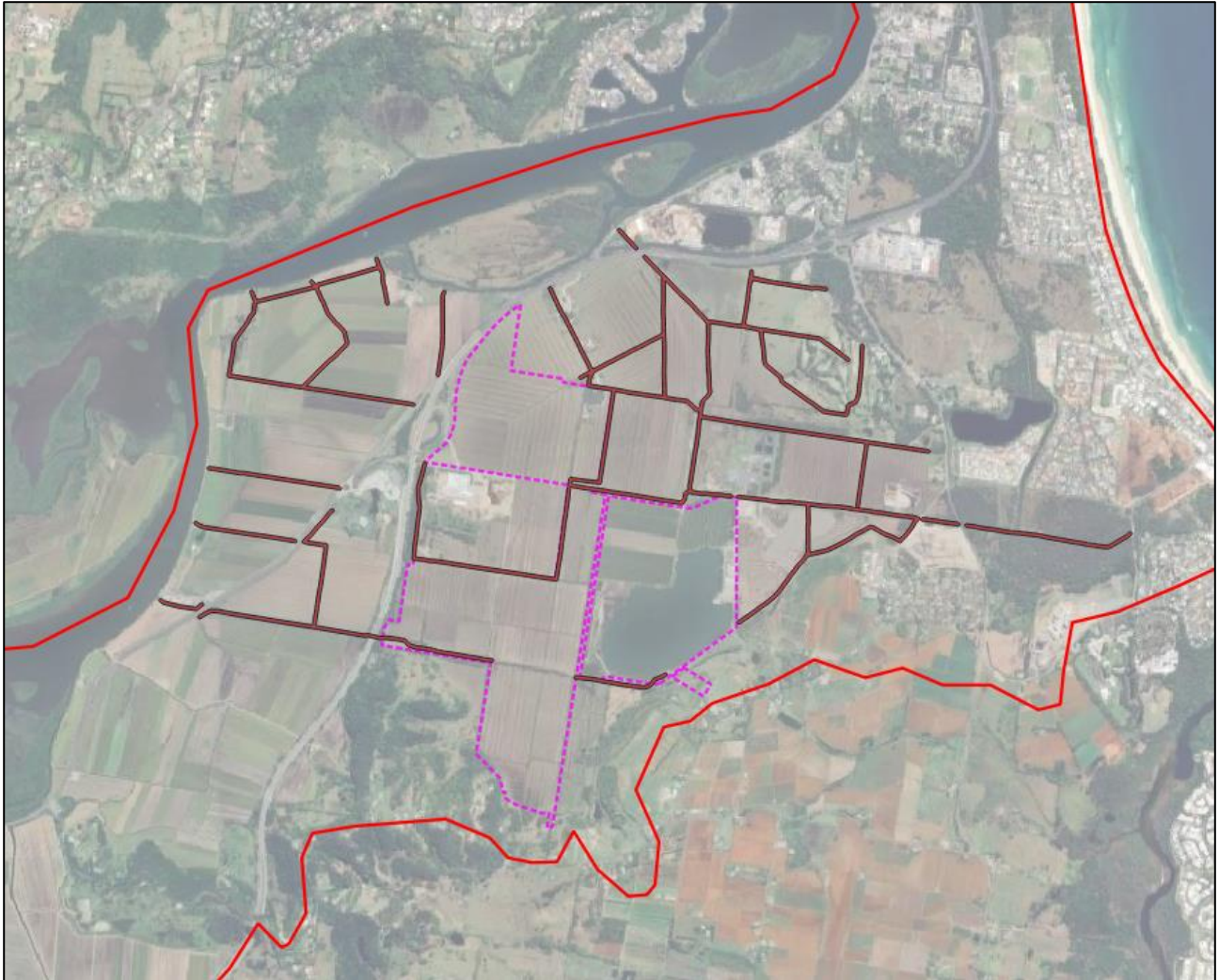


Figure 5.1 2m Cell Refinement Locations

5.1.2 Regional Inflow SA Distribution

Inflows locations adopted for the regional flood assessment are generally consistent with the Tweed River Flood Model, however have been modified in the following ways:

- Inflows associated with RF_20.21 have been reduced based on the area within the model code to ensure flows are not 'double counted'.
- Inflows associated with RF_20.24 have been reduced based on the area within the model code to ensure flows are not 'double counted'
- Inflows associated with RF_55.01 have been split based on the location of the lake. Inflows have been represented this way as during development scenarios, an uneven proportion of catchment flows were being applied to the lake areas when the SA was not split.



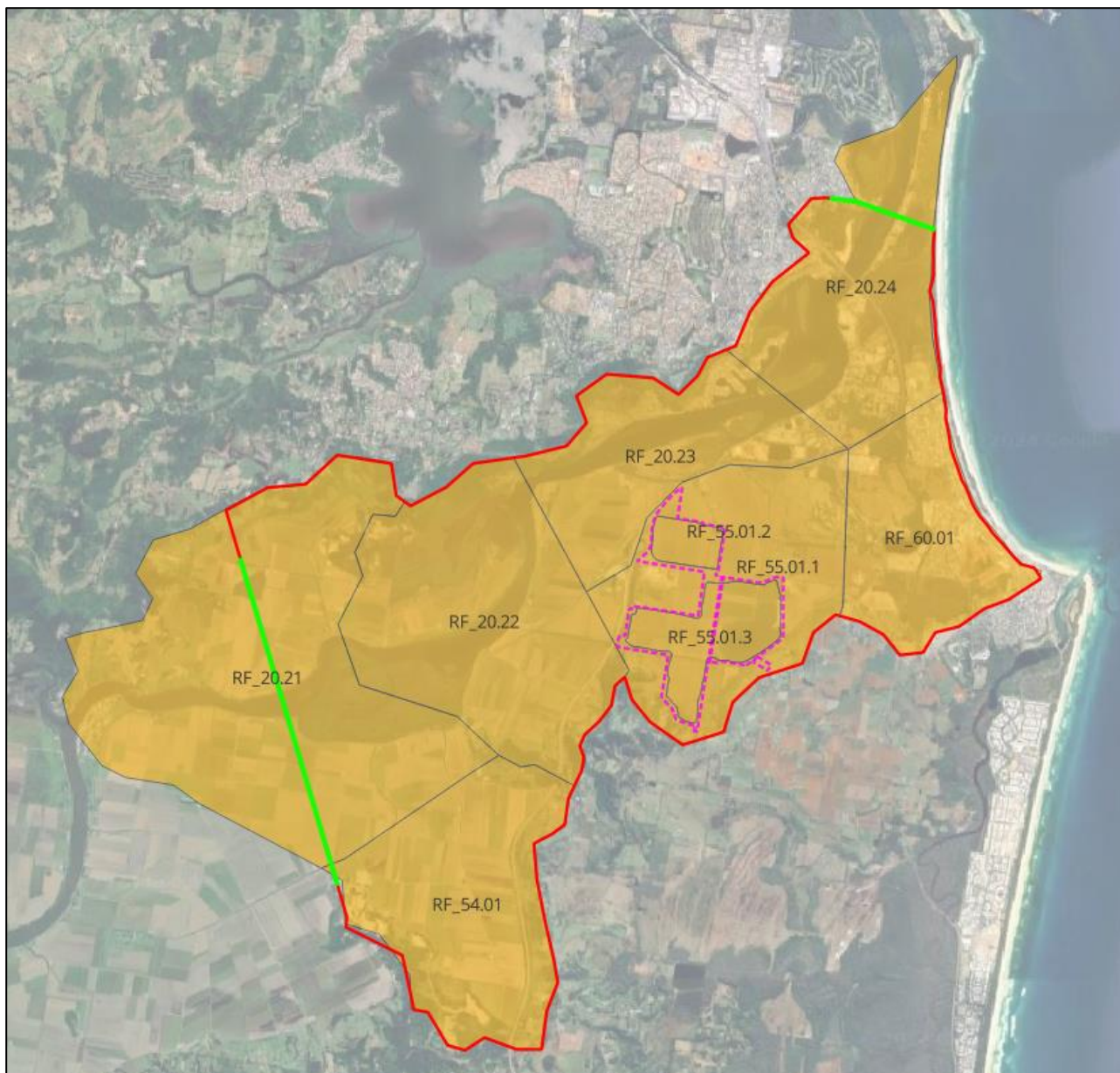


Figure 5.2 Regional Inflow Distribution

Table 5.2 Regional Sensitivity Test SA Flow Proportions

SA ID	Flow Proportion
RF_20.21	0.450
RF_20.24	0.750
RF_55.01.1	0.722
RF_55.01.2	0.061
RF_55.01.3	0.217



5.1.3 Updated Roughness Parameters

Utilising the latest aerial imagery (detailed in Figure 2.1), the surface roughness for parts of the floodplain have been updated when compared with the Council Tweed River Flood Model. This has been completed to more accurately reflect current floodplain conditions. The primary changes were the following:

- Updating of the site roughness from 'Sugarcane – $n = 0.150$ ' to 'Cleared – $n = 0.060$ '.
- Updating of neighboring site roughness where existing sand extraction lakes are, from 'Sugarcane – $n = 0.150$ ' to 'Water Body – $n = 0.022$ '
- Updating of neighbouring site roughness where existing quarry, sewer treatment plant and golf course are, from 'Sugarcane – $n=0.150$ ' to 'Cleared – $n=0.060$ '.

Mannings Roughness Mapping is located in Appendix C of this report.

5.2 Development Representation

The hydraulic model has considered the sand plant expansion for a series of development scenarios (Phase 7, 9 and 11). The development has been represented in the following ways:

- Areas of sand extraction have been reduced to a depth of RL -20 m AHD.
- Areas of sand extraction have a Manning's Roughness value of 0.022.
- In the regional and local flood event the proposed lakes have been modelled as full at the start of the event, i.e. Lake 1 at RL 0.5 m AHD and Lake 2 at RL 0.7 m AHD.
- The proposed new process facility was lifted to the Designated Flood Level for the site (RL 3.22 m AHD).
- The proposed bunding of Lake 2 at RL 1.0 m AHD has been represented in the hydraulic modelling, with lower bunding at RL 0.7 m AHD to allow water to discharge the lake.
- The proposed haulage route at RL 1.35 m AHD has been represented in the hydraulic modelling.
- All proposed hydraulic structures (culverts) associated with the development.

5.3 Model Calibration

The TUFLOW model was calibrated against the existing Tweed River Flood Model results at refined cell size (40m to 8m). The refined TUFLOW model was calibrated 1% AEP flood result from the regional council flood model. Refinements to the hydraulic model were made for a better representation of the drainage system this included:

- 1m resolution topography data;
- Defined farmers drains;
- Additional 1D elements (survey information);
- Revised SA inflow location.

Calibration of the model was achieved through an iterative process in which input parameters were adjusted. Input parameters adjusted included:

- Topographic model roughness (Manning's R =roughness); and



- Boundary condition location/type.

A number of other factors should be noted which can influence calibration including the following:

- Accuracy of topographic source data, typically +/- 300mm (E.g. Council LiDAR topography vs detailed bathymetry survey);
- Hydraulic model accuracy, understood to be typically +/- 10mm

With consideration of the above factors the TUFLOW model built for this report was calibrated to what was considered an acceptable level.

The results of the calibration are presented in Figure 05 of Appendix D. As shown the refined model is generally within 10mm to 20mm of the approved Council result.



6. Flood Results

6.1 Local Hydraulic Results

With the expansion of the plant and sand extraction area the existing hydraulic regime will be altered. To assess the impact of this, the following flooding has been quantified in the existing and proposed ultimate scenario (Phase 11):

- Peak flow at each of the floodplain's drainage points (the two culverts sets that run beneath the M1);
- Impact Assessment of the change in water level within the floodplain surrounding the development;;
- Time of inundation on the surrounding agricultural properties.

6.1.1 Peak Flow Assessment

The following peak flows at each of the site's Legal Point of Discharge (LPD) have been calculated for the existing and proposed developed condition as shown in [Table 6.1](#) and [Table 6.2](#). It is demonstrated from the results that the peak flows at the site's LPDs are generally reduced in the post-developed scenario.

It is noted that there are some events where a very small increase in peak flow is observed, these increases are generally limited to interim phases of the development. For all events there is a decrease in peak flow for the ultimate development scenario. The increase is considered negligible, as the overall volume of flow through these structures has been reduced and flood level on the surrounding properties has also reduced, as is evident in the local flood afflux maps.

Table 6.1 Peak Flow Assessment LPD 1 (Northern M1 Culverts)

Scenario	Event Flow Rate (m ³ /s)					
	0.5EY	20%	10%	5%	2%	1%
Existing	2.0	2.4	2.6	3.0	3.4	3.7
Phase 7	2.1	2.4	2.6	2.9	3.3	3.6
Phase 9	2.1	2.4	2.6	3.0	3.4	3.6
Phase 11	1.4	1.8	1.9	2.2	2.9	3.4



Table 6.2 Peak Flow Assessment LPD 2 (Southern M1 Culverts)

Scenario	Event Flow Rate (m ³ /s)					
	0.5EY	20%	10%	5%	2%	1%
Existing	3.4	5.4	6.5	8.0	10.0	11.5
Phase 7	1.8	3.4	5.0	6.7	9.8	11.7
Phase 9	2.0	3.4	4.6	6.1	9.3	11.7
Phase 11	2.0	3.3	4.5	5.9	8.6	10.8

6.1.2 Local Hydraulic Impact Assessment

To assess the impacts of the proposed lakes and the associated bunding the peak water levels within the model domain were interrogated. Afflux mapping has been prepared in Appendix F of this report. All afflux associated with the development in the local scenario is within the limits of the defined acceptable afflux, discussed in [Section 4.7.1](#).

6.1.3 Time of Inundation

A time of inundation assessment was completed for the local flooding condition that reviewed flooding for all surrounding agricultural properties. The review focused on any significant changes to the rise and fall of flood waters on the subject site. The results of the inundation assessment are included in Appendix E.

It has been determined that the proposed sand plant expansion does not result in any significant changes to time of inundation for any of the surrounding low-lying properties.

6.2 Regional Hydraulic Flood Results

A summary of the regional flooding at the subject site has been included in the below sections. The regional flood assessment also involved an impact assessment of the development effect on the surrounding water level.

6.2.1 Existing Flood Behaviour

The results of the hydraulic modelling were interrogated and assessed against the project objectives. Flooding at the subject site and within the model domain can be summarised as follows:

- The Designated Flood Level (DFL) for the subject site varies between RL 3.22 m AHD and 3.30 m AHD. The DFL refers to the 1% AEP event.
- The site is inundated from the west as flood waters from the Tweed river are conveyed over and under the M1.
- The M1 is overtopped by flood waters in approximately a 5% AEP flood event.
- Generally flooding at the site is low in velocity with peak velocities reaching 0.2 m/s. The highest velocity at the site reaches 0.6 m/s at the southern M1 culvert set.
- The hydraulic categorisation of flooding at the site can be defined as a flood storage area.
- The primary floodway within the model exists within the Tweed River.
- Parts of the Chinderah and Kingscliff townships are inundated in the existing condition.
 - In the 1% AEP the average flood depth in Chinderah is above 1.2m. Velocity in this area is low and the area can be defined as flood storage area.



- In the 1% AEP the average flood depth in the area bounded by Kingscliff St and Sand St is above 0.8m. This area can be defined as flood fringe area.

6.2.2 Post-Development Flood Behaviour

The regional results of the hydraulic modelling for the ultimate developed case are generally the same as the existing scenario with the overall characteristics of flooding being unchanged. The proposed lakes allow flood waters to be conveyed across them with less resistance than the existing farm paddocks, creating a marginal change to the level of flooding in some areas of the model domain. Further discussion on the impacts caused by the development is included in [Section 6.2.3](#).

The proposed development maintains a flood free processing plant up to the 1% AEP event, in times of flood equipment will be stored here and be safe from damage.

Peak water surface level and velocity plots for the modelled events have been included in Appendix F of this report.

The following design flood levels have been determined for the subject site in the post-development, the flood levels vary across the site area due to its size, so the maximum flood level at the location of the future washdown facility has been taken for each event.

Table 6.3 Flood Levels at the Subject Site (Washdown Facility Vicinity)

Flood Event (AEP)	Design Flood Levels (m AHD)	
	Existing Scenario	Ultimate Developed Scenario
20%	1.41	1.43
20% with 1% AEP tailwater	1.41	1.43
5%	2.28	2.28
1%	3.24	3.25
1% + CC	3.97	3.98
0.2%	4.70	4.73
0.0005%	7.63	7.63

6.2.3 Regional Hydraulic Impact Assessment

The changes that the development proposes to flooding within the Tweed Floodplain have been assessed against the acceptable afflux limits outlined in [Section 4.7.1](#). Generally the proposed expansion of the sand plant results in acceptable flood impacts across the model domain. Afflux results are contained within Appendix F of this report.

Within the model domain, small pockets of afflux (consisting of a small number of model cells) exist. These pockets of afflux have been removed from the assessment as they are classified as 'model noise'. Discussion on how this erroneous afflux is caused is provided in [Section 4.6.2](#).

6.2.4 Cumulative Development Scenario

Consideration has been given to the cumulative development scenario recommended by the Tweed Valley Floodplain Risk Management Study (BMT WBM, 2014). The results of the cumulative



development scenario indicate that the addition of the proposed lakes maintain the desired flood outcome with consideration for all future development within the Lower Tweed River Floodplain. That is:

- A 'no change' modelling tolerance of 30 mm;
- Increase of peak flood levels of up to 35 mm limit for existing residential zoned areas; and
- Increase of peak flood levels of up to 100 mm limit for existing rural zoned areas in the floodplain.

Results of the cumulative development scenario are included in Appendix F of this report.

6.3 Flood Storage Assessment

The proposed expansion of the sand plant will result in a significant gain in flood storage volume. Flood storage calculations taken from the DFL (3.24 m AHD) to the standing water level at site (0.7 m AHD) have been completed and are summarised in the following table. It is important to note that the flood storage volume have been taken at a lake full condition and therefore can be considered conservative.

Table 6.4 Flood Storage Balance

Existing Flood Storage Volume	Proposed Flood Storage Volume (Final Phase of Development)	Balance
5,421,933 m ³	5,910,556 m ³	Gain of 488,626 m ³



7. Conclusion

Burchills Engineering Solutions have been engaged by Hanson Construction Materials Pty Ltd to prepare a Flood & Stormwater Assessment (FSA) for Hanson's Tweed Sand Plant, which is located on Altona Road in Cudgen, NSW. The proposed development intends to expand the sand extraction area and increase operations from 500,000 tonnes/year to 950,000 tonnes/year.

A local flood assessment has been completed and it has been determined that the proposed development does not have an adverse impact on the local hydrological regime. No downstream properties will be negatively impacted by the proposed development with respect to stormwater quantity.

The hydraulic modelling has assessed the potential impacts caused by the proposed development in accordance with the *SEARs* documentation and Tweed Shire Council feedback. It has been determined that the proposed development is unlikely to cause adverse impacts on the regional flood behaviour for the design event simulated in the Ultimate development state.



8. Discussion

8.1 Risks

The interpretation of flood maps and other design modelling results should be done with an appreciation of any limitations in their accuracy. While the hydraulic modelling is intended to provide a reliable and accurate prediction of design flood behaviour, the following limitations should be considered:

- Recognition that no two floods behave in exactly the same manner;
- Design floods are a best estimate of an 'average' flood for their probability of occurrence;
- The model topography is generated from ALS data with an average reported vertical accuracy of +/- 0.25 metre and interpolated in areas of dense vegetation. As flood depths and flood extents are determined using this data, their accuracy should be interpreted accordingly;
- The assessment is based on available data and numerical tools at the time of reporting. Changes in technology and improved data collection may provide more accurate modelling in the future.
- The accuracy of hydrologic and hydraulic computer models is dependent on the amount and range of reliable rainfall and flood level recordings for model calibration. An uncalibrated model's results have a greater error margin than a calibrated model.

8.2 Limitations

The hydrologic and hydraulic modelling supplied by Council is representative of information available at the time of the model's creation and to the industry standards applicable (IFD and AR&R 2021 methodologies). It is simply provided as a tool to aid in the assessment of the development and is not entirely representative of all physical processes and the floodplains physical characteristics.

Strict validation to the Council model is subject to the application and to the RPEQ's professional judgement. The assessment provided herein is based on the technological tools available at the time of assessment and based on best possible information.

Although the hydraulic model developed utilises the latest available information, the model is representative of the topographic features of the present day and is not inclusive of any future bridges, wetlands, causeways or developments within the floodplain and therefore cannot be purely indicative of potential flood extents. Furthermore, the model does not incorporate the City's stormwater network, detention basins and therefore cannot be considered accurate for frequent flood events.

The purpose of the Hydraulic Impact Assessment is to represent regional and local flood behaviour. Hence the resolution of the model is limited in urban areas. In particular, the flood model generally does not account for minor stormwater drainage infrastructure, such as street drainage. As such, urban areas may also experience local stormwater flooding in addition to the regional flooding presented in the flood maps.



9. References

- BMT WBM (2009), Tweed Valley Flood Study – 2009 Update, ref: TSC00290_TweedValleyFloodStudy2009Update.pdf, October 2009
- BMT WBM (2014a), Tweed Valley Floodplain Risk Management Study - Final, ref: TSC06390_Tweed_Valley_Floodplain_Risk_Management_Study_Final_October_2014.pdf, October 2014
- TSC (2012), Flood Risk Management – Policy, Version 1, ref: Flood Risk Management.pdf, Tweed Shire Council, adopted 18 December 2012
- Venant Solutions (2020), Combined Development Application & Construction Certificate – Lot 21 DP1082482 Flood Impact Assessment Report
- Retallick, M., & Babister, M. (2018). Defining acceptable Impacts for flood impact assessments. *Hydrology and Water Resources Symposium*
- TUFLOW. (2010). TUFLOW Forum. Retrieved from TUFLOW Modelling/Miscellaneous/Probable Error: <https://www.TUFLOW.com/forum/index.php?/topic/727-probable-error/>
- Australian Rainfall and Runoff. (2012). Revision Projects - Project 15 Two Dimensional Modelling in Urban and Rural Floodplains. Engineers Australia
- AECOM. (2009). Kenmore Bypass EAR Final Draft Public Release - Chapter 5.0 - Hydrology and Hydraulics. TMR.
- ARUP. (2017). Parramatta Light Rail - Flooding Technical Paper. NSW Government: Transport For NSW.
- Moreton Bay Regional Council. (2018). Flood Impact Assessment Guideline. In Regional Floodplain Database.
- Olsen, L., Lowe, R., & Arnbjerg-Nielsen, K. (2017). *Flood Damages Assessment – Literature review and recommended procedure*. Monash University, Clayton VIC: Cooperative Research Centre for Water Sensitive Cities.
- Retallick, M., & Babister, M. (2018). Defining acceptable Impacts for flood impact assessments. *Hydrology and Water Resources Symposium*;
- SMEC. (2017). Suncoast Power Project - Flood Investigation Report. Energex.
- Sunshine Coast Council, Sunshine Coast Airport. (2014). Sunshine Coast Airport Expansion Project - EIS - Chapter B5 Airport and Surrounds - Flooding.
- TUFLOW. (2010). TUFLOW Forum. Retrieved from TUFLOW Modelling/Miscellaneous/Probable Error: <https://www.tuflow.com/forum/index.php?/topic/727-probable-error/>



WSP. (2018). Mordialloc Bypass - Surface Water Impact Assessment. Victorian Government: Major Roads Project Authority.

Gilbert and Sutherland (2021). Revised Water Balance Modelling, Tweed Sand Plant Expansion, Cudgen, New South Wales.



Appendix A –Proposed Sand Plant Phasing



Appendix B – Local Drainage Schematic



Appendix C – Hydraulic Model Features Maps



Appendix D – Hydraulic Calibration Results



Appendix E – Time of Inundation Assessment Results



Appendix F – Hydraulic Results



Appendix G – Detailed Survey

