

# Notice of Meeting

## Floodplain Management Advisory Committee Meeting

A Floodplain Management Advisory Committee Meeting of  
Byron Shire Council will be held as follows:

Venue	Conference Room, Station Street, Mullumbimby
Date	Tuesday, 19 September 2023
Time	1:00pm

Phil Holloway  
Director Infrastructure Services

I2023/1394  
Distributed 12/09/23

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## CONFLICT OF INTERESTS

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**What is a “Conflict of Interests”** - A conflict of interests can be of two types:

**Pecuniary** - an interest that a person has in a matter because of a reasonable likelihood or expectation of appreciable financial gain or loss to the person or another person with whom the person is associated.

**Non-pecuniary** – a private or personal interest that a Council official has that does not amount to a pecuniary interest as defined in the Code of Conduct for Councillors (eg. A friendship, membership of an association, society or trade union or involvement or interest in an activity and may include an interest of a financial nature).

**Remoteness** – a person does not have a pecuniary interest in a matter if the interest is so remote or insignificant that it could not reasonably be regarded as likely to influence any decision the person might make in relation to a matter or if the interest is of a kind specified in the Code of Conduct for Councillors.

**Who has a Pecuniary Interest?** - a person has a pecuniary interest in a matter if the pecuniary interest is the interest of the person, or another person with whom the person is associated (see below).

**Relatives, Partners** - a person is taken to have a pecuniary interest in a matter if:

- The person’s spouse or de facto partner or a relative of the person has a pecuniary interest in the matter, or
- The person, or a nominee, partners or employer of the person, is a member of a company or other body that has a pecuniary interest in the matter.

N.B. “Relative”, in relation to a person means any of the following:

- (a) the parent, grandparent, brother, sister, uncle, aunt, nephew, niece, lineal descends or adopted child of the person or of the person’s spouse;
- (b) the spouse or de facto partners of the person or of a person referred to in paragraph (a)

**No Interest in the Matter** - however, a person is not taken to have a pecuniary interest in a matter:

- If the person is unaware of the relevant pecuniary interest of the spouse, de facto partner, relative or company or other body, or
- Just because the person is a member of, or is employed by, the Council.
- Just because the person is a member of, or a delegate of the Council to, a company or other body that has a pecuniary interest in the matter provided that the person has no beneficial interest in any shares of the company or body.

### Disclosure and participation in meetings

- A Councillor or a member of a Council Committee who has a pecuniary interest in any matter with which the Council is concerned and who is present at a meeting of the Council or Committee at which the matter is being considered must disclose the nature of the interest to the meeting as soon as practicable.
- The Councillor or member must not be present at, or in sight of, the meeting of the Council or Committee:
  - (a) at any time during which the matter is being considered or discussed by the Council or Committee, or



- (b) at any time during which the Council or Committee is voting on any question in relation to the matter.

**No Knowledge** - a person does not breach this Clause if the person did not know and could not reasonably be expected to have known that the matter under consideration at the meeting was a matter in which he or she had a pecuniary interest.

**Non-pecuniary Interests** - Must be disclosed in meetings.

There are a broad range of options available for managing conflicts & the option chosen will depend on an assessment of the circumstances of the matter, the nature of the interest and the significance of the issue being dealt with. Non-pecuniary conflicts of interests must be dealt with in at least one of the following ways:

- It may be appropriate that no action be taken where the potential for conflict is minimal. However, Councillors should consider providing an explanation of why they consider a conflict does not exist.
- Limit involvement if practical (eg. Participate in discussion but not in decision making or vice-versa). Care needs to be taken when exercising this option.
- Remove the source of the conflict (eg. Relinquishing or divesting the personal interest that creates the conflict)
- Have no involvement by absenting yourself from and not taking part in any debate or voting on the issue as of the provisions in the Code of Conduct (particularly if you have a significant non-pecuniary interest)

**Committee members are reminded that they should declare and manage all conflicts of interest in respect of any matter on this Agenda, in accordance with the [Code of Conduct](#).**

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## RECORDING OF VOTING ON PLANNING MATTERS

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### Clause 375A of the Local Government Act 1993 – Recording of voting on planning matters

- (1) In this section, **planning decision** means a decision made in the exercise of a function of a council under the Environmental Planning and Assessment Act 1979:
- (a) including a decision relating to a development application, an environmental planning instrument, a development control plan or a development contribution plan under that Act, but
- (b) not including the making of an order under that Act.
- (2) The general manager is required to keep a register containing, for each planning decision made at a meeting of the council or a council committee, the names of the councillors who supported the decision and the names of any councillors who opposed (or are taken to have opposed) the decision.
- (3) For the purpose of maintaining the register, a division is required to be called whenever a motion for a planning decision is put at a meeting of the council or a council committee.
- (4) Each decision recorded in the register is to be described in the register or identified in a manner that enables the description to be obtained from another publicly available document and is to include the information required by the regulations.
- (5) This section extends to a meeting that is closed to the public.

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## **OATH AND AFFIRMATION FOR COUNCILLORS**

Councillors are reminded of the oath of office or affirmation of office made at or before their first meeting of the council in accordance with Clause 233A of the Local Government Act 1993. This includes undertaking the duties of the office of councillor in the best interests of the people of Byron Shire and the Byron Shire Council and faithfully and impartially carrying out the functions, powers, authorities and discretions vested under the Act or any other Act to the best of one's ability and judgment.

# BYRON SHIRE COUNCIL

## BUSINESS OF MEETING

### 1. APOLOGIES

### 2. DECLARATIONS OF INTEREST – PECUNIARY AND NON-PECUNIARY

### 3. ADOPTION OF MINUTES FROM PREVIOUS MEETINGS

- 3.1 Adoption of Minutes from previous meeting..... 6

### 4. STAFF REPORTS

#### **Sustainable Environment and Economy**

- 4.1 Community Education Strategy and Review of Flood Options - Project  
Introduction ..... 16
- 4.2 Byron Bay Drainage Upgrade - Project Update ..... 21

## BYRON SHIRE COUNCIL

### ADOPTION OF MINUTES FROM PREVIOUS MEETINGS

3.1

### ADOPTION OF MINUTES FROM PREVIOUS MEETINGS

#### **Report No. 3.1      Adoption of Minutes from previous meeting**

**Directorate:** Infrastructure Services



5    **File No:** I2023/1369

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#### **RECOMMENDATION:**

10    **That the minutes of the Floodplain Management Advisory Committee Meeting held on 16 May 2023 be confirmed.**

#### **Attachments:**

15    1    Minutes 16/05/2023 Floodplain Management Advisory Committee, I2023/718 , page 10  

# BYRON SHIRE COUNCIL

## ADOPTION OF MINUTES FROM PREVIOUS MEETINGS

3.1

### Report

The attachment to this report provides the minutes of the Floodplain Management Advisory Committee Meeting of 16 May 2023 .

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### Report to Council

The minutes were reported to Council on

### Comments

10

In accordance with the Committee Recommendations, Council resolved the following:

**23-270**     **Resolved** that Council does not adopt Committee Recommendation(s) 4.2 as shown in the attachment to this report, but instead adopts the Management Recommendation:

#### **Report No. 4.2 North Byron Sky Pump Proposal**

##### Committee Recommendation 4.2.1

That the Flood Advisory Committee recommends Council support the scope of the North Byron Sky Pumps Proposal with the following changes:

1. That there be four scenarios namely:
  - a) 100-year rainfall with 20-year ocean level;
  - b) 20-year rainfall with 100-year ocean level;
  - c) 20-year rainfall with 20-year ocean level;
  - d) 100-year rainfall plus 100-year Climate change with 20-year ocean level plus 100-year Climate Change
2. That the locations change:
  - a) North of sports field at New Brighton (153.5503, -28.5063).
  - b) South of levee at SGB (154.5499, -28.4984).
  - c) Remnant dredged channel from 1970s in Billinudgel Nature Reserve (intersects remnant channels) (153.5506, -28.4856).

Management Recommendation

The above scenarios a) to d) do not allow for a potential east coast low that could hit the region bringing 100 year rain with 100 year ocean levels. Further scenario c) is a minor event when compared to 100 year events and is not really relevant to this investigation.

It is recommended that scenario c be changed to '100-year rainfall with 100-year ocean level;'.

Recommended resolution:

That Council support the scope of the North Byron Sky Pumps Proposal with the following changes:

1. That there be four scenarios namely:

- a) 100-year rainfall with 20-year ocean level;
- b) 20-year rainfall with 100-year ocean level;
- c) 100-year rainfall with 100-year ocean level;
- d) 100-year rainfall plus 100-year Climate change with 20-year ocean level plus 100-year Climate Change

2. That the locations change:

- a) North of sports field at New Brighton (153.5503, -28.5063).
- b) South of levee at SGB (154.5499, -28.4984).
- c) Remnant dredged channel from 1970s in Billinudgel Nature Reserve (intersects remnant channels) (153.5506, -28.4856).

**23-271 Resolved** that Council adopts the following Committee Recommendations:

**Report No. 4.4 Byron Shire Post 2022 Flood Analysis Update**

Committee Recommendation 4.4.1

That the Floodplain Management Advisory Committee recommends Council:

- 1. Notes the report, the update by DPE and the Floodplain Management Advisory Committee minutes;
- 2. Expresses its concern at how long this project is taking;
- 3. Makes the Post-Event Flood Level Survey public, so that:

## **BYRON SHIRE COUNCIL**

### **ADOPTION OF MINUTES FROM PREVIOUS MEETINGS**

**3.1**

- a) It gets checked by those who provided the information, or were flooded, and
  - b) It can be amended where necessary prior to the expensive task of flood modelling;
- 4. Thanks DPE for funding all the post-event technical analyses; and
  - 5. Asks DPE to share draft reports as soon as possible with this Floodplain Advisory Committee, including via an Extraordinary Meeting if necessary.

## Minutes of Meeting

### Floodplain Management Advisory Committee Meeting

Venue	Conference Room, Station Street, Mullumbimby
Date	Tuesday, 16 May 2023
Time	11.30am





**BYRON SHIRE COUNCIL**

ADOPTION OF MINUTES FROM PREVIOUS MEETINGS

3.1 - ATTACHMENT 1

**BYRON SHIRE COUNCIL**

FLOODPLAIN MANAGEMENT ADVISORY COMMITTEE MEETING MINUTES 16 MAY 2023

**Minutes of the Floodplain Management Advisory Committee Meeting held on Tuesday, 16 May 2023**

**File No:** I2023/718

PRESENT: Cr M Lyon (Mayor)

Staff: Samuel Frumpui (Manager Works)  
James Flockton (Infrastructure Planning Coordinator)  
Scott Moffett (Flood and Drainage Engineer)  
David Filipczyk (Team Leader Bush Regeneration)  
Peter Brown (Project Manager Infrastructure Planning)  
Dominika Tomanek (Minute Taker)

Committee: Rebecca Brewin, Matthew Lambourne, Robert Crossley.

Visitor: Cristina Chiu, Arcadis (Consultant)

*Cr Lyon (Chair) opened the meeting at 11:34 am and acknowledged that the meeting was being held on Bundjalung Country.*

ATTENDANCE VIA AUDIO-VISUAL LINK:

Cr C Coorey, Cr D Dey, Catherine Lane, Ziwar Sattouf, Belinda Devine (SES), Martin Rose (Dept of Planning and Environment), Peter Mair (SES)

APOLOGIES:

Phil Holloway (Director Infrastructure Services)

Karl Allen

Steven Harris

DECLARATIONS OF INTEREST – PECUNIARY AND NON-PECUNIARY

There were no declarations of interest.

BYRON SHIRE COUNCIL

FLOODPLAIN MANAGEMENT ADVISORY COMMITTEE MEETING MINUTES 16 MAY  
2023

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ADOPTION OF MINUTES FROM PREVIOUS MEETINGS

**Report No. 3.1      Adoption of Minutes from Previous Meeting**  
**File No:            I2023/678**

**Committee Recommendation:**

**That the minutes of the Floodplain Management Advisory Committee Meeting held  
on 14 February 2023 be confirmed.** (Dey/Lyon)

*The recommendation was put to the vote and declared carried.*

**BUSINESS ARISING FROM PREVIOUS MINUTES**

There was no business arising from previous minutes.

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STAFF REPORTS - INFRASTRUCTURE SERVICES

**Report No. 4.1      Federation Bridge Debris Control Measures**  
**File No:            I2023/651**

**Committee Recommendation:**

**That the Floodplain Advisory Committee notes the attached report, the presentation  
and approves the preferred option 3 in accordance with the multi criteria analysis  
detailed within attachment 1 (E2023/41906) Federation Bridge Debris Control  
Options Assessment.** (Brewin/Lambourne)

*The recommendation was put to the vote and declared carried.*

BYRON SHIRE COUNCIL

FLOODPLAIN MANAGEMENT ADVISORY COMMITTEE MEETING MINUTES 16 MAY 2023

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**Report No. 4.2**      **North Byron Sky Pump Proposal**  
**File No:**            I2023/652

**Committee Recommendation:**

That the Flood Advisory Committee recommends Council support the scope of the North Byron Sky Pumps Proposal with the following changes:

1. That there be four scenarios namely:
  - a) 100-year rainfall with 20-year ocean level;
  - b) 20-year rainfall with 100-year ocean level;
  - c) 20-year rainfall with 20-year ocean level;
  - d) 100-year rainfall plus 100-year Climate change with 20-year ocean level plus 100-year Climate Change
2. That the locations change:
  - a) North of sports field at New Brighton (153.5503, -28.5063).
  - b) South of levee at SGB (154.5499, -28.4984).
  - c) Remnant dredged channel from 1970s in Billinudgel Nature Reserve (intersects remnant channels) (153.5506, -28.4856).

(Dey/Crossley)

*The recommendation was put to the vote and declared carried.*

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**Report No. 4.3**      **Byron Drainage Upgrade Strategy**  
**File No:**            I2023/653

**Committee Recommendation:**

That the Floodplain Management Advisory Committee notes the update on the Byron Drainage Upgrade Strategy and seeks updates throughout the project.

(Lyon/Lambourne)

*The recommendation was put to the vote and declared carried.*

**BYRON SHIRE COUNCIL**

FLOODPLAIN MANAGEMENT ADVISORY COMMITTEE MEETING MINUTES 16 MAY 2023

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**Report No. 4.4**      **Byron Shire Post 2022 Flood Analysis Update**  
**File No:**            I2023/654

**Committee Recommendation:**

**That the Floodplain Management Advisory Committee recommends:**

- 1. Council notes the report, the update by DPE and the Floodplain Management Advisory Committee minutes;**
- 2. Council expresses its concern at how long this project is taking;**
- 3. Council makes the Post-Event Flood Level Survey public, so that:**
  - a) It gets checked by those who provided the information, or were flooded, and**
  - b) It can be amended where necessary prior to the expensive task of flood modelling;**
- 4. Council thanks DPE for funding all the post-event technical analyses; and**
- 5. Council asks DPE to share draft reports as soon as possible with this Floodplain Advisory Committee, including via an Extraordinary Meeting if necessary.**

(Dey/Brewin)

*The recommendation was put to the vote and declared carried.*

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*There being no further business the meeting concluded at 1:40 pm.*

STAFF REPORTS - SUSTAINABLE ENVIRONMENT AND ECONOMY

## Report No. 4.1      Community Education Strategy and Review of Flood Options - Project Introduction

5    **Directorate:**                      Sustainable Environment and Economy

**Report Author:**                Steve Twohill, Flood and Drainage Engineer  
    Chloe Dowsett, Biodiversity and Sustainability Coordinator

**File No:**                            I2023/979

### Summary:

10    Byron Shire Council (Council) has received grant funding through the AGRN 1012 - Local Government Recovery Grant Fund which supports a variety of flood related projects and initiatives that contribute to preparedness and social recovery of residents and communities.

15    Jeremy Benn Pacific ("JBP") Scientists and Engineers has been engaged by Council to deliver the 'Community Education Strategy and Review of Flood Options' project which commenced in June 2023.

The project aims to explore the status of flood mitigation options and to improve community understanding of the flood studies and flood management work completed by Council to date focussing on the Northern Byron Shire Area.

20    The purpose of the study is to address the concerns and requests of the Northern Byron Shire community as related to flood management and mitigation options. The project focus is primarily on the North Byron villages of New Brighton, Ocean Shores, Billinudgel and South Golden Beach.

Key outcomes of the project are:

- 25        • Improved community and stakeholder understanding;
- Education on flood risk and flood risk management.

Outputs of the project will be a report that will include:

- Findings of review of flood studies, options and recommendations as to which options (if any) should progress to further consideration;
- 30        • Findings of stakeholder and community consultation;
- Any final opportunities or recommendations for further investigations.

## BYRON SHIRE COUNCIL

### STAFF REPORTS - SUSTAINABLE ENVIRONMENT AND ECONOMY

4.1

JBP will present to the Floodplain Management Advisory Committee to introduce the project and gain feedback from the committee on project elements, data, stakeholders and community engagement.

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#### **RECOMMENDATION:**

10 **That the Floodplain Management Advisory Committee note the commencement of the 'Community Education Strategy and Review of Flood Options' project which focusses on the Northern Byron Shire communities.**

## **Report**

Byron Shire recently experienced unprecedented floods in February and March 2022 which impacted many residents in the northern villages (i.e. New Brighton, Billinudgel, Ocean Shores and South Golden Beach). Similar to many flooding events, following a major event there is concern from the community that progress isn't being made in implementing the right mitigation options, regardless of their status as having been investigated or not.

The purpose of the project is to address the concerns and requests of the community as related to flood management and mitigation options. The project aims to explore the status of flood mitigation and options to reduce the impact of flooding and to improve community understanding of the work completed to date. It involves peer reviewing existing investigations, analysing mitigation options and their previous modelling (such as dredging and rock wall modifications), engaging with directly affected residents and key stakeholders, and providing community education on the flood modelling process.

The project will be conducted through a combination of desktop analysis, literature review, flood modelling peer review, and community engagement initiatives. The ultimate goal is to contribute to the social recovery and well-being of the affected residents by informing them about the issues and potential solutions related to flooding.

Key outcomes of the project are:

- Improved community and stakeholder understanding;
- Education on flood risk and flood risk management.

Outputs of the project will be a report that will include:

- Findings of review of flood studies, options and recommendations as to which options (if any) should progress to further consideration.
- Findings of stakeholder and community consultation.
- Any final opportunities or recommendations for further investigations.

JBP Scientists and Engineers has been engaged by Council to deliver the 'Community Education Strategy and Review of Flood Options' project which commenced in June 2023.

JBP will be providing a presentation to the Floodplain Management Advisory Committee. the purpose of the presentation is to introduce the project and gain feedback from the committee on project elements, data, methods for community education and engagement and any other concerns/feedback/comments on the project.

## **Next steps**

The Floodplain Advisory Management Committee will be updated as the project progresses. Committee members will be provided an opportunity to be further involved during the later stage of the project at an options workshop (date not yet confirmed).



## Strategic Considerations

### Community Strategic Plan and Operational Plan

CSP Objective	CSP Strategy	DP Action	Code	OP Activity
3: Nurtured Environment	3.3: Protect the health of coastline, estuaries, waterways, and catchments	3.3.2: Floodplain management - Mitigate the impact of flooding on private and public property	3.3.2.3	Floodplain Risk Management Committee coordination

## 5 Legal/Statutory/Policy Considerations

The study will align with the framework established by the NSW Floodplain Development Manual and national best practice as outlined in the Australian Institute for Disaster Resilience Handbook 7: Managing the floodplain: best practice in flood risk management in Australia (AIDR, 2017).

## 10 Financial Considerations

This is a grant funded project comprising consultancy fees only of \$37,940 (excl. GST).

## Consultation and Engagement

A Community and Stakeholder Engagement Plan (CSEP) has been developed for the project for implementation. The CSEP aims to collate community and stakeholder concerns and ideas and address all concerns after reviewing management options and data. The CSEP considers different approaches to communications and engagement, following the IAP2 Public Participation Spectrum. The key outcomes of the project is improved community and stakeholder understanding and education on flood risk and flood risk management, as such the below is proposed:

- 20 • Council Staff/DPE representatives are given a steering role (Empowered).
- Council's Advisory Committees are *Involved*, particularly through our community and stakeholder workshop.
- The community is *Involved* within the project. This is deliberately not at a level that would allow their request for new mitigation scenarios to be tested without checks from flood engineers to ensure they are viable; however, it will ensure they are a focus on this project.



## Report No. 4.2      **Byron Bay Drainage Upgrade - Project Update**

**Directorate:** Sustainable Environment and Economy

**Report Author:** Steve Twohill, Flood and Drainage Engineer

5    **File No:** I2023/980

### **Summary:**

The Byron Bay Drainage Upgrade Strategy is a Floodplain Management Measure in the Council adopted Belongil Creek Floodplain Risk Management Plan (2015).

10    The project is funded by the "Preparing Australian Communities" grant to develop the drainage strategy through Concept Design to Detailed Design. Essentially developing a construction ready project.

This report provides a status update for the project.


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### **RECOMMENDATION:**

**That the Floodplain Management Advisory Committee notes the update on the Byron Drainage Upgrade Strategy.**

### 20    **Attachments:**

- 1      Byron Bay Drainage Upgrade Strategy - Proof of Concept Review Report by Engeny, E2023/35297 , page 28 

25

## **Report**

The Byron Bay Drainage Upgrade Strategy is a Floodplain Management Measure in the Council adopted Belongil Creek Floodplain Risk Management Plan (2015). The project is funded by the "Preparing Australian Communities" grant to develop the drainage strategy through Concept Design to Detailed Design. Essentially developing a construction ready project.

The project has three (3) proposed stages that make up the Byron Bay Drainage Upgrades. They can be delivered separately or together as follows:

- Town Centre – Includes upgrades of the gravity drainage system within the town centre.
- Shirley Street – Includes construction of the town's main pump station, a levee protecting the properties of the Shirley Street area from regional flooding and installation of flood pumps to cater for local drainage within the leveed area.
- Cowper Street – Includes construction of a flood storage basin (Sandhills wetland) and upgrades to Cowper Street pipe outlet to Clarkes Beach. It also includes upgrades to cross drainage linkages between the Town Centre drainage, Cowper Street trunk drainage and possible flood pump. (The Sandhills Wetland can be delivered separately to the peripheral works).

# BYRON SHIRE COUNCIL

## STAFF REPORTS - SUSTAINABLE ENVIRONMENT AND ECONOMY

4.2

There are five (5) stages to deliver the detailed design of the drainage upgrades. The scope, status, dependencies and timeframes are summarised below:

Stage	Scope	Status	Dependencies / Update	Program Timeframe
1	Strategy Review			
	Deliverable: Strategy Review report identifying issues with the current strategy and opportunities for optimisation in concept design	100% Completed	Review is complete and has resulted in the original concept being generally fit for purpose. A copy of the outcomes report is provided at attachment 1.	14/4/2023
2	Detailed Survey of project area			
		100% Completed	All accessible surface and pipe inverts have been collected. A small amount of inaccessible pits will be collected as part of the pot holing process to collect below ground utilities information.	30/4/2023
3	Concept Design of drainage upgrades			
3a	Deliverable: Draft Concept Design Drawings and report including flood modelling results and mapping	70%	Concept design process is well underway. Works are delayed beyond the program timeframe due to delays in completing the detail survey. Adoption of the concept design is not currently delayed.	25/8/2023
3b	Councillor Workshop	0%	Project review and general concept	Planned date

# BYRON SHIRE COUNCIL

## STAFF REPORTS - SUSTAINABLE ENVIRONMENT AND ECONOMY

4.2

			discussion	July 2023.  Now programmed for 6 <sup>th</sup> October 2023
3c	Deliverable:  Final Concept Design Drawings and report	0%	Draft Review and milestone Meeting with Technical Staff	11/9/2023
3d	Report to Council General Meeting  Council Adoption of Concept Design	0%	Finalisation of Concept Design	Oct 2023
4	Environmental Assessment			
	Deliverable: Environmental studies, documentation and proposed approvals	0%	Identification of planning and regulatory pathways  (Note that timing will vary depending on specialist studies and need for EIS)  Finalise Concept Design	6/11/2023
5	Detailed Design			
	Deliverable: Construction drawings and specifications	0%	Council adoption of concept design  Pot holing to obtain utility depths  Environmental assessments and approvals  Electrical design and Essential Energy approvals (for pump stations)	26/3/2024

## Key issues

The project scope overlaps with several other Council projects currently in progress and future masterplan projects. The drainage design upgrades will need to integrate with:

- 5 • Sandhill's Wetland – The detailed design of the Sandhills Wetland is complete, and EIS is currently being prepared.
- 10 • Road Reconstruction projects - Including the underground drainage upgrades with road reconstruction / renewals is the best delivery method for Council. It benefits the community by minimising disruption and avoids the costs associated with temporary works or reinstatement costs that would be necessary if drainage works were solely undertaken separately from road works.
- 15 • The detailed design of the drainage upgrades will cover the necessary underground works required within the footprint of the Lawson Street and Byron Street Road reconstruction projects currently in Councils Capital Works program.
- 20 • Consultant Engeny will work with the Place Manager for Byron Bay to develop a civil works scoping report for locations where the road and footpath shape will likely remain unchanged or changed. The locations where change is warranted or planned would be the higher priority for full street upgrades. This reporting will help guide full street upgrade designs that need to be prepared.
- 25 • The Clarks Beach Master Plan is about to commence on Main Beach reserve and will need to include any upgrade works that will be required to the Cowper Street Outfall. This is in the early stages and will be a point of discussion at steering committee meetings.
- 30 • Byron Bay Town Centre Master Plan -The drainage strategy has also been requested / listed at the next Byron Town Centre Master Plan meeting for a presentation / briefing for early April to coincide with the completion of the Drainage Strategy Review Report.

The contracted program from Engeny planned delivery of detail design in March 2024 ahead of the grant deadline of June 2024. Due to the delays in detail survey collection it is unlikely this deadline will be met. However, delivery within the grant deadline is expected.

## Next steps

- Workshop concept design with Councillors
- Approve concept design

- Continue regular meetings with the internal Project Reference Group
- Commence detail design and community consultation

## **Strategic Considerations**

### **5 Community Strategic Plan and Operational Plan**

<b>CSP Objective</b>	<b>CSP Strategy</b>	<b>DP Action</b>	<b>Code</b>	<b>OP Activity</b>
<b>3: Nurtured Environment</b>	<b>3.3: Protect the health of coastline, estuaries, waterways, and catchments</b>	<b>3.3.2: Floodplain management - Mitigate the impact of flooding on private and public property</b>	<b>3.3.2.5</b>	<b>Undertake survey and concept design for Byron Bay drainage upgrade</b>

## **Recent Resolutions**

- 22-608, 22-573, 22-350

## **Legal/Statutory/Policy Considerations**

10 The Floodplain Development Manual supports the policy and guides councils through the floodplain risk management process. The manual helps councils develop and implement local floodplain risk management plans and outlines the technical assistance provided by the NSW Government.

The manual details the roles and responsibilities of various NSW agencies and includes information on:

- 15
- ☐ the preparation of flood studies, floodplain risk management studies and plans
  - ☐ floodplain risk management options
  - ☐ flood planning levels and areas
  - ☐ hydraulic and hazard categorisation
  - ☐ emergency response planning.

20 The manual was gazetted in 2005 as the manual relating to the development of flood-labile land for the purposes of section 733 of the *Local Government Act 1993*.



## **Financial Considerations**

The budget for this stage of the project is \$1,280,000.00

- 5 Detailed Design is a provisional item within the contract for Engineering Design and will be subject to final pricing at the completion and adoption of concept design when the scope can be confirmed.

Environmental planning assessments are excluded from the Engeny's engineering design scope and is subject to a separate engagement. Appointment of a planning consultant planned is underway.

- 10 The project is currently projected to be delivered under budget.

Staff are currently seeking funding for the construction stages of the project and will update the committee as opportunities arise.

## **Consultation and Engagement**

- 15 A communication plan has been prepared in consultation with Council's Communications team and is discussed at the monthly internal Project Reference Group meeting.

Community engagement will commence once Council have supported the concept design.



# BYRON SHIRE COUNCIL

## Byron Bay Drainage Strategy Review

QC2003\_002-REP-001-0

4 APRIL 2023



## DISCLAIMER

*This Report has been prepared on behalf of and for the exclusive use of Byron Shire Council and is subject to and issued in accordance with Byron Shire Council instruction to Engeny Australia Pty Ltd (Engeny). The content of this Report was based on previous information and studies supplied by Byron Shire Council.*

*Engeny accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this Report by any third party. Copying this Report without the permission of Byron Shire Council or Engeny is not permitted.*

Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
0	4/04/2023	Draft	Sean Willie Jesse Hunter	Mark page	Tim Randell	Mark Page
Signatures:						



# CONTENTS

<b>1. Introduction</b>	<b>1</b>
1.1 Overview	1
1.2 Scope of Works	2
1.3 Review Approach	2
<b>2. Project Input Data</b>	<b>3</b>
2.1 Project Data	3
2.1.1 Tide Levels	3
2.1.2 Belongil Creek Flood Levels	3
2.1.3 Ocean Levels and Climate Change Consideration	4
<b>3. Preferred Drainage Scheme</b>	<b>5</b>
3.1 Proposed Scheme	5
3.1.1 SMEC (2010) Drainage Upgrade	5
3.1.2 BMT WBM Flood Risk Management Study and Plan (2013 and 2015) – Alternative Drainage Upgrade	5
3.1.3 Sandhills Wetland Basis of Design (AWC 2021)	5
3.2 Summary of Current Drainage Scheme	6
<b>4. Hydrologic Modelling</b>	<b>1</b>
4.1 Introduction	1
4.2 Existing Hydrologic Models	1
4.2.1 Belongil Creek Flood Study (SMEC, 2009)	1
4.2.2 Belongil Creek Floodplain Risk Management Study and Plan, Discussion Paper 1: TUFLOW Model Review (BMT WBM, 2011)	1
4.3 Modelling Approach	1
4.4 Model Inputs	2
4.4.1 Catchment and Sub-Catchment Delineation	2
4.4.2 WBNM Model Inputs	7
4.5 Model Validation and Calibration	10
4.5.1 Historical Events	10
<b>5. Hydraulic Modelling</b>	<b>12</b>
5.1 Introduction	12
5.2 Previous Hydraulic Models	12
5.2.1 Belongil Creek Flood Study (SMEC, 2009)	12
5.2.2 Belongil Creek Floodplain Risk Management Study and Plan, Discussion Paper 1: TUFLOW Model Review (BMT WBM, 2011)	12
5.2.3 Belongil Creek Floodplain Risk Management Plan (BMT WBM, 2015)	12
5.2.4 Sandhills Wetland Byron Bay - Flood Impact Assessment (BMT, 2023)	12
5.3 Hydraulic Model Development	13
5.3.1 Model Extent and Topography	13
5.3.2 Boundary Conditions	14
5.3.3 Hydraulic Roughness	16
5.3.4 Drainage Network	17
5.3.5 Simulated Events	17



5.4	Hydraulic Model Verification	19
5.4.1	March 2022	19
5.4.2	Existing Case Results - Design Events	22
5.5	Developed Case Hydraulic Model Results	23
5.5.1	Shirley Street	23
5.5.2	Town Centre	24
5.5.3	Cowper Street	25
5.5.4	March 2022	26
6.	Drainage Scheme REVIEW	28
6.1	General	28
6.1.1	Flood Modelling	28
6.1.1	Land Tenure	28
6.1.2	General Stormwater Pump Station Considerations	29
6.1.3	Public Utility Plant (PUP) Conflicts	29
6.1.4	Environmental Approvals	29
6.2	Shirley Street (Area 1)	30
6.2.1	Butler Street Drain and Flood Levee	30
6.2.2	Pump Stations	30
6.3	Jonson Street (Area 2)	34
6.3.1	Drainage Network Upgrade	35
6.3.2	Town Centre Pump Station	35
6.3.3	Summary	37
6.4	Middleton and Cowper Street (Area 3)	38
6.4.1	Drainage System Upgrade	38
6.4.2	Sandhills Wetland	38
6.4.3	Clarkes Beach Outlet Duplication	39
6.4.4	Summary	40
6.5	Alternate Strategic Approaches Considered	41
6.5.1	Rationalisation of Pump Stations	41
6.5.2	Additional Pump Stations	41
6.5.3	Private Property Resumption for Drainage Reserves	41
6.5.4	Northern Rivers Reconstruction Corporation Resilient Homes Program	42
6.6	Costs	42
7.	Basis of Concept design	44
7.1	General	44
7.2	Flooding Basis of Design	44
7.2.1	Stormwater Network	44
7.2.2	Pump Station Basis of Design	45
8.	Summary and Recommendations	48
8.1	Forward Work Plan	50
9.	References	51
10.	Qualifications	52
<b>Appendices</b>		
<b>Appendix A: AR&amp;R 2019 Data Output</b>		53



Appendix B: Design Event Results, 1:100 AEP Storm Surge (2.6 m AHD)	55
Appendix C: Design Event Results, Highest Astronomical Tide (1.1 m AHD)	56
Appendix D: Design Event Results, 1:20 AEP Storm Surge (2.2 m AHD)	57
Appendix E: Flood Modelling Basis	58
Appendix F: Environmental Constraints and Approvals Desktop Review	60

## Tables

Table 2.1: Tidal Planes For The Tweed-Byron Region Derived From Tidal Constituents (BMT WBM, 2013)	3
Table 4.1: Byron Bay Township WBNM Catchment Information	5
Table 4.2: Percentage Difference IN ARR 2019 and ARR 1987 IFD Values (negative value indicates lower ARR 2019 value)	7
Table 4.3: NSW Transformational Pre-Burst Depths (mm)	9
Table 4.4: NSW Probability Neutral Burst Loss Rainfall Depths (Mm)	9
Table 4.5: March 2022 Flood Debris Survey	10
Table 5.1: Adopted Tailwater Conditions	15
Table 5.2: Adopted Hydraulic Roughness	16
Table 5.3: Model Simulation Summary	18
Table 5.4: March 2022 Flood Level Comparison	19
Table 5.5: Shirley St Peak Pump Outflow Rates	23
Table 5.6: Town Centre Peak Pump Performance	24
Table 5.7: Town Centre Pipe Outlet Performance	25
Table 5.8: Cowper St Pipe Outlet Performance	25
Table 5.9: Historical Event Pump Performance	26
Table 6.1: Area 1 Pump Stations in Preferred Drainage Strategy (SMEC, 2010)	31
Table 6.2: Pump Stations Area 1 – Minimum Pump Storage Required	32
Table 6.3: PS1 (Kendall Street) Catchment Summary (Area 1)	32
Table 6.4: PS2 (Dryden Street) Catchment Summary (Area 1)	33
Table 6.5: PS3 Catchment Summary (Area 1)	34
Table 6.6: PS4 Catchment Summary (Area 1)	34
Table 6.7: Town Centre Pump Station	36
Table 6.8: Town Centre (Jonson Street) Catchment Summary (Area 2)	37
Table 6.9: Cowper Street Catchment Summary (Area 3)	40
Table 7.1: General Basis of Design	44
Table 7.2: Basis of Design – Rainfall, Floodplain and Storm Tide	44
Table 7.3: Climate Change Sensitivity Testing	44
Table 7.4: Stormwater Network Basis Of Design	45
Table 7.5: Pumping General Basis of Design	45
Table 7.6: Peak Pump Design Modelled Outflow Rate Estimates	46
Table 7.7: Pump Station Target Levels to Reduce Flooding in 10% AEP	46
Table 7.8: Pumping Power Considerations Basis of Design	47
Table A.1: Intensity-Frequency-Duration Depths (mm)	54



## Figures

Figure 1.1: 10% AEP Event Peak Flood Depth (WMA, 2015) (Belongil Creek Floodplain Risk Management Study and Plan).....	1
Figure 2.1: Extract from BSC LEP 2014 Climate Change Strategic Planning Policy No 14/006. ....	4
Figure 3.1: Drainage Upgrade .....	1
Figure 4.1: Regional Sub-Catchment Delineation Extent .....	3
Figure 4.2: Byron Bay Township Sub-Catchment Delineation Extent.....	4
Figure 4.3: Byron Bay (Belongil Creek Bridge) (558099) March 2022 Gauged Rainfall .....	11
Figure 5.1: TUFLOW Model Extent and Terrain .....	14
Figure 5.2: TUFLOW Stormwater Network and Boundaries .....	15
Figure 5.3: TUFLOW Hydraulic Roughness .....	16
Figure 5.4: Flood Debris Survey Locations .....	20
Figure 5.5: March 2022 Modelled Flood Depth.....	21
Figure 5.6: 1% AEP Flood Extent Comparison (1.1m AHD tailwater scenario).....	22
Figure 5.7: March 2022 Flood Level Afflux.....	27
Figure 6.1: Shirley Street Area 1 Scheme Layout.....	31
Figure 6.2: Town Centre Drainage Scheme .....	35
Figure 6.3: Cowper Street Drainage Scheme (Area 3).....	38
Figure 6.4: Potential Massinger Street Trunk Stormwater Diversion Alignment .....	39
Figure 6.5: Previous Scheme Cost Estimate (BMT, 2015).....	43



# 1. INTRODUCTION

## 1.1 Overview

This report addresses the first stage of the Byron Bay Drainage Upgrade Design Project, which comprised a review of Byron Shire Council's (Council's) drainage strategy as it stands based on the preferred drainage scheme by BMT (BMT WBM 2015). The intent of the review is to establish a preferred drainage strategy for further assessment and design.

Byron Bay township is susceptible to inundation from both intense short duration storms over the town catchment and ocean storm tide events which influence the Belongil Creek estuary. Peak flood levels across the township can occur within 1 to 6 hours of commencement of significant rainfall, and is significantly influenced by high tides and Belongil Creek flooding.

Byron Bay has old underground drainage infrastructure which either discharges west into Belongil Creek via the Byron Bay town drain (Butler Street Drain) or north to the Clarkes Beach outlet (1350mm diameter pipe). Rainfall runoff within the township of Byron Bay, east of the North Coast Railway line does not have direct overland escape and water levels can be independent of the flooding from Belongil Creek, due to the constrained stormwater drainage system. However, high creek levels due to either Belongil Creek catchment flooding, creek mouth closure or high ocean levels can also significantly impact stormwater discharge from the township.

Previous studies have determined that the local stormwater network in Byron Bay has limited capacity (estimated capacity of less than 63% AEP) and is often unable to adequately manage local stormwater runoff. Stormwater discharge is limited by a flat hydraulic gradient between the low-lying township, Belongil Creek floodplain and beach outlets. The Belongil Creek catchment and key drainage features are illustrated in Figure 2.2 and Figure 2.3.



FIGURE 1.1: 10% AEP EVENT PEAK FLOOD DEPTH (WMA, 2015) (BELONGIL CREEK FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN)

In order to improve drainage to the most impacted areas of the township, previous studies (SMEC, 2010 and BMT, 2015) identified a scheme of stormwater upgrades across several areas of the town. These schemes focussed on improving drainage to the following areas:

- Shirley Street and Byron Street adjacent to the Butler Street Drain.
- Jonson Street and Byron Street in the town centre.
- Middleton Street.
- Cowper Street.





Due to the low ground levels and gradients through these areas relative to ocean and Belongil Creek levels, the scheme relies on flood levees and stormwater pumping systems to manage trapped stormwater. Additionally, the Cowper Street catchment scheme includes a combined detention basin/wetland and upgrade and duplication of the existing 1350mm diameter stormwater outfall pipe to Clarkes Beach.

The holistic drainage scheme was last updated in 2015, and requires review in context of current Council requirements, engineering standards and general feasibility.

## 1.2 Scope of Works

Engeny has been engaged to undertake the following tasks relating to the proposed drainage upgrade scheme:

- (1) Review the existing preferred drainage strategy, which was last modified in 2015 (BMT WBM, 2015).
- (2) Undertake detailed ground survey across the catchments of interest to inform the design.
- (3) Develop concept design of the schemes to inform Council's next steps for the works.

This report addresses the first stage of the project, which is a review of Council's drainage strategy as it stands based on BMT's 2015 scheme. This review has been undertaken in parallel to the commissioning of detailed engineering survey of the catchments of interest with a view to commence concept design following Council endorsement of the strategy review outcomes and completion of ground survey.

## 1.3 Review Approach

A summary of the approach and task undertaken for the drainage strategy review are as follows:

- (a) Data Collection and Review.
- (b) Preparation of updated hydrological model.
- (c) Preparation of updated hydraulic model.
- (d) Hydraulic model validation.
- (e) Design event modelling.
- (f) Preferred drainage strategy scheme modelling.
- (g) Drainage upgrade strategy review assessment.



## 2. PROJECT INPUT DATA

### 2.1 Project Data

Byron Shire Council provided electronic data that has been used to create a GIS database (using the computer program QGIS) of the catchment, which includes:

- Aerial Photography.
- Cadastral Data and road reserve layout.
- Potable and recycled water Infrastructure.
- Floor level data base (2016) Infrastructure.
- Drainage Infrastructure.
- Significant tree register.

The LiDAR and aerial photography adopted for the study was:

- 1m digital elevation model (DEM) of existing topography sourced from ELVIS, dated October 2010.
- Aerial photography sourced from Nearmap, dated November 2022.

#### 2.1.1 Tide Levels

A summary of the tide levels adopted in the study are outlined in Table 2.1.

TABLE 2.1: TIDAL PLANES FOR THE TWEED-BYRON REGION DERIVED FROM TIDAL CONSTITUENTS (BMT WBM, 2013)

Tidal plane	Level (m AHD)
Highest Astronomical Tide (HAT)	Approx. 1.0 – 1.1
Mean High Water Springs (MHWS)	0.66
Mean High Water Neaps (MHWN)	0.37
Mean Sea Level (MSL)	0.0
Mean Low Water Neaps (MLWN)	-0.37
Mean Low Water Springs (MLWS)	-0.66
Lowest Astronomical Tide (LAT)	-1.0

#### 2.1.2 Belongil Creek Flood Levels

Belongil Creek estuary is defined as an intermittent closed and open lake or lagoon (ICOLL) system. The Belongil Creek mouth outlet to Belongil beach often closes due to accumulated sand from coastal processes. Due to various water quality issues from contaminants within the Belongil catchment such as to Byron Bay STP treated effluent and urban pollutants, creek flows are often contaminated and discharge to the ocean has known environmental and community impacts.

Council holds a NSW marine park permit (MEAA22/32) for management of artificial opening of the ICOLL to minimise environmental impacts of creek flows regularly flowing to the beach. Council is permitted to artificially excavate a creek mouth outlet to the ocean when the level



in the estuary is 1.0m AHD or higher as measured at the Ewingsdale Road bridge provided there is forecast or actual rainfall of 20mm within the Belongil Creek catchment within 24 hours following the expected opening time. The status of the creek outlet opening has a significant influence on water levels in the Butler Street drain and local drainage adjacent to Belongil Creek. Belongil Creek ICOLL has been reported to operate in a range of levels from 0.2m AHD at low tide / open outlet conditions to as high as 2.0 – 2.5m AHD during closed outlet and small rainfall events that prohibit artificial mouth opening (Alluvium 2021). This requires consideration in design of appropriate design tailwater levels and sensitivity testing of the system under high ICOLL levels.

### 2.1.3 Ocean Levels and Climate Change Consideration

The Byron Bay Local Environmental Plan (2014) specifies 1% AEP storm tide levels for use in planning relating to Belongil Creek and the tidal zone. An extract from the LEP (2014) is shown in Figure 2.1 that specifies the storm tide levels to be used in planning and flood studies for the 1% AEP. The adoption of ocean tailwater levels takes an envelope approach as recommended by NSW Department of Planning and Environment (DPE) Floodplain Risk Management Guidelines.

Council's Coastal Hazard assessment (BMT, 2013b) provides further discussion of these storm tide levels and the basis for their derivation. It also provides alternative storm tide levels at Byron Bay; however these are based on somewhat conservative tide assumptions and are up to 0.39m higher than the LEP. For the purposes of this study, the LEP levels shown in Figure 2.1 have been adopted.

For more frequent events from 39% AEP to 5% AEP, the Flood Risk Management Manual (DPE, 2022) specify the use of higher high water springs (HHWS) as a suitable ocean water boundary condition. Therefore, HAT of 1.1m AHD has been adopted as the ocean boundary for the more frequent events from 39% AEP to 5% AEP which will be critical for design of stormwater systems.

Scenario	Predicted Sea Level Rise (Metres above 1990 mean sea levels)	Catchment inflow (rainfall event)	Ocean Boundary Peak Tailwater Condition in (M)AHD	Increase in rainfall intensity
100 year event Current Conditions	0	20 year ARI 100 year ARI	*2.6 (Ocean Dominated) 2.2 (Rain Dominated)	0
100 year event in 2050	0.4	20 year ARI 100 year ARI	2.6 (Ocean Dominated) 2.4 (Rain Dominated)	0
100 year event in 2100 (FPL event)	0.9	20 year ARI 100 year ARI	3.1 (Ocean Dominated) 2.9 (Rain Dominated)	0
Sensitivity test 1	0.4	20 year ARI 100 year ARI	2.6 (Ocean Dominated) 2.4 (Rain Dominated)	10%
Sensitivity test 2	0.9	20 year ARI 100 year ARI	3.1 (Ocean Dominated) 2.9 (Rain Dominated)	30%
Sensitivity test 3	0.9	100 year ARI	3.1 (Ocean & Rainfall Dominated)	30%
<b>Source:</b> Figures are in accordance with recommendations from DECCW Sea Level Rise Policy Statement April 2009 and DECCW Practical Consideration of Climate Change guideline 2007. *The 100 year peak ARI ocean level of 2.6m AHD is based on a coastal assessment undertaken nearly 30 years ago and includes wave and wind set up and barometric pressure effects. It is considered to have some allowance for sea level rise but the amount is unknown. It is the accepted level across the state for the 100 year flood tailwater condition and its application in Byron Shire dates back to the Brunswick River Flood Study (1986) and Belongil Creek Flood Study (1986).				

FIGURE 2.1: EXTRACT FROM BSC LEP 2014 CLIMATE CHANGE STRATEGIC PLANNING POLICY NO 14/006.



## 3. PREFERRED DRAINAGE SCHEME

### 3.1 Proposed Scheme

The preferred Byron Bay drainage upgrade was initially proposed by SMEC in the report Byron Bay Drainage Strategy (2010). This report undertook 2D flood modelling using the Belongil Creek flood model, and design of new stormwater networks using DRAINS software. In 2013, this was reviewed by BMT and revised with some changes to the proposed Cowper Street scheme. This consisted of removal of several proposed stormwater pump stations. These facilities were replaced with the proposed 'Sandhills' wetland detention basin and duplication of Clarkes Beach outfall. There is no record of the changes being tested through quantitative flood modelling.

In 2015 BMT developed the Byron Bay FRMP which incorporated the scheme and included costing of the upgrades. Engeny has reviewed this previous work in detail and provides commentary in the following sections.

#### 3.1.1 SMEC (2010) Drainage Upgrade

The scheme was developed to a feasibility level for costing purposes. The objective of the design was to develop a scheme to achieve sizing for a new 10-year ARI stormwater system in the areas that experience severe flash flooding. The objectives of the drainage strategy as listed by SMEC were as follows:

- To alleviate flooding at nominated flood prone sites within the Belongil Creek catchment.
- To provide a drainage system containing piped networks for minor flows and where possible safe defined overland flow paths for major floods.
- To provide flood immunity against ocean storm surges.
- To provide a system that is adaptable to future projected sea level rise and increased rainfall intensities associated with climate change.
- To reduce stormwater pollution at Clarkes Beach and in the Belongil Estuary.
- Consider removal of the Clarkes Beach outlet.

#### 3.1.2 BMT WBM Flood Risk Management Study and Plan (2013 and 2015) – Alternative Drainage Upgrade

The scheme update completed by BMT addressed Council's key concerns regarding the cost and reliance on pump stations in the Cowper Street catchment, and the abandonment of the strategy to remove a stormwater outlet from Clarkes Beach. The Cowper Street and Marvell Street stormwater pump stations (total 4m<sup>3</sup>/s capacity) proposed by SMEC (2010) was replaced with:

- A 3.0 ha proposed retention/detention wetland storage which has become known as the 'Sandhills wetland' to capture first flush flows and improve stormwater quality to Clarkes Beach.
- A new swale and weir to connect the flood plain from Middleton Street system to the Clarkes Beach outfall pipe.
- Duplication of the 1350mm diameter pipe outfall to Clarkes Beach to double the outlet capacity to approximately 6 - 7m<sup>3</sup>/s.

No flood modelling or design was documented to support the changes to the scheme proposed by BMT. However, the report states the changes resulted in a reduction of 0.5 m for the 1:100 AEP flood level at the proposed Cowper Street and Marvell Street area. Costing of the scheme was also undertaken, with the scheme nominated to cost in the order of \$11 million.

#### 3.1.3 Sandhills Wetland Basis of Design (AWC 2021)

The Sandhills wetland design progressed independently of the drainage scheme in 2019. Council has progressed the wetland design in response to the Byron Bay alternative drainage strategy basic requirement for a 3.0 ha detention/retention wetland to manage stormwater, as well as other water quality objectives and public amenity drivers. During the design process, the area available for the wetland was reduced due to various cost and approvals constraints, and the final designed wetland footprint is now approximately 1.6 ha.



The wetland design was undertaken by Australian Wetland Consultants (AWC). AWC (2021) reported that no assessment of flood storage performance or impacts has been made as part of the original design, and the wetland objective was to not modify any outlet conditions or overall movement of water across the site. It was also reported that the wetland will provide approximately 6000 m<sup>3</sup> of flood storage in a 1:10 AEP event.

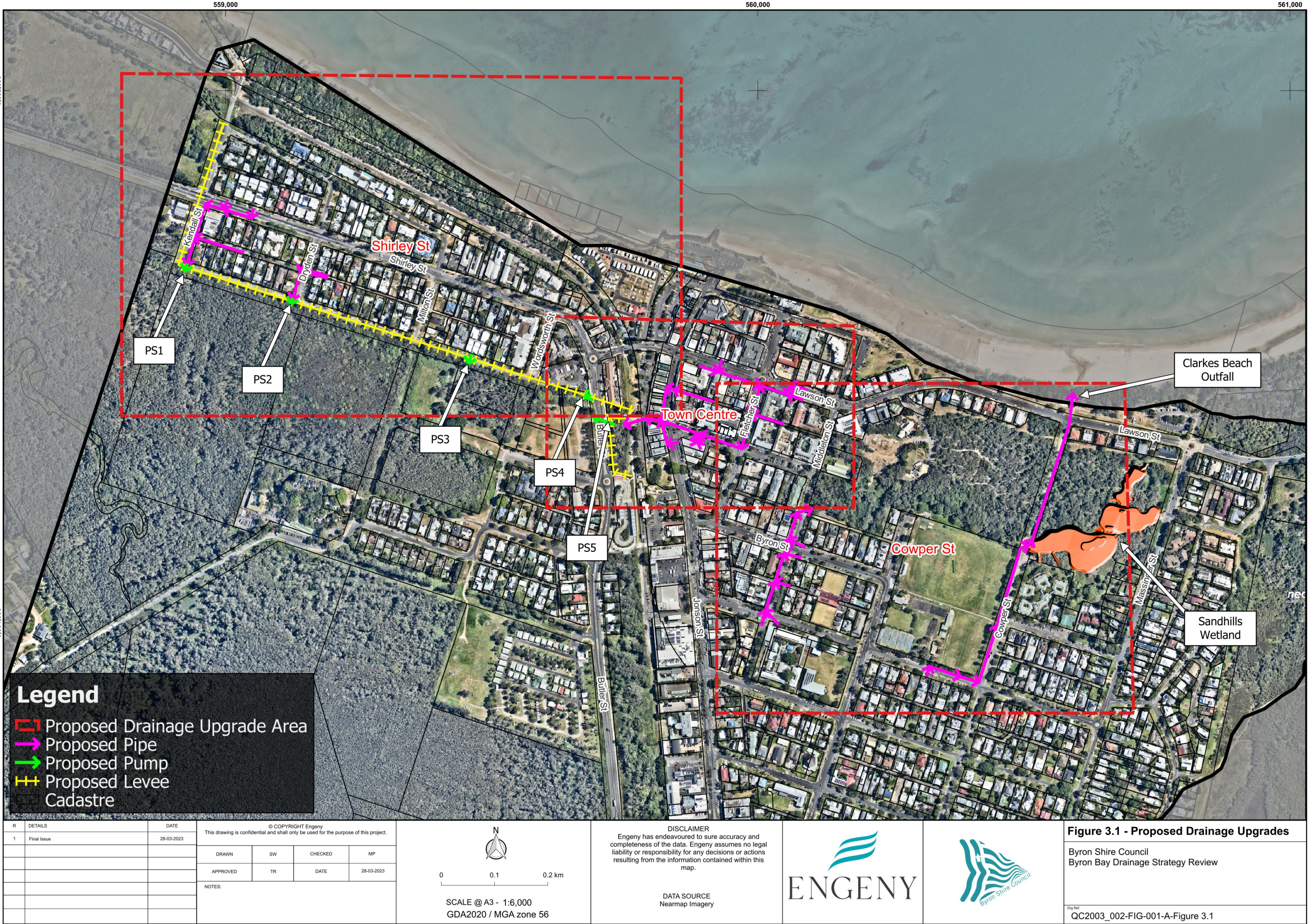
The flood impact assessment of the Sandhills wetland was undertaken by BMT WBM (2023). This assessment indicated the wetland provides flood level improvements in the vicinity of Cowper, Tennyson, Fletcher and Marvel streets up to the 1: 100 AEP. This assessment was for the wetland project in isolation and did not consider other aspects of the drainage scheme such as the augmentation of the Clarkes Beach outlet, or potential new stormwater networks in the surrounding Cowper, Carlyle or Middleton Street road reserves.

At the time of writing this report, the Sandhills Wetland design has been completed and is now subject to final EIS approvals.

### 3.2 Summary of Current Drainage Scheme

Based on the project progression detailed in the sections above, an updated plan of the scheme has been developed for modelling analysis in this study. **Figure 3.1** provides a summary plan of the current proposed drainage strategy containing the latest information for each aspect of the scheme. This is the scheme that required analysis and testing in context of updated flooding modelling.









## 4. HYDROLOGIC MODELLING

### 4.1 Introduction

To inform the strategy review, a new hydrological model has been developed for the Byron Township. This is required to better capture the detailed drainage behaviour within the township and its interaction with the Belongil Creek floodplain and ocean tailwater levels. The existing XP-RAFTS hydrological model has only received minor updates since it was originally constructed by SMEC (2009) as part of BMT WBM (2011) update. Since this time, the industry standards for hydrological modelling has changed significantly, the software that was originally used for the Belongil Creek hydrological study has become outdated and the focus area of this study no longer aligns with the modelling of the entire Belongil Creek catchment.

The following sections describe the history of existing models for the Byron Bay Township, and the key tasks and assumptions adopted in the development of the WBNM hydrological model used for this assessment.

### 4.2 Existing Hydrologic Models

#### 4.2.1 Belongil Creek Flood Study (SMEC, 2009)

The oldest available hydrologic model for Byron Bay was completed in 2009 as part of SMEC's Belongil Creek Flood Study. This model was developed using the rainfall-runoff hydrological software XP-RAFTS, with the model being developed to generate inflow hydrographs for the study's hydraulic model.

The model used a total of 43 sub-catchments to represent the Belongil Creek catchment, with the Byron Bay Township having 12 catchments representing it. The percentage impervious applied to each catchment was defined using the latest aerial photography and catchment slope from the latest available topographic data. No stream routing parameters were used for the assessment as all catchment hydrographs were applied locally within the hydraulic model, and therefore was not required. A review of the catchment delineation within the township showed that catchments typically followed the general topography of the township and generally did not consider either the stormwater network or road alignments.

Catchment losses utilised for this study were based on a review of the soil classification within the catchment, with pervious surfaces having an initial loss of 10 mm, and a continuing loss of 3.5 to 10 mm/hr depending on the location. Impervious surfaces used an initial and continuing loss of 1 mm and 0 mm/hr respectively.

The hydrological model was used to simulate the 1-year, 2-year, 5-year, 10-year, 20-year, 100-year ARI's and Probable Maximum Flood (PMF) events, however only the 5-year, 10-year, 20-year and 100-year ARI's and PMF storms were modelled hydraulically. In addition to these events, three historical events were also simulated for the purpose of model calibration, those being the 1974, 1984 and 2003 events. These events each only had historical rainfall and peak flood height data available, and so the hydrological model was used to provide inflows for the hydraulic model to assess the flood heights. The initial and continuing losses for all these events were modified to achieve a better fit with the peak flood height records in the hydraulic model.

#### 4.2.2 Belongil Creek Floodplain Risk Management Study and Plan, Discussion Paper 1: TUFLOW Model Review (BMT WBM, 2011)

Part of Belongil Creek Floodplain Risk Management Study (BMT WBM, 2011), an initial stage in BMT's investigation involved amending the existing SMEC TUFLOW model to be fit for the purposes of their investigation. Whilst not a major component of this report, it is noted that BMT made a minor change to SMEC's hydrological model, introducing a catchment 35A, located to the east of catchment 36 and south of 35.

### 4.3 Modelling Approach

As previously established, given that the existing hydrological models were originally developed for the purpose of the regional Belongil Creek Flood Study, they lack sufficient detail to accurately model the Byron Bay Township, as required for this assessment. As such, the development of a new hydrological model was undertaken. This model utilises the existing catchment delineation completed by SMEC where suitable and also includes the necessary adjustments to improve the representation of the main study areas.



For this assessment, the runoff – routing software Watershed Boundary Network Model (WBNM) was elected for use to replace the previously utilised XP-RAFTS software used by SMEC and BMT WBM. The switch from XP-RAFTS to WBNM is being undertaken as XP-RAFTS is no longer a supported standalone software package, with updates for it ending in 2020. Therefore, it was considered good practice to move to a current software package.

WBNM was used to hydrologically model the existing catchment conditions for the Byron Bay Township to provide runoff hydrographs for use as hydrological inflows in the hydraulic model. The events simulated were the 50%, 20%, 10%, 5%, 2%, 1% AEP design events, as well as the March 2022 rainfall event. WBNM was built in accordance with the Australian Rainfall and Runoff (ARR) guidelines (Ball et. al, 2019), as well as NSW's Office of Environment and Heritage (now DPE) *Floodplain Risk Management Guide* (2019).

The intent and purpose of the initial model build documented in the following section is to provide a robust modelling platform to allow design development and assessment of the drainage scheme to occur in future phases of the project. The model results presented in this report are not final and are likely to change in future phases of the project as required.

## 4.4 Model Inputs

### 4.4.1 Catchment and Sub-Catchment Delineation

A total of 89 sub-catchments were delineated for the Byron Bay Township and adjacent external catchments. This results in a total catchment area of 10.25 km<sup>2</sup>, with the Byron Township accounting for approximately 2.52 km<sup>2</sup>. Figure 4.1 provides the entire model sub-catchment delineation and Figure 4.2 provides Byron Township specific sub-catchment delineation extent.

Unlike the existing hydrological models which simulated the entirety of the Belongil Creek catchment, the catchment delineation for this assessment was limited to only include the catchments that immediately feed the floodplain adjacent to the Byron Bay Township, as Belongil Creek and its influence will be controlled in the hydraulic model with the use of set tail water levels. Instead, a greater focus was given to the Byron Bay Township, with catchments within the study area being delineated using a combination of road crests and stormwater network.

#### 4.4.1.1 Fraction Impervious

The fraction impervious percentage was calculated for each catchment based on the latest available aerial imagery, captured November 2022. The finalised outputs for WBNM are provided in Figure 4.1.



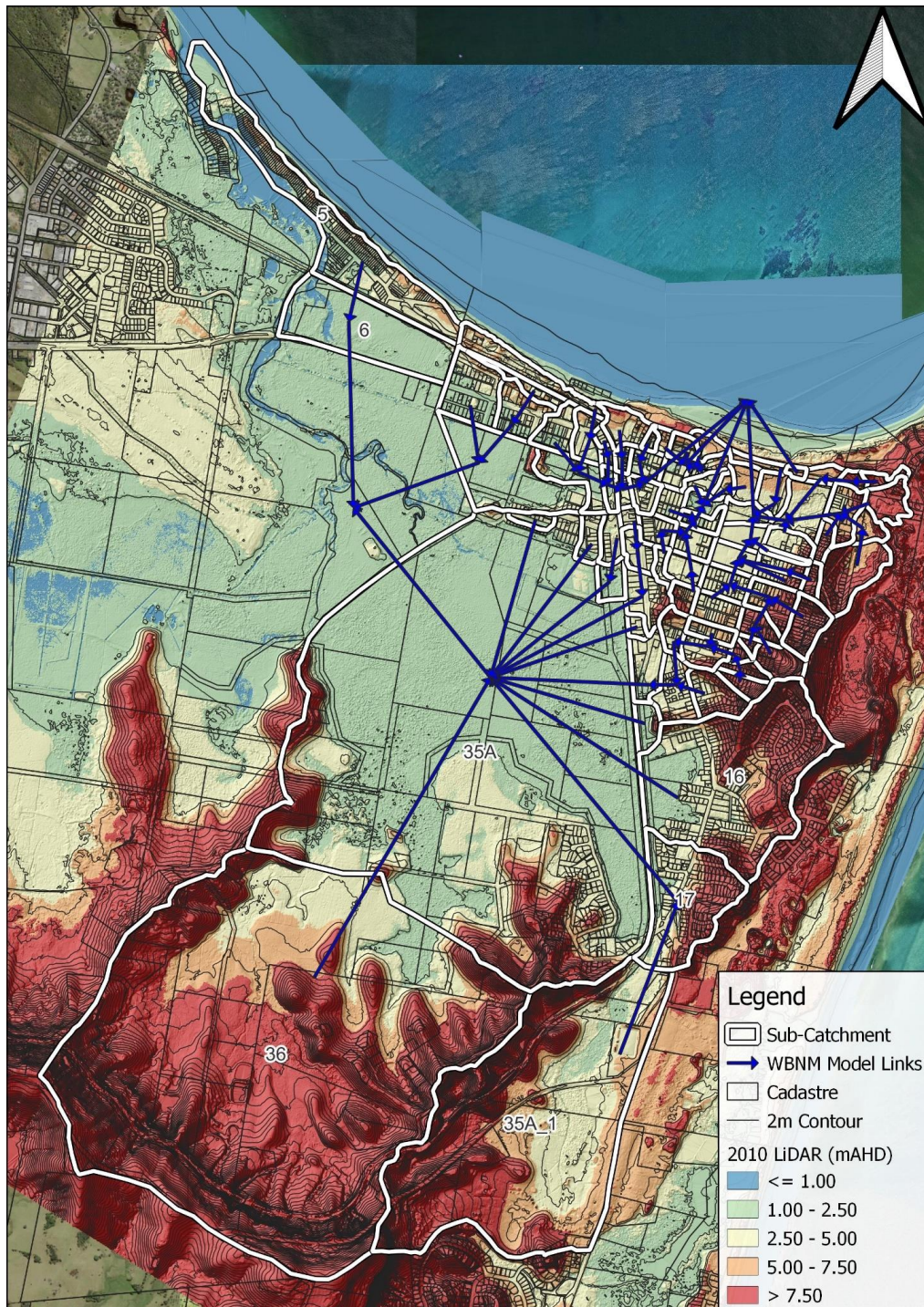


FIGURE 4.1: REGIONAL SUB-CATCHMENT DELINEATION EXTENT



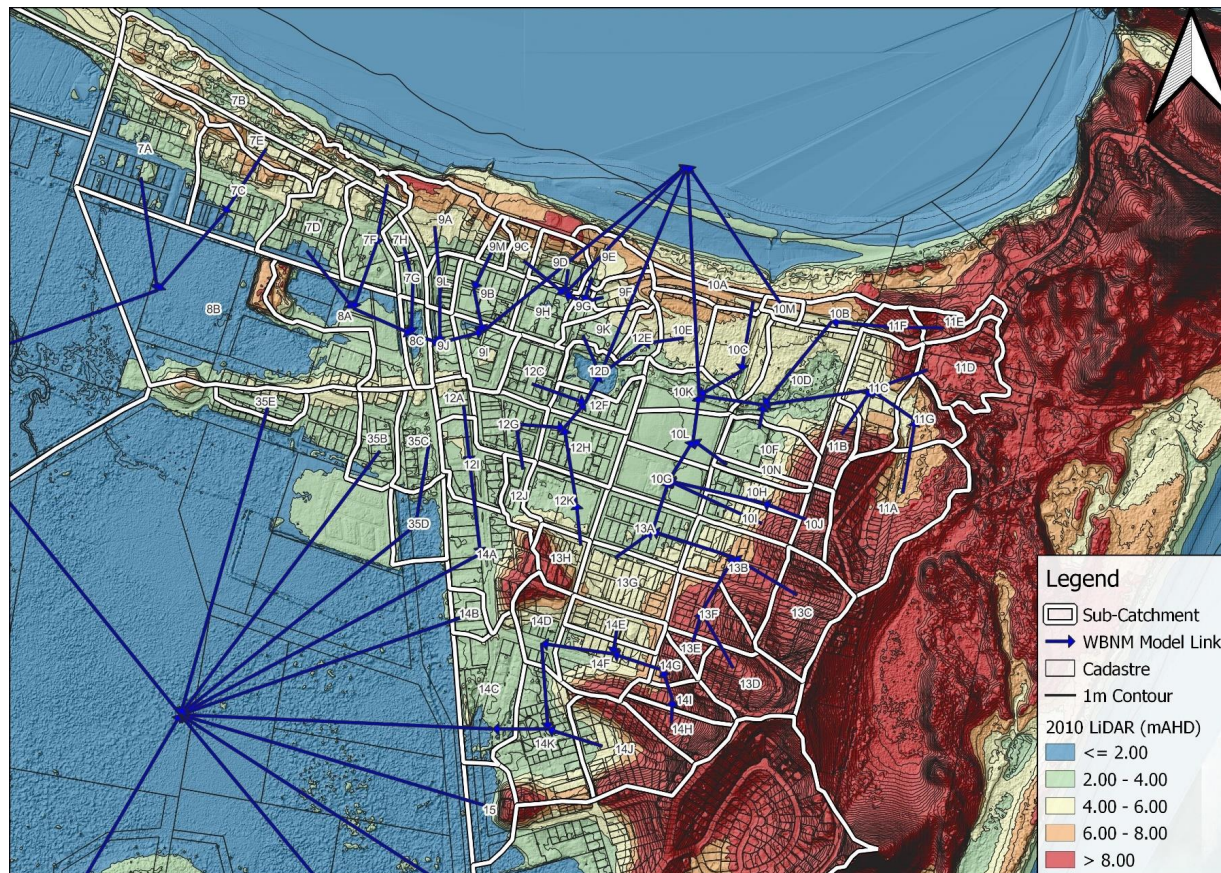


FIGURE 4.2: BYRON BAY TOWNSHIP SUB-CATCHMENT DELINEATION EXTENT

# BYRON SHIRE COUNCIL

## STAFF REPORTS - SUSTAINABLE ENVIRONMENT AND ECONOMY

## 4.2 - ATTACHMENT 1



TABLE 4.1: BYRON BAY TOWNSHIP WBNM CATCHMENT INFORMATION

Catchment ID	Local Catchment Area (ha)	Impervious Fraction (%)	Catchment ID	Local Catchment Area (ha)	Impervious Fraction (%)
5	28.75	17	11A	7.82	23
6	21.72	6	11B	1.37	42
7A	7.82	45	11C	3.62	51
7B	6.09	15	11D	3.14	18
7C	5.15	48	11E	1.12	25
7D	3.36	48	11F	0.92	22
7E	2.03	18	11G	1.93	21
7F	2.86	45	12A	0.87	66
7G	0.69	47	12C	1.92	72
7H	0.52	58	12D	1.77	9
8A	5.09	15	12E	0.95	8
8B	17.98	12	12F	1.58	60
8C	1.25	36	12G	2.32	69
9A	3.39	50	12H	2.59	51
9B	2.2	89	12I	2.46	78
9C	0.85	86	12J	1.08	57
9D	1.52	66	12K	2.48	38
9E	1.49	20	13A	3.13	50
9F	1.07	61	13B	3.93	51
9G	0.47	68	13C	4.04	34
9H	1.68	74	13D	3.17	44
9I	1.91	75	13E	0.6	43

# BYRON SHIRE COUNCIL

## STAFF REPORTS - SUSTAINABLE ENVIRONMENT AND ECONOMY

## 4.2 - ATTACHMENT 1



Catchment ID	Local Catchment Area (ha)	Impervious Fraction (%)	Catchment ID	Local Catchment Area (ha)	Impervious Fraction (%)
9J	1.13	42	13F	2.51	44
9K	1.35	15	13G	3.17	50
9L	0.91	76	13H	1.52	48
9M	0.58	92	14A	4.64	46
15	2.44	20	14B	0.91	62
16	52.68	31	14C	4.5	40
17	20.26	32	14D	2.21	47
10A	1.19	42	14E	1.7	51
10B	1.29	38	14F	2.9	46
10C	2.75	14	14G	0.84	40
10D	5.48	11	14H	1.9	23
10E	2.29	4	14I	1.48	44
10F	2.49	27	14J	4.72	36
10G	2.64	19	14K	5.11	37
10H	1.49	55	35A	299.39	6
10I	1.61	51	35A_1	114.43	5
10J	1.22	45	35B	2.39	46
10K	2.09	5	35C	2.38	30
10L	2.53	7	35D	2.32	16
10M	0.45	30	35E	1.32	47
10N	0.54	67	36	287.17	4
			<b>Total</b>	<b>1025.62</b>	<b>13%</b>



## 4.4.2 WBNM Model Inputs

The following section below provide further information regarding other hydrological inputs used for this study.

### 4.4.2.1 ARR 2019 Data Hub Parameters

#### 4.4.2.1.1 Intensity-Frequency-Duration (IFD) Data

ARR 2019 IFD data for Byron was sourced from the Bureau of Meteorology using the online 2019 Rainfall IFD request system. Data was requested for the catchment centroid, represented by the coordinates of -28.658, 153.605. Refer to Table A.1 in Appendix A: for the IFD depths for the site.

#### 4.4.2.1.2 IFD data comparison ARR 1987 vs ARR 2019

A major update introduced in the 2019 ARR update was the modification of IFD depths for all events, resulting in changes to modelled flood behaviour. It is therefore considered valuable to get an understanding of the impact this has on the Byron Township, as the existing hydrological models have used the 1987 ARR depths. Table 4.2 provides a breakdown of the percentage difference between the 1987 and 2019 ARR rainfall depths for Byron Bay. These demonstrates that in general, the 2019 IFD depths are less than their 1987 counterparts for a short durations (up to 3 hour) which are likely to be most relevant to the drainage design. All AEP events up to 3 hour duration have a -1% to -16% difference, which should in theory translate to lower modelled flows for the new model than for previous ARR87 XPRAFTS model.

TABLE 4.2: PERCENTAGE DIFFERENCE IN ARR 2019 AND ARR 1987 IFD VALUES (NEGATIVE VALUE INDICATES LOWER ARR 2019 VALUE)

Duration - AEP	63%	39%	18%	10%	5%	2%	1%
5 min	-14%	-15%	-14%	-10%	-9%	-7%	-5%
10 min	-9%	-11%	-11%	-8%	-7%	-7%	-6%
15 min	-9%	-10%	-11%	-8%	-8%	-8%	-8%
20 min	-9%	-11%	-12%	-9%	-9%	-9%	-9%
25 min	-10%	-12%	-13%	-10%	-10%	-10%	-9%
30 min	-11%	-13%	-14%	-11%	-11%	-10%	-10%
45 min	-12%	-14%	-15%	-12%	-12%	-11%	-10%
1 hour	-13%	-15%	-16%	-13%	-12%	-11%	-9%
1.5 hour	-13%	-15%	-16%	-12%	-11%	-9%	-7%
2 hour	-13%	-15%	-15%	-11%	-10%	-7%	-5%
3 hour	-12%	-13%	-13%	-9%	-6%	-4%	-1%
4.5 hour	-10%	-11%	-10%	-5%	-3%	0%	3%
6 hour	-8%	-9%	-7%	-3%	0%	3%	6%
9 hour	-5%	-6%	-5%	1%	4%	7%	9%
12 hour	-4%	-5%	-3%	3%	5%	8%	10%
18 hour	-3%	-3%	-2%	3%	6%	8%	9%
24 hour	-3%	-3%	-2%	3%	4%	6%	7%
30 hour	-4%	-4%	-3%	1%	3%	4%	4%
36 hour	-4%	-5%	-4%	0%	1%	1%	1%
48 hour	-5%	-6%	-6%	-3%	-2%	-2%	-3%
72 hour	-6%	-7%	-8%	-5%	-5%	-6%	-7%



#### 4.4.2.1.3 Temporal Rainfall Patterns

East Coast (South) ARR 2019 temporal patterns, downloaded from the ARR Data Hub, were adopted for the Byron Township. ARR 2019 states that point temporal patterns should be used for catchments less than 75 km<sup>2</sup>, as is the case for the Byron Bay Township model.

#### 4.4.2.1.4 Initial and Continuing Loss Model

ARR Data Hub provides estimates for an initial loss of 27 mm and continuing loss of 2.1 mm/hr for pervious areas. An initial loss of 1 mm and continuing loss of 0 mm/hr for impervious areas was also utilised for this study.

#### 4.4.2.1.5 Pre-Burst Application

Due to the lack of availability of standard ARR pre-burst values, no standard ARR pre-burst rainfall depths have been used for this assessment.

### 4.4.2.2 NSW Specific Guidelines

With the introduction of ARR 2019, NSW DPE organised the review of the impacts of the updates introduced in the latest guidelines and found several issues with the proposed changes, as documented in their *Floodplain Risk Management Guide*. To remedy these issues, OEH recommended making several modifications to the base ARR Data Hub outputs. When undertaking an assessment within NSW, a hierarchical approach to loss and pre-burst estimation is required, going from most preferred (1) to least (5), which is as follows:

- (4) Use the average of calibration losses from the actual study on the catchment if available.
- (5) Use the average calibration losses from other studies in the catchment, if available and appropriate for the study.
- (6) Use the average calibration losses from other studies in the similar adjacent catchments, if available and appropriate for the study.
- (7) Use the NSW FFA-reconciled losses available through the ARR Data Hub. These losses may be used within the catchment in which they were derived (available through the ARR Data Hub) or similar adjacent catchments with appropriate scrutiny. This is used with the unmodified ARR Data Hub initial losses which requires the application of additional scrutiny to the balance between initial loss and pre-burst to ensure it is reflective of flood history and observations for the catchment being investigated in the lead-up to events. This is particularly important in catchments of 100 km<sup>2</sup> or less.
- (8) Use default ARR data hub continuing losses with a multiplication factor of 0.4. This is used with the unmodified ARR Data Hub initial losses which requires the application of additional scrutiny to the balance between initial loss and pre-burst to ensure it is reflective of flood history and observations for the catchment being investigated in the lead-up to events. This is particularly important in catchments of 100 km<sup>2</sup> or less.

For the initial model simulations for the Byron Bay Township, Approach 5 has been utilised, as it provided the best initial model inputs for this assessment. This requires the modification to the previously referenced AR&R 2019 Data Hub as discussed in the following sections.

#### 4.4.2.3 Initial and Continuing Loss Model

Under the NSW Guideline recommendations, it is recommended that the Initial Loss provided by ARR 2019 be reduced, in this case using a set of supplied Transformational Pre-Burst depths, which are provided in Table 4.3. For each AEP and duration, it is therefore recommended to reduce the original AR&R 2019 datahub loss of 27 mm by this amount, resulting in the final Probability Neutral Burst Loss Rainfall Depths in Table 4.4. These losses were utilised as the initial loss for all design events cases.

Finally, the ARR 2019 continuing loss value of 2.1 mm/hr was factored by 0.4 as recommended by the NSW guidelines, resulting in a continuing loss value of 0.84 mm/hr being applied to the Byron Bay Township model.



TABLE 4.3: NSW TRANSFORMATIONAL PRE-BURST DEPTHS (mm)

Duration	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1 hour	2.8	13.8	14.7	15	16.2	19.3
1.50 hour	1.9	12.3	13.7	15	16.8	18.7
2 hours	4.6	13.6	14	15.9	16.7	20.9
3 hours	5.1	13.3	14.4	16.8	17.4	21.8
6 hours	7.1	14.2	14.8	16.1	15.9	23.5
12 hours	5.1	11.7	12	14.8	13.2	22.5
18 hours	1.2	7.9	7.4	12.1	10.3	21.6
24 hours	0	5.3	5.6	10.5	12.7	21.1
36 hours	0	0.6	2.2	7.4	9.1	20.8
48 hours	0	0	0.4	3.3	3.8	20
72 hours	0	0	0	0	0	15.3

TABLE 4.4: NSW PROBABILITY NEUTRAL BURST LOSS RAINFALL DEPTHS (MM)

Duration	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1 hour	24.2	13.2	12.3	12	10.8	7.7
1.50 hour	25.1	14.7	13.3	12	10.2	8.3
2 hours	22.4	13.4	13	11.1	10.3	6.1
3 hours	21.9	13.7	12.6	10.2	9.6	5.2
6 hours	19.9	12.8	12.2	10.9	11.1	3.5
12 hours	21.9	15.3	15	12.2	13.8	4.5
18 hours	25.8	19.1	19.6	14.9	16.7	5.4
24 hours	29.9	21.7	21.4	16.5	14.3	5.9
36 hours	35.3	26.4	24.8	19.6	17.9	6.2
48 hours	37.4	27.7	26.6	23.7	23.2	7
72 hours	42.3	32.6	32.1	29.6	27.3	11.7



## 4.5 Model Validation and Calibration

For the purpose of calibrating the hydrological and hydraulic models, modelling of historical events should be undertaken to determine the accuracy of the relevant models. The following sections detail the known relevant historical events and what was modelled for this assessment.

### 4.5.1 Historical Events

#### 4.5.1.1 1974, 1987, 2003 Event

The SMEC Belongil Creek Flood Study had previously assessed the 1974, 1984 and 2003 historical events, as documented in their report (SMEC, 2010a). For this assessment, these events were not assessed, as it is recognised that there have been significant changes in the relevant catchment since this time.

#### 4.5.1.2 March 2022 Flood Event

From the morning of the 28<sup>th</sup> to the 31<sup>st</sup> March, the Byron Bay LGA experienced significant rainfall that resulted in flooding within the Byron Bay Township area. After the peak storm event had subsided, flood debris survey was collected across the township, which will be utilised for this assessment. Table 4.5 provides the surveyed flood debris height collected.

TABLE 4.5: MARCH 2022 FLOOD DEBRIS SURVEY

Survey Address	Surveyed Debris Height (mAHD)	Time of Survey
78 Shirley Street	2.190	1/04/2022 8:35
60 Byron Street	2.268	-
60 Shirley Street	2.316	1/04/2022 9:27
Lawson - Jonson Street	2.695	4/04/2022 12:51
Lawson-Fletcher Street	2.632	4/04/2022 12:21
4 Lawson Street	2.711	1/04/2022 11:57
17 Fletcher Street	2.719	1/04/2022 12:18
52 Jonson Street	2.875	1/04/2022 11:40
28 Lawson Street	2.727	1/04/2022 14:34
35/43 Jonson Street	2.642	1/04/2022 11:28
57 Jonson Street	2.760	4/04/2022 15:51
Somerset Street	2.164	1/04/2022 15:09
Railway Park	2.987	1/04/2022 10:50
Little Burns Street	2.138	4/04/2022 14:02

Pluviograph data available for the March 2022 event was limited to 15-minute rainfall intervals, with the main rainfall burst event provided in Figure 4.3. The entire rainfall event was not simulated, as the surveyed debris data only started being collected from the 1<sup>st</sup> of April onwards, and as the second burst was bigger, negated the need to include this event.



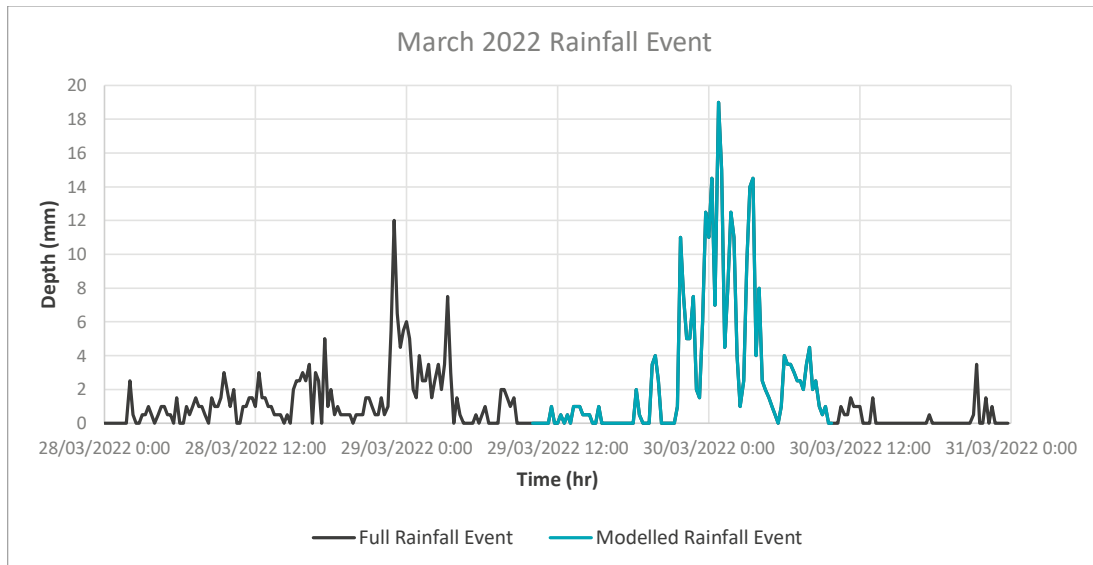


FIGURE 4.3: BYRON BAY (BELONGIL CREEK BRIDGE) (558099) MARCH 2022 GAUGED RAINFALL



## 5. HYDRAULIC MODELLING

### 5.1 Introduction

Development of a new hydraulic model was undertaken to facilitate the assessment of the drainage strategy. The existing 2D TUFLOW hydraulic model was considered unfit for purpose, as due to its focus on the entirety of the Belongil Creek catchment, it lacked the refinement and level of detail required over the Byron Bay Township that this investigation necessitates. Components of the latest BMT (2015) hydraulic model were utilised to expediate the process of developing the Byron Bay Township TUFLOW model, however over time most of this was replaced as the accuracy of the inputs were found to be lacking.

### 5.2 Previous Hydraulic Models

#### 5.2.1 Belongil Creek Flood Study (SMEC, 2009)

The oldest available hydraulic model for Byron Bay was completed in 2009 as part of SMEC's Belongil Creek Flood Study. This model was developed using the 1D/2D hydraulic software package TUFLOW, for the purpose of mapping the flood extent due to Belongil Creek flooding.

The model covered the entirety of the Belongil Creek catchment, utilising a 2D 20m cell size. The model also incorporated Belongil Creek using 1D representation. The hydraulic model was calibrated for the 1974, 1984 and 2003 historical flood events. Design events simulated were the 20%, 10%, 5%, 1% AEP and Probable Maximum Flood (PMF) events.

#### 5.2.2 Belongil Creek Floodplain Risk Management Study and Plan, Discussion Paper 1: TUFLOW Model Review (BMT WBM, 2011)

The BMT WBM Belongil Creek Floodplain Risk Management Study involved the updating of the existing SMEC hydraulic model. The updates involved the removal of the 1D representation of Belongil Creek, improvements to the stormwater network details and the updates to the hydrological inflows.

#### 5.2.3 Belongil Creek Floodplain Risk Management Plan (BMT WBM, 2015)

Modelling of the proposed flood modification from the Byron Drainage Strategy was undertaken as a part of this assessment, utilising the amendment base case model developed as part of Discussion Paper 1.

#### 5.2.4 Sandhills Wetland Byron Bay - Flood Impact Assessment (BMT, 2023)

To assess the viability of the upgrades proposed to the Sandhill wetland, flood modelling was undertaken using design surfaces to determine the benefit of the project. This was completed using a modified version of the model previous used by BMT WBM in 2015.



## 5.3 Hydraulic Model Development

### 5.3.1 Model Extent and Topography

The existing model topography was based on the following data provided by BSC:

- 1m DEM LiDAR
- Butler Street As-Constructed survey.

The proposed preferred drainage strategy model (developed case) included the following topographic changes:

- Sandhills wetland ground survey.
- Sandhills wetland proposed design surface for the Cowper Street upgrade scenario.

A 1m grid cell resolution was adopted for the Study and selected to ensure that flooding and overland flow is represented in the highest possible detail. It was determined that Sub-Grid Sampling (SGS) was not required given the fine cell resolution and would significantly increase model simulation time with no material improvement to output quality.

Due to poor definition in the DEM or other data inaccuracies, modifications to the model terrain have been implemented using TUFLOW z-shape tools to represent the following:

- Road crest lines using TUFLOW break lines.
- Butler Street outlet bed and banks using assumed channel geometry.
- Proposed levees for the Town Centre and Shirley Street upgrade scenarios.
- Pipe sump/basin for the Town Centre upgrade scenario.

Limitations still exist in the model terrain that may cause inaccuracies in detailed road and kerb heights and field inlet pit locations during this initial phase of modelling. The adopted model extent and topography for the existing scenario is shown below in Figure 5.1.

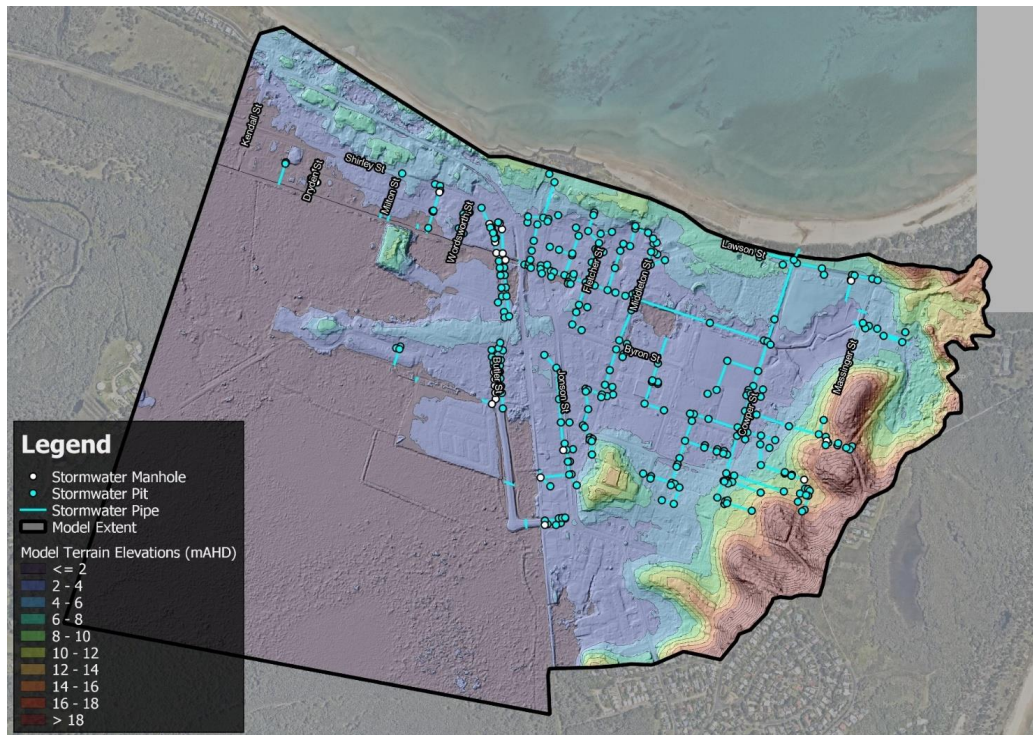


FIGURE 5.1: TUFLOW MODEL EXTENT AND TERRAIN

### 5.3.2 Boundary Conditions

Inflows to the TUFLOW model have been applied as local catchment hydrographs as determined by the WBNM model described in Section 4. Local catchment hydrographs were applied directly to the 2d cells connected to the 1d stormwater network where available within each sub-catchment, where stormwater network did not exist, the flows were applied to the 2d domain near the catchment outlet.

Outflow boundaries have been applied using the HT flag which allows TUFLOW to calculate a level-discharge outflow relationship based on a specified tailwater level. Outflow boundaries have been applied at the western extent of the model to represent the impact of Belongil Creek, as well as a 1D point boundary at the headwall outlet at Clarks Beach.

Time-varying tailwater levels have been adopted for the March 2022 event extracted from the Rainbow Bridge on Ewingsdale Rd (Gauge Station H558099). There are no other gauges in the area that could be used to inform historical event tailwater conditions, therefore a tailwater of Highest Astronomical Tide (HAT) has been adopted at the initial Clarke Beach outlet for the simulation of the March 2022 flood event.



TABLE 5.1: ADOPTED TAILWATER CONDITIONS

Storm Event	Belongil Creek Tailwater Level	Clarks Beach Outlet Tailwater Level
March 2022	Time-varying (peak at 2.01mAHD)	Highest Astronomical Tide (1.1mAHD)
Design Events (1% AEP to 50% AEP)	Mean High Water Springs (1.1mAHD)	Highest Astronomical Tide (1.1mAHD)
	1% AEP Storm Surge (2.6mAHD)	1% AEP Storm Surge (2.6mAHD)
	5% AEP Storm Surge (2.2mAHD)	5% AEP Storm Surge (2.2mAHD)



FIGURE 5.2: TUFLOW STORMWATER NETWORK AND BOUNDARIES





### 5.3.3 Hydraulic Roughness

The hydraulic roughness has been selected based on the inspection of aerial imagery and applied using the boundary cadastre data as supplied by BSC. The adopted Manning's 'n' Roughness values are summarised below in Table 5.2 and the spatial distribution of the materials layer is provided in Figure 5.3.

TABLE 5.2: ADOPTED HYDRAULIC ROUGHNESS

Material	Hydraulic Roughness
Road Reserve	0.025
Open Water Body / Ocean	0.030
Low-Density Residential	0.150
Medium-Density Residential	0.200
Commercial	0.250
Open Space	0.040
Light Vegetation	0.060
Medium-Dense Vegetation	0.080
Swamp	0.050
Community Facilities	0.100

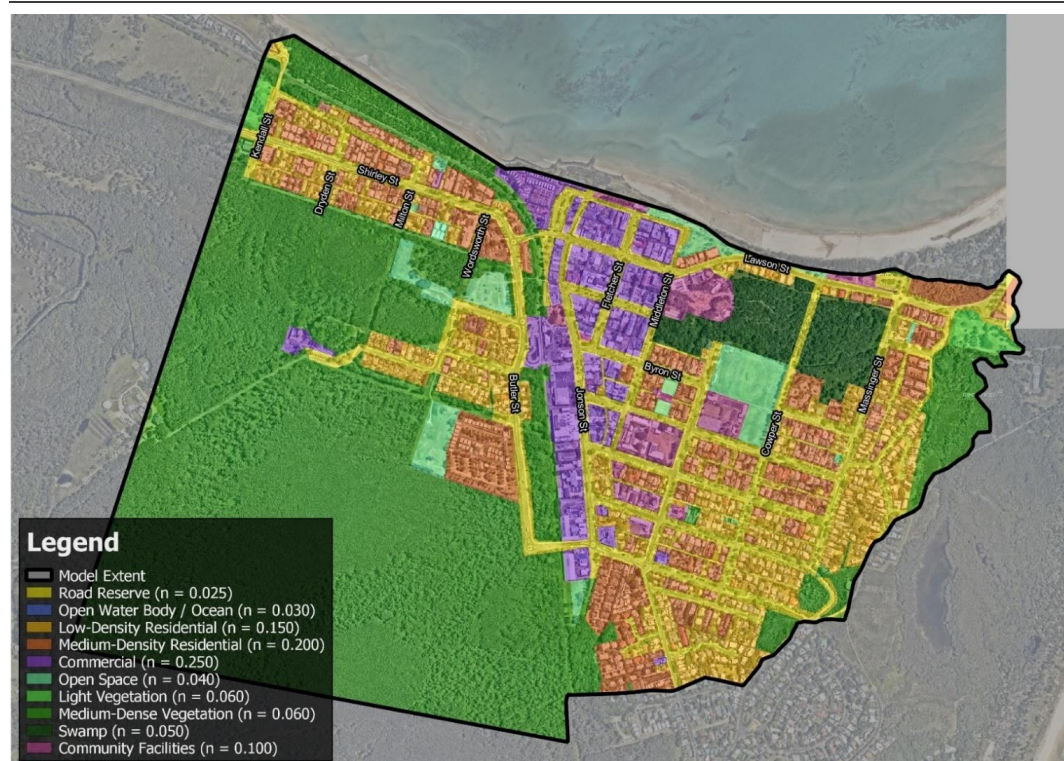


FIGURE 5.3: TUFLOW HYDRAULIC ROUGHNESS



The selection of hydraulic roughness values has considered the impact of typical urban furniture and buildings and the change to overland flow behaviour that they generate. Buildings have not been applied as 2D obstructions as this artificially reduces the available flood storage within the model and is therefore considered to produce unrealistically high flood levels. Given the high density of buildings and commercial structures present in the model, especially within the Town Centre, it is considered unreasonable to adopt 2D building obstructions and an increased hydraulic roughness has been adopted.

#### 5.3.4 Drainage Network

The stormwater network adopted in the TUFLOW model is based on the following information:

- Belongil Creek Floodplain Risk Management Plan (BMT, March 2015).
- Council's GIS Stormwater Network.

A preliminary review of the above data indicated that significant additional network exists beyond what was included with the Belongil Creek Floodplain Risk Management Plan, based on the BSC GIS Stormwater Network provided. The adopted network was therefore developed using original BMT stormwater network and extended to include the missing features as included in the BSC GIS database. It is noted that a significant amount of key structural information required to represent the stormwater network was missing from the BSC GIS database, such as:

- Manhole and pipe inverts.
- Pipe sizes.
- Inlet pit sizes.

Missing pit and pipe information was in-filled in the model stormwater network based on the following assumptions:

- Minimum pipe grades.
- Minimum 0.6m cover to reinforced concrete pipes.
- Minimum 0.3m cover to reinforced concrete box culverts.
- Pipe sizes based on upstream or surrounding network.

Existing stormwater pits have been assumed to be 1mx1m rectangular pits with capture curves automatically calculated by TUFLOW, as no information exists that would indicate otherwise. All proposed stormwater pits as part of the drainage upgrade works have adopted the BCC capture curves for the relevant lintel lengths and inlet type, however as part of the initial investigation unlimited pit capacity has been represented to test performance of the pipe network. The stormwater network is shown below in Table 5.3. It is expected significant improvement of the modelled 1D network will be possible during concept design incorporating ground survey.

#### 5.3.5 Simulated Events

The simulated temporal patterns have been selected based on the pattern that most closely represents middle-loaded behaviour. ARR 2019 provides guidance around burst-loading which is referred to as the distribution of rainfall within a storm burst and is a defining characteristic of a rainfall event. Burst-loading is characterised as one of three options, being front- middle- or back-loaded, and is defined based on when the first 50% of rainfall occurs within a burst, in accordance with the criteria below:

- Front-loaded – 0 to 40%
- Middle-loaded – 40 to 60%
- Back-loaded – 60 to 100%

Simulation of the middle-loaded temporal pattern allows for a set of representative flood results to be produced without compromising model run time by simulating the full suite of 10 temporal patterns. At this stage of the project where high-level testing of the preferred drainage strategies is being completed, it is considered suitable to adopt the middle-loaded temporal pattern only for each storm duration. Additional temporal pattern simulations will be discussed at the Concept Design phase.

The full summary of simulated events is summarised in Table 5.3.



TABLE 5.3: MODEL SIMULATION SUMMARY

Material	Storm Event	Storm Duration	Storm Temporal Pattern	Tailwater Condition	Drainage Scenario
Design Events	1% AEP	30-minute	9	HAT, 1: 20 AEP Storm Surge,  Envelope approach also adopted 5% AEP with 1:100 AEP100 SS level	Existing, Developed
		60-minute	6		
		120-minute	1		
		180-minute	10		
	2% AEP	30-minute	9	HAT, 1:20 AEP SS	Existing, Developed
		60-minute	6		
		120-minute	1		
		180-minute	10		
	5% AEP	30-minute	8	HAT, 1:20 AEP SS	Existing, Developed
		60-minute	7		
		120-minute	6		
		180-minute	4		
	10% AEP	30-minute	8	HAT	Existing, Developed
		60-minute	7		
		120-minute	6		
		180-minute	4		
	20% AEP	30-minute	7	HAT	Existing, Developed
		60-minute	5		
		120-minute	4		
		180-minute	5		
	50% AEP	30-minute	7	HAT	Existing, Developed
		60-minute	5		
		120-minute	4		
		180-minute	5		
Historical Event	March 2022	1440-minute		Time-Varying	Existing, Developed





## 5.4 Hydraulic Model Verification

### 5.4.1 March 2022

Hydraulic model validation was undertaken by simulating the March 2022 historical event and comparing the estimated flood levels to recorded debris marks collected following the rainfall event. As discussed above in Section 4, The second burst of the storm event which occurred in late March was simulated, and debris survey is understood to have been collected between 1 April and 4 April 2022. The locations of the flood debris survey marks are provided in Figure 5.4 and the flood level comparison outcomes are summarised in Table 5.4. The flood depth map for the simulated March 2022 event is provided in Appendix F.

The flood level comparisons for the March 2022 event were observed to range between 410mm below and 117mm above the surveyed flood heights. Investigation into the provided flood heights has flagged that two of the recorded flood heights, at the Little Burns Street and Lawson-Jonson Street data points, are located below the input terrain data and outside of the simulated flood extents. Furthermore, the Great Northern and The Corner data points record an inconsistent hydraulic grade. That is, whilst the "The Corner" data point is located upstream of the Great Northern and at a ground elevation 10mm higher, the Great Northern data point records a flood height 233mm higher than The Corner. This brings into question the adequacy and accuracy of the supplied flood debris data as the level discrepancy is not considered possible given the terrain. Using debris marks to validate peak flood levels from a hydraulic model can be limited where debris marks are influenced by physical factors such as moving vehicles causing waves which artificially elevate the flood level. There is a high likelihood of this occurring in the Byron Bay, particularly given the flood depths are generally below 300mm and may have been trafficable during the event. In addition to these observations, it is also noted that comparisons to the historical March 2022 event are being completed using flood extents based on outdated 2010 LiDAR as this is the most recent terrain data available at the time of the study.

Based on the above, it is considered that the input data provided for the flood model verification, that is the flood height information and 2010 LiDAR, is not suitable for validation of the flood model outputs, and validation runs should be re-attempted following update of the model DEM with survey data.

TABLE 5.4: MARCH 2022 FLOOD LEVEL COMPARISON

Debris Marker ID	Debris Marker Location	Surveyed Flood Level (mAHD)	Modelled Flood Level (mAHD)	Modelled Flood Depth (m)	Flood Level Difference (m)
26	LITTLE BURNS ST	2.14	Out of flood extent	Out of flood extent	Out of flood extent
27	RAILWAY PARK	2.99	Out of flood extent	Out of flood extent	Out of flood extent
28	SOMERSET ST	2.16	Out of flood extent	Out of flood extent	Out of flood extent
29	FUNDIES	2.76	Out of flood extent	Out of flood extent	Out of flood extent
30	THE CORNER	2.64	2.46	0.23	-0.18
31	BB LIBRARY	2.73	2.76	0.07	0.03
32	GREAT NORTHERN	2.88	2.46	0.24	-0.42
33	BAY WHALERS	2.72	2.75	0.27	0.03
34	THE CELLAR	2.71	2.65	0.41	-0.06
35	LAWSON-FLETCHER	2.63	2.75	0.18	0.12
36	LAWSON-JOHNSON	2.70	Out of flood extent	Out of flood extent	Out of flood extent
37	SHIRLEY-DRYDEN T	2.32	2.01	0.49	-0.31
38	KENDALL ST-EWNGS 1	2.27	2.01	0.37	-0.26
40	KENDALL ST-EWNGS 2	2.19	2.01	0.35	-0.18



FIGURE 5.4: FLOOD DEBRIS SURVEY LOCATIONS



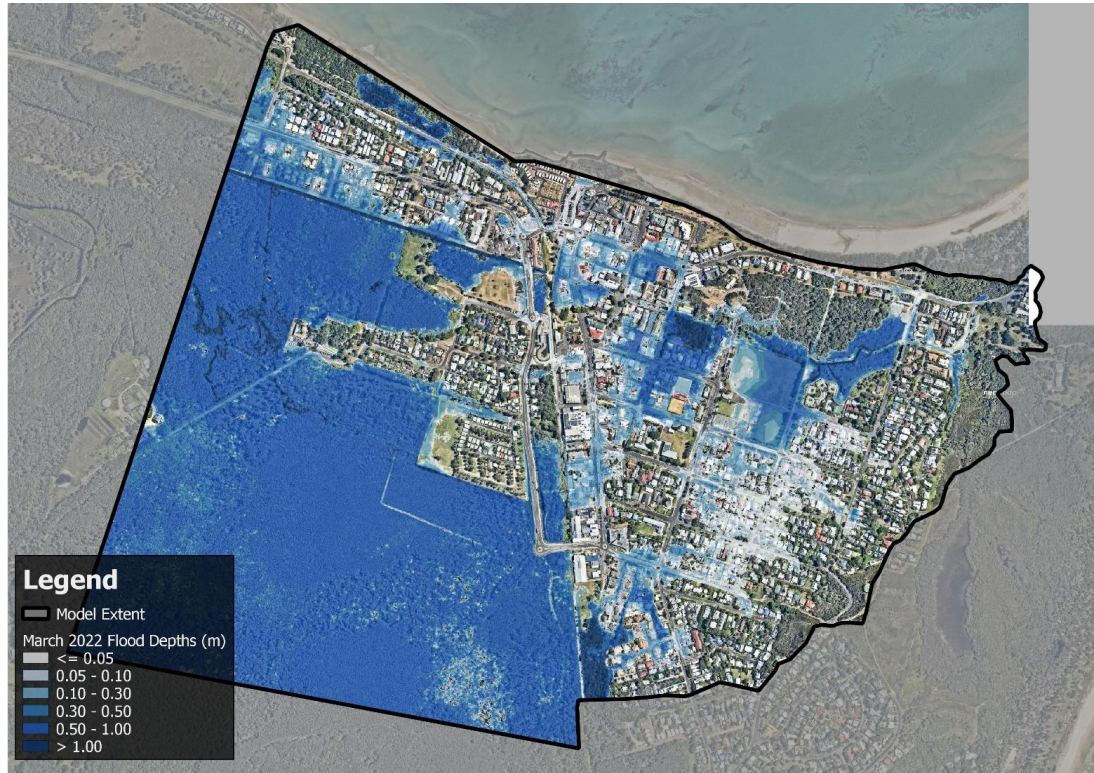


FIGURE 5.5: MARCH 2022 MODELLED FLOOD DEPTH



### 5.4.2 Existing Case Results - Design Events

A review and comparison of the design flood levels produced by the local hydraulic model for Byron Bay indicates that modelled flood heights are higher than the previous flood models. Investigation into the previous modelling indicates that only the 12-hour storm duration was modelled, it is anticipated that this was the identified critical duration for the Belongil Creek catchment. However, all simulated storm durations with the local hydraulic model developed by Engeny are shorter than the previous modelling as these are identified to be critical given the smaller areas of contributing catchments relevant to the drainage study.

Further to the above, Engeny have improved representation of flow by sub-delineating catchments to a much finer resolution and defining a 1m model cell size to capture the behaviour of minor overland flow paths. It is understood that the previous models were simulated using a 10m cell size (5m output cell resolution) which is far too coarse to accurately inform a local drainage study.

Based on the above, it is not considered suitable to compare flood levels directly to the previous modelling given the differences in modelled storm durations and cell resolution, however a high-level review indicates that flood extents are generally consistent with the previous studies. A comparison of the flood extents is provided below in Table 5.5.

Flood depth mapping for the design and historical events is provided in Appendix C.

Flood level afflux mapping for the design and historical events is provided in Appendix D.

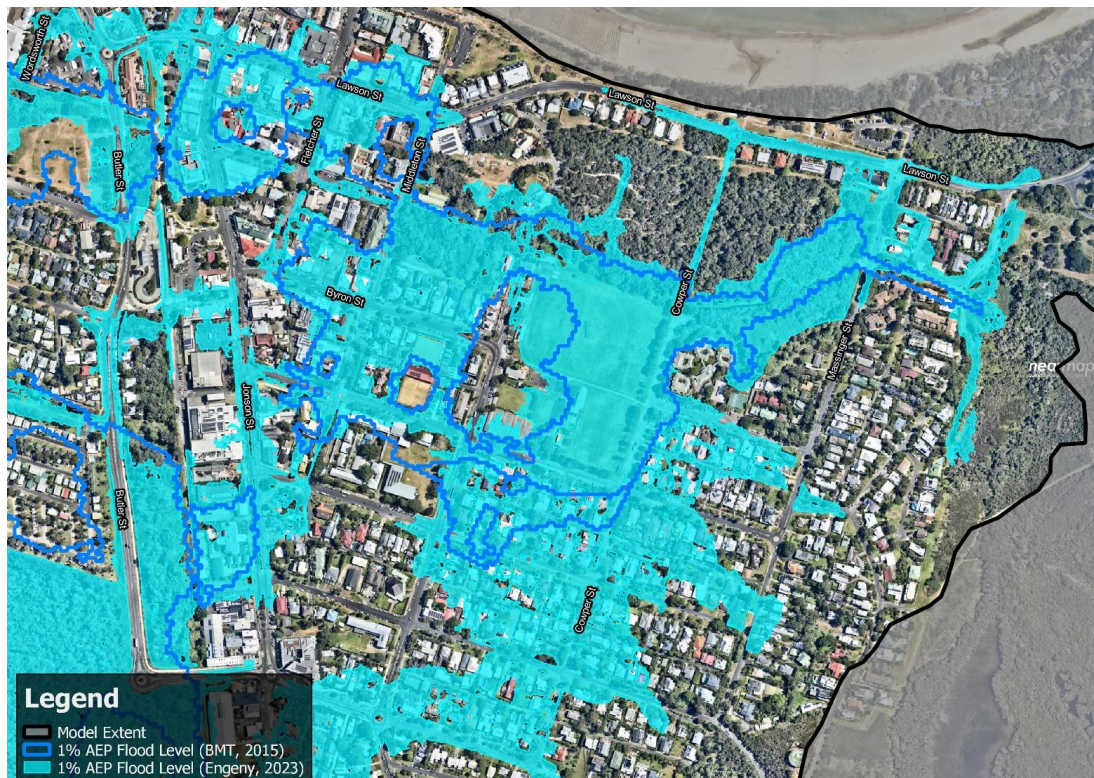


FIGURE 5.6: 1% AEP FLOOD EXTENT COMPARISON (1.1M AHD TAILWATER SCENARIO)



## 5.5 Developed Case Hydraulic Model Results

The following sections summarise the model amendments and associated results for the proposed Byron Bay drainage scheme.

### 5.5.1 Shirley Street

The Shirley Street drainage upgrades modelled included the following:

- Levee at 2.9m AHD adjacent Butler St drain.
- 4 x pump stations on Kendall St, Dryden St, Milton St and Wordsworth Street assuming no specific pump storage and idealised pumping conditions.
- Pipe network drainage upgrades on Kendall St and Dryden Street.

Investigation of the HAT tailwater results has indicated that for:

- The 10% AEP;
  - Significant reductions in flooded extent between Kendall St and Dryden St.
  - Reductions of up to 270mm on Dryden St.
  - Reductions of up to 300mm between Milton St and Wordsworth St.
  - Flood increases of up to 30mm between Dryden St and Milton St due to runoff ponding against the levee at a local sag where a pump station was not proposed.
  - Flood increases on Butler St as a result of the proposed levee, up to 120mm.
  - Flood worsening in the Butler Street drain up to 100mm due to levee impacts and pumped outflows to the drain.
- The 1% AEP;
  - Significant reductions in flooded extent between Kendall St and Dryden St.
  - Reductions of up to 40mm on Dryden St and up to 300mm on the access street between Dryden St and Kendall St.
  - Increases of up to 60mm between Milton St and Wordsworth St.
  - Flood increases of up to 150mm between Dryden St and Milton St due to runoff ponding against the levee at a local sag where a pump station was not proposed.
  - Flood increases on Butler St as a result of the proposed levee, up to 120mm.

Significant improvements to inundation, in the 1% AEP Storm Surge scenario, were observed in the 10% AEP and 1% AEP, as large as 850mm, due to the proposed levee protecting properties from tidal ingress.

Peak pump flows in the 10% AEP and 1% AEP design event for the HAT tailwater conditions are summarised below in Table 5.5.

TABLE 5.5: SHIRLEY ST PEAK PUMP OUTFLOW RATES

Location	10% AEP (m <sup>3</sup> /s)	1% AEP (m <sup>3</sup> /s)
PS1	1.0	1.6
PS2	1.3	1.3
PS3	0.8	0.8
PS4	0.3	0.9





The peak pump flows indicate that additional capacity is available at PS1 and PS4 in the 10% AEP and are only running at capacity in the 1% AEP, however PS2 and PS3 are running at maximum capacity in the 10% AEP. This requires further analysis in concept design to determine appropriate pump rates based on final inflow characteristics and pump storage arrangements and may present an opportunity to reduce pump sizes.

Further assessment and modelling is required of the system to define how many properties have significant flooding improvements and to what extent the 10% AEP desired level of service is achievable in each of the Streets which currently show flood improvements. Additionally further investigation into the overland flow paths between Dryden, Milton and Wordsworth Street is required to determine the extent of private property flood improvement that can be achieved in these areas as it may not be feasible to make all properties flood free in the 10% AEP.

An area of concern is the existing Butler Street road drainage network that may be impacted by the proposed flood levee and consideration of if this system should be connected to the Shirley street system or Town centre pump station requires further analysis of levels and understanding of levee arrangements.

### 5.5.2 Town Centre

The Town Centre upgrades included the following:

- Pit and pipe drainage upgrades on Lawson Street, Fletcher Street, Byron Street and Jonson Street.
- A sump and pump station east of Butler Street adjacent the rail line assuming idealised pumping.

Investigation of the HAT tailwater results has indicated that for:

- The 10% AEP;
  - Flooding is contained to the kerb and channel within Lawson St east of Fletcher St, Fletcher St, Jonson St south of Byron St and Byron St west of Fletcher St.
  - Significant drying across properties south of Lawson St, south of Byron St and west of Jonson St.
  - Road crown inundation still present on Lawson St west of Fletcher St and Jonson St north of Byron St, however flood depths have reduced by up to 40mm and 20mm, respectively, at these locations.
  - Peak flood levels within the sump east of Butler St are pumped to achieve a level no greater than 1.0mAHD.
- The 1% AEP;
  - Flooding is contained to the kerb and channel within Fletcher St, Byron St and Jonson St south of Byron St.
  - Significant drying across properties south of Lawson St, south of Byron St and west of Jonson St.
  - Road crown inundation still present on Lawson St west of Fletcher St and Jonson St north of Byron St.
  - Peak flood levels within the sump east of Butler St reach 1.3mAHD.

The proposed levee east of Butler Street has facilitated a free draining stormwater network in the modelled HAT, 1:20 AEP SS and 1:100 AEP SS tailwater scenarios and is no longer affected by these tailwater conditions. As a result, the mapping of the higher tailwater conditions show significant improvements to flooding within the Town Centre with reductions estimated as high as 900mm. It is evident that protection of the stormwater network against tidal conditions is critical in improving the effects of flooding during a rainfall event.

Peak pump flows in the 10% AEP and 1% AEP design event for the HAT tailwater conditions are summarised below in Table 5.6.

TABLE 5.6: TOWN CENTRE PEAK PUMP PERFORMANCE

Infrastructure	10% AEP (m <sup>3</sup> /s)	1% AEP (m <sup>3</sup> /s)
PSS	3.6	5.5

In order to fully utilise the proposed pump arrangement, both the new drainage system and current drainage system are designed to discharge into the sump. Peak pipe flows for each of these outlets are summarised in Table 5.7.



TABLE 5.7: TOWN CENTRE PIPE OUTLET PERFORMANCE

Infrastructure	10% AEP (m <sup>3</sup> /s)	1% AEP (m <sup>3</sup> /s)
Current Pipe Outlet	1.6	2.1
Proposed Pipe Outlet	1.8	3.3

### 5.5.3 Cowper Street

The Cowper St upgrades included the following:

- Pit and pipe drainage upgrades on Middleton St discharging to the existing swamp south of the Courthouse.
- Pit and pipe drainage upgrades on Carlyle St and Cowper St discharging to the trunk pipe that connects to the Clarkes Beach outlet.
- Construction of the Sandhills wetland within the existing swamp east of Cowper St and north of Marvell St.

Investigation of the HAT tailwater results indicates that for:

- The 10% AEP;
  - Widespread flood level reductions of up to 70mm within the vicinity of Middleton St, however the road crown is still inundated. This is attributed to the system only out letting to the local swamp that is low lying and has no flood relief and is reliant on storage only.
  - Flooding along Carlyle St west of Cowper St is now contained to the kerb and channel.
  - Reductions of up to 160mm at the sag point on Cowper St (at Marvell St).
  - Reductions of up to 280mm across the sports field west of Cowper St.
- The 1% AEP;
  - Widespread flood level reductions of up to 220mm within the vicinity of Middleton St.
  - Flood reductions south of Carlyle St of up to 20mm.
  - Flood reductions of up to 260mm at the sag point on Cowper St.
  - Flood reductions of up to 250mm across the sports field west of Cowper St.

As the drainage upgrades along Middleton St discharge to the swamp which has no formal outlet, the flood level reductions are understood to be a result of a combination of additional storage created within the stormwater network and protection from tidal effects. In the Existing Scenario the current stormwater network is connected to the Town Centre network and is therefore hydraulic connected and influenced by tidal conditions. The new stormwater network is unaffected by tidal impacts and therefore is not exposed to an initial water level condition at the start of the model simulation, thus providing storage across the network and free-draining conditions for the existing infrastructure. Although the additional storage provides benefits to the Middleton St area, stormwater runoff captured in the swamp is unable to discharge to Belongil Creek or the ocean as a pump arrangement was previously discarded by Council, evaporation / infiltration is therefore the only current opportunity for stormwater runoff to escape the system.

The drainage network upgrades within Cowper St include a duplication of the existing pipes discharging to Clarkes Beach, the performance of the existing and proposed pipes in the 10% and 1% AEP design storm events is summarised in Table 5.8.

TABLE 5.8: COWPER ST PIPE OUTLET PERFORMANCE

Infrastructure	10% AEP (m <sup>3</sup> /s)	1% AEP (m <sup>3</sup> /s)
Current Pipe Outlet	2.5	2.8
Proposed Pipe Outlet	2.6	3.2



The peak flows above are summarised as flows for each pipe, so the total outlet capacity in the 1% AEP is estimated as 6.0m<sup>3</sup>/s. The new duplicate pipe is observed to perform 15% better in the 1% AEP, this increase in performance is due to it being a standalone outlet with less losses than the existing pipe as it is not connected to the Lawson St stormwater network.

#### 5.5.4 March 2022

Flood afflux for the proposed drainage upgrades when assessed for the March 2022 event is provided in Figure 5.7. Under this scenario the proposed drainage scheme demonstrates significant improvements across the township. A summary of the results are:

- Significant flood level reductions of up to 370mm along Shirley St and across the properties to the south.
- Flood level increases on Butler St upstream of the proposed levee as a result of insufficient drainage which can daylight to the Butler St drain. This requires addressing through design optimisation and may be able to be mitigated.
- Widespread drying of flood waters across the Town Centre with several properties completely immune to estimated flooding.
- Some road crown overtopping is still present within the Town Centre, however flood levels within the road have reduced by up to 400mm.
- Flood level reductions across Middleton St are observed to be as great as 310mm, with several properties immune to historical flooding.
- Flood level reductions are observed up to 20mm south of Carlyle St, with reductions of up to 400mm at the Cowper St sag.

Pump performance in the historical event is summarised in Table 5.9.

TABLE 5.9: HISTORICAL EVENT PUMP PERFORMANCE

Location	March 2022 Event, Peak Pump flow (m <sup>3</sup> /s)
PS1	0.8
PS2	1.3
PS3	0.8
PS4	0.9
PS5	4.9



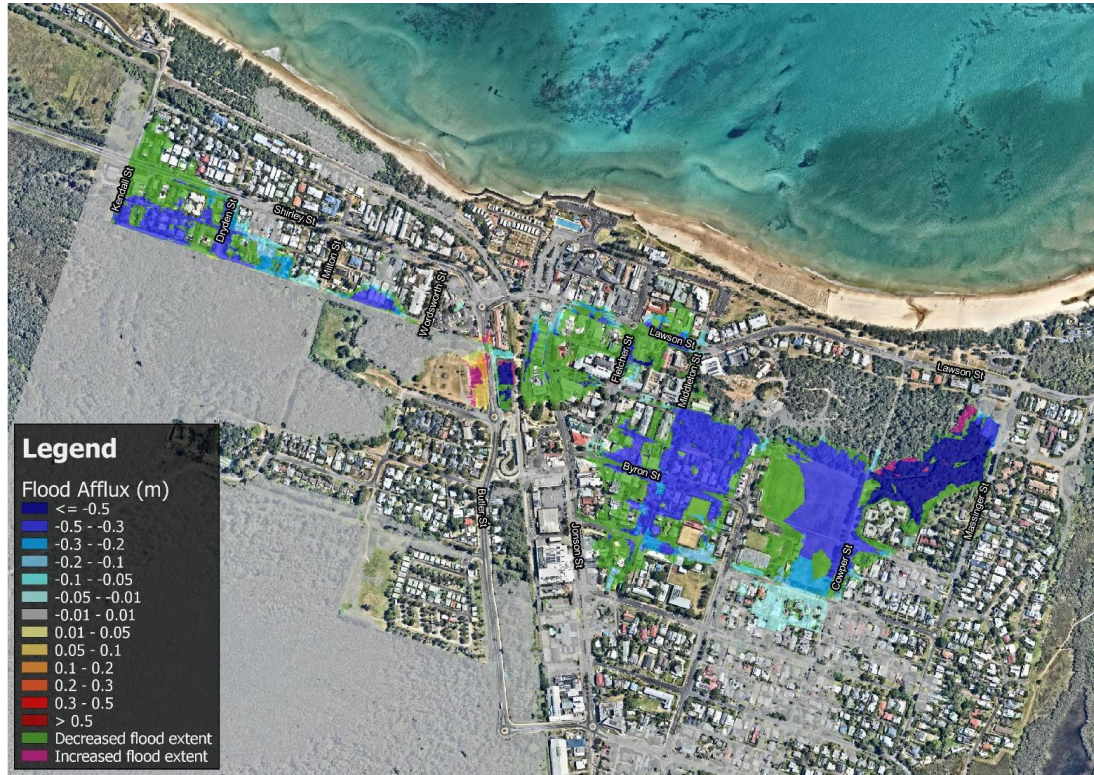


FIGURE 5.7: MARCH 2022 FLOOD LEVEL AFFLUX



## 6. DRAINAGE SCHEME REVIEW

### 6.1 General

A summary of the technical review of the drainage scheme is outlined in the following sections. This contains comments regarding risks and potential issues with the system, as well as opportunities for Council to consider prior to commencing the next phase of design.

#### 6.1.1 Flood Modelling

A review of the previous flood modelling undertaken for the scheme has identified the following:

- The Council GIS data has been input into model, but no checks appear to have been done regarding pipe levels and data errors are carried through into the flood modelling. This presents an opportunity to better represent the existing network and improve model accuracy.
- The rainfall IFDs adopted are using ARR1987 which is now superseded by ARR2019. The comparative analysis shown in Table 4.2 indicates the new design rainfalls may be in the order to 10-15% less than previous rainfall for the short duration events that are critical in the small township catchments.
- The design event analysis in DRAINS is for very short duration events (0.5 -1.0 hours). This approach does not account well for flat topography and flood storage in the catchment and it is considered 2D modelling should be adopted to assess the 1d stormwater network.
- Revised ocean storm tide levels have been derived since the scheme was development in 2010 and should be assessed per current Council planning policy.

##### 6.1.1.1 Stormwater Network Design

Review of the previous stormwater system design modelling has identified the following:

- There is opportunity to optimise the network based on current IFD curves which are likely to have lower rainfall intensities than previously assumed. The previously adopted minor storm is 10 year ARI with a critical duration of 30 minutes (rainfall intensity of 100mm/hr), Major storm of 100 year ARI with a critical duration 30 minutes (rainfall intensity of 142mm/hr).
- No inclusion of climate change was made in the DRAINS modelled design events which requires further consideration and sensitivity testing.
- No consideration of the existing flow capacity in the current stormwater network was made (albeit minor capacity).
- No consideration of existing service conflicts or PUP requirements was made which may dictate some components of the design sizing, levels and alignment.
- No consideration of power demands and reliability of the power network during flood events.
- Large 3.6m lintel stormwater pits adopted in all cases.

#### 6.1.1 Land Tenure

Key land tenure issues identified to date are located on the land parcels identified below. Confirmation of the ownership and requirements for each of these lots is required to identify suitability for use in construction of the flood mitigation infrastructure. Obtaining suitable land tenure over these areas is critical to the project and may fatally flaw components of the scheme if suitable agreements cannot be made with landowners.

- Crown reserve land between Wordsworth Street and Butler Street (389/DP728537 and 390/DP728538).
- Railways NSW land at the location of the proposed town pump station (2/DP1289363).
- Crown Reserve between Middleton and Cowper Street (457/DP1087879).

Mapping of these areas is provided in Appendix F.



## 6.1.2 General Stormwater Pump Station Considerations

### 6.1.2.1 Design

Design of the stormwater pump systems requires consideration of various constraints and factors including:

- The trade-off between space and capacity. The size of pumps, maintenance requirements and pump efficiency needs to be balanced with available space, redundancy and flexibility required of the system. It is likely all the proposed pump stations are space constrained and therefore fewer, larger pumps may be required.
- Likely submersible pump stations are required as dictated by space and amenity requirements. This requires consideration of lifting capability (either mobile or on site) for retrieval, maintenance, and cleaning of pumps.
- Management of solids, floating debris and water quality. Inlet screens will be required on the pump stations depending on the catchment debris and solids load. This requires specific design consideration.
- Hydraulic design of intakes is important for pump operation to avoid uneven velocity distribution, vortices or entrained air in the system. Consideration of the pump well geometry and need for baffles or other measures is required.
- Long periods of inactivity potentially requiring pump well drainage (i.e. small drain pumps).
- Custom pump station versus package pump station selection.

All of these items require some consideration at concept design, particularly the likely space constraints which are considered likely to be a major factor in the flexibility (or lack thereof) in pump station configuration.

### 6.1.2.2 Power Supply

Power supply for pumping infrastructure and controls requires further investigation. It is recommended an initial application be made to Essential Energy immediately during concept design to determine potential impacts and constraints in the existing power network surrounding the proposed pump stations. It has been assumed to date there is adequate network supply close to the pump station locations, however no consideration of power infrastructure feasibility, costs, connections or operating costs has made to date.

Additionally, network reliability should be considered as power failures are common in extreme storms when utilisation of the pump stations is critical. It is likely to be expensive to provide back up power supply generators and fuel storage at the pump stations due to the likely large power demands and low utilisation of the pumps. Additionally, backup power systems require additional space which may be a challenge at the constrained pump station sites.

Based on initial pump motor sizing and assumed pump utilisation on rainy days, an approximate annual total power demand budget of 400MWh has been estimated for the stormwater pumping of the preferred drainage system. Based on Council's *Annual inventory of Council's emissions* report (2021/22), Council's total annual electricity use was approximately 5842MWh, and the five proposed pump stations could constitute an increase in total electricity use by Council of approximately 6%- 8%.

## 6.1.3 Public Utility Plant (PUP) Conflicts

Public utility plant impacts are likely to be numerous for the proposed underground drainage systems and pump stations. Early engagement with PUP providers is required during concept design to inform design, as trunk PUP may dictate elements of the design. PUP impacts are likely to be most severe in the town centre where large RCBC drainage structures are required at relatively shallow depth through the road reserves.

Additionally, Essential Energy impacts to power lines along the Butler Street Drain requires consultation and further investigation into works around power poles and stays.

Significant impacts are expected to Council's existing water, sewer and recycled water infrastructure and close engagement with Council's water and sewer team will be required to facilitate relocations of water and sewer assets.

## 6.1.4 Environmental Approvals

A review of the environmental, cultural heritage and other approvals requirements of the relevant project areas for the proposed drainage scheme has been undertaken and is attached in Appendix F.



## 6.2 Shirley Street (Area 1)

The following sections provides discussion of the key components of the Shirley Street preferred drainage scheme.

### 6.2.1 Butler Street Drain and Flood Levee

The proposed town drain levee is potentially some 700m long and was nominated to have a crest level of RL 2.9m AHD. This level may require revision to 3.1m AHD based on latest storm tide predictions and freeboard requirements. Significant constraints of this levee include:

- Surrounding land lies at between 1.2 m and 2.2 m AHD.
- Development of the road network has occurred since the levee was originally proposed with the Belongil Creek bridge on Ewingsdale road upgraded and the Butler Street bypass road being constructed at each end of the levee. Road raising is likely to be required at Ewingsdale Road (by approximately 1.2m raise to 3.1m AHD) and Butler Street Bypass.
- The levee is located in the Kendall Street and Byron Street road reserve, however to the east there is a narrow corridor the levee would be required to cross that lies on Crown reserve land, between Wordsworth Street and Butler Street.
- Consideration of the local drainage catchments around the Butler Street / Lawson Street roundabout and Police Station would be required as they may also potentially become trapped by the levee and require stormwater modifications.
- An existing shared pedestrian/cycle path lies on the proposed levee alignment and informal resident access and community amenity provided by the corridor may be impacted.
- Service conflicts including sewer, sewerage rising main, recycled water, communications and overhead power.
- New and existing drainage systems behind the levee will require gated outlet systems to allow gravity drainage at times of low tide, but isolation in times of high tide or creek flooding. If gated systems are implemented, drainage behind the levee will be completely reliant on the available flood storage available and pump capacity installed to dewater the area.

### 6.2.2 Pump Stations

Four stormwater pump stations were proposed in the Shirley Street area to align with existing or proposed stormwater pipe outlets into the Town drain. These are shown in Figure 6.1 and summarised in Table 6.1.

Based on the information provided, indicative pump storage volumes have been calculated to identify potential footprint requirements for the pump stations. Adopting a maximum of 8 pump starts/ hour minimum pump volumes have been calculated as shown in Table 6.2.

Pump storage is typically required below the level of the drainage pipe into the pump system to avoid impacting the stormwater network performance, and review of the topography adjacent to the proposed pump station sites indicates relatively low flood storage volumes are available in the natural topography before property flooding occurs. Hence it is assumed excavated storage would be required at the pump stations. On this basis, very large underground storage may need to be provided for the nominated rates, with significant diameter tanks at depths up to 7m below ground level.

Based on these initial numbers, it would be possible to construct facilities of this size in the road reserve at PS1 and PS2 (Kendall and Dryden streets), however there is not likely to be adequate land available at either PS3 or PS4. Relocation of PS3 and PS4 to the Milton Street or Wordsworth Street cul de sac locations respectively may be possible, however adds additional stormwater pipework, overland flow paths and significant depth to the pump stations. Excavation of pump wells up to approximately 7m below ground level would also pose challenges to manage geotechnical conditions and groundwater.

On this basis, PS 1 and PS 2 are potentially feasible in their proposed location, however the nominated location of PS3 and PS4 are not considered to be suitable sites for the facilities and would likely require land resumption to implement. Further investigation of the pump station sites, refinement of the flow and storage requirements and local constraints is required in the concept design to determine if feasible arrangement exists for PS3 and PS4.





TABLE 6.1: AREA 1 PUMP STATIONS IN PREFERRED DRAINAGE STRATEGY (SMEC, 2010)

Reference	Location	Nominated peak flow rate (m3/s)	Inflow pipe size	Comment
PS1	Kendall St	1.7	Proposed diameter RCP	1050mm Size subject to further concept design
PS2	Dryden St	1.3m	Proposed diameter RCP	600mm Size subject to further concept design
PS3	Between Milton St and Wordsworth St	0.8m	Existing 450 mm diameter RCP	Pump station likely requires moving to Milton St with extension of stormwater system
PS4	Butler St	1.3m	Existing 375 mm diameter RCP	Pump station may requires moving to Wordsworth St with extension of stormwater system.  Consider if Butler St road drainage may be routed to Town Centre Pump Station



FIGURE 6.1: SHIRLEY STREET AREA 1 SCHEME LAYOUT



TABLE 6.2: PUMP STATIONS AREA 1 – MINIMUM PUMP STORAGE REQUIRED

	PS1	PS2	PS3	PS4
Flow rate (m3/s)	1.7	1.3	0.8	1.3
Minimum Storage (m3) (max. 8 pump starts/hour)	191	146	90	135
Approx Motor size (kW)	200	150	95	150
Existing ground level at proposed site (m AHD)	1.35	1.35	1.17	2.03
Pump well footprint (m2)	115	95	65	95
Pump well depth (m)	7m	7m	7m	7m

In addition to the land requirement for the pump stations, consideration should be made to the potential impact to the local amenity impacts associated with the pump stations. Pumping facilities of this size will require:

- Significant power supply, lighting and switchboards likely housed in a small kiosk at each site above the 1:100 AEP flood level.
- Vehicle access and potentially a gantry crane for removal and maintenance of pumps.

The facilities will impact on existing resident use of the local streets, reduce available carparking and consideration of the impacts on visual amenity and noise should also be considered.

Whilst budget costing has not been undertaken of the updated scheme at this stage, to provide context for the size of the pump stations a rule of thumb comparison cost for sewage pump stations (all in budget cost) is in the order of \$1M per 100kW pump size. On this basis each of the pump stations could cost in the order of \$1M-\$2M respectively for civil works, concrete, pumps, electrical supply and pipework. This is before site specific considerations such as additional pump storage requirements, PUP interactions, flood levees or modifications and upgrades to the surrounding stormwater network and road reserves.

#### 6.2.2.1 Area 1 Summary

The following tables outline the various components of the drainage strategy in Area 1 and summarise the risks, challenges and potential feasibility of each system.

TABLE 6.3: PS1 (KENDALL STREET) CATCHMENT SUMMARY (AREA 1)

Component	Feasibility	Challenges	Relative Cost to the overall scheme
1:10 AEP underground stormwater system	Likely	Only functions to design capacity in relatively low tailwater levels (i.e. when Belongil mouth open) unless pump assisted Low gradients may require maintenance. Kerb inlet pit capture efficiency	Medium
Non return outlet to Creek	Likely	One way valve likely to be feasible at outlet headwall into Butler Street Drain. Corrosion and blockage of gates may impact function and design life. Maintenance may be required.	Low



Component	Feasibility	Challenges	Relative Cost to the overall scheme
		Channel works in Butler Street drain is an opportunity to improve drainage function in low creek conditions	
Stormwater Pump Station	Marginal. Further feasibility costing and modelling required	<p>Pumping storage of at least 250m<sup>3</sup> required to achieve functional pumping at nominated 1.7m<sup>3</sup>/s max flow rate.</p> <p>Footprint available limited by road reserve extents.</p> <p>Geotechnical and groundwater investigation required, as significant excavation is likely required below water table for pump station.</p> <p>Required switchboards to be sited above 1:100 AEP flood level (i.e. on levee or raised plinth). Available space may limit pump station and backup generator options.</p> <p>Reliability of mains power requires investigation.</p>	Very High
Flood Levee	Likely	<p>Limited land available in Byron Street road reserve</p> <p>Utilities (power poles, water and sewer mains, cycle path) interactions</p> <p>Ewingsdale Road requires raise by 1.2m to 2.9m AHD at levee crossing.</p> <p>Butler Street Bypass Road requires raise by 0.65m to 2.9m AHD at levee crossing. Potentially 150m lineal m of road raising on Butler Street.</p> <p>Geotechnical conditions and groundwater in construction adjacent Town Drain. This may require some sections in the narrow corridor to have retaining walls or concrete channel treatments.</p> <p>Land tenure between Wordsworth and Butler Street requires clarification.</p>	High (due to utilities impacts).

TABLE 6.4: PS2 (DRYDEN STREET) CATCHMENT SUMMARY (AREA 1)

Component	Feasibility	Key Challenges	Relative Cost to the overall scheme
1:10 underground stormwater system	AEP Likely	Similar to Kendall Street	Medium
Non return outlet to Creek	Likely	Similar to Kendall Street	Low
Stormwater Pump Station	Marginal. -Further feasibility costing and modelling required	<p>Pumping storage of at least 200m<sup>3</sup> required to achieve functional pumping at nominated 1.3m<sup>3</sup>/s max flow rate.</p> <p>Footprint available limited by road reserve extents.</p> <p>Geotechnical and groundwater investigation required, as significant excavation is likely required below water table for pump station</p> <p>Required switchboards to be sited above 1:100 AEP flood level (i.e. on levee or raised plinth). Available space may limit pump station and backup generator options.</p> <p>Reliability of mains power requires investigation.</p>	Very High



TABLE 6.5: PS3 CATCHMENT SUMMARY (AREA 1)

Component	Feasibility	Key Challenges	Relative Cost to the overall scheme
1:10 AEP underground stormwater system	Likely, but deep	No network upgrade nominated, but likely network extension required to a proposed pump station site.  No opportunity for local upgrades if required as existing stormwater system crosses private property without easements	Low
Non return outlet to Creek	Likely	Pending condition assessment of existing outlet for retrofit	Low
Stormwater Station	Pump	Not feasible in proposed location – Possibly relocate to Wordsworth Street and combine with PS4  Flood storage of at least 120m3 required to achieve functional pumping at nominated 0.8/s max flow rate.  Inadequate footprint available in Byron Street Road reserve. Would potentially require resumption of 6-10 Shirley Lane.  May be potentially sited in Milton Street, however drainage upgrade and other requirements need to be confirmed.	Not feasible

TABLE 6.6: PS4 CATCHMENT SUMMARY (AREA 1)

Component	Feasibility	Key Challenges	Relative Cost to the overall scheme
1:10 AEP underground stormwater system	Likely, but deep	No network upgrade nominated, but likely network extension required to a proposed pump station site.  No opportunity for local upgrades if required as existing stormwater system crosses private property without easements	Low
Non return outlet to Creek	Likely	Pending condition assessment of existing outlet for retrofit	Low
Stormwater Station	Pump	Not feasible in proposed location - Possibly relocate to Wordsworth Street and combine with PS3  Flood storage of at least 150m3 required to achieve functional pumping at nominated 1.2m3/s max flow rate.  Footprint available in Wordsworth Street Road reserve.  Geotechnical and groundwater investigation required, as significant excavation is likely required below water table for pump station.  Required switchboards to be sited above 1:100 AEP flood level (i.e. on levee or raised plinth). Available space may limit pump station and backup generator options.	Not feasible

## 6.3 Jonson Street (Area 2)

The following provides discussion of the key components of the Jonson Street preferred drainage scheme as shown in Figure 6.2.





Figure 6.2: Town Centre Drainage Scheme

### 6.3.1 Drainage Network Upgrade

The proposed town centre drainage network upgrade is a substantial increase to the piped drainage system capacity in the Byron Bay CBD. The catchment area of the network is approximately 16 ha and this ultimately drains towards the intersection of Byron and Jonson streets, where it is proposed to connect via 2/1.8m x0.9m RCBC's into the stormwater pump station located immediately west of the rail corridor.

Ground levels in the road reserve throughout the town centre range from 1.9m AHD to 3.2m AHD and surface grades range from 0.4% to 1%. In response to this, the proposed drainage upgrade consists of wide, shallow box culverts generally located in roads rather than along kerbs.

The rail line embankment currently provides a barrier to overland flows with the old culvert in this location being 95% built over with very little overland flow relief once the existing pipe network (1500x1500mm RCBC) is at capacity.

The construction of the new drainage network and an overland flow path will provide a significant improvement to local drainage particularly during low tide events. In storm tide events there is a risk to the township from the greater hydraulic connection to the Belongil Creek floodplain that requires management through a gated system to prevent floodplain backflow.

Limited investigation into PUP conflicts has been undertaken to date, and following survey it is considered the regrading of kerb lines may be beneficial to better define pit location and sag points to improve inlet capacity to the proposed network. Additionally, self-cleansing grades and maintenance of the RCBC's through tighter access chamber spacing may warrant further consideration as the system may be flatter than commonly accepted minimum grades for stormwater networks.

### 6.3.2 Town Centre Pump Station

At times of high tailwater (Belongil Creek flood or storm tide) it is impossible for the town centre drainage network to function to its desired standard of service in due to inadequate hydraulic grade in the system. Therefore, pumping of stormwater from the system is proposed. This requires that the town centre drainage network and catchment is be isolated completely from the floodplain by a flood levee to allow the system to be managed in isolation.



### 6.3.2.1 Levee

The town centre pump station levee is a flood protection structure to protect the proposed pump station from Belongil creek flooding and will be co-located with the final position of the pump station. This levee would be potentially 150m-200m in length and was nominated to be at 3.0m AHD crest level. This level may require revision to 3.1m AHD based on latest storm tide predictions and freeboard requirements. As it is likely that the northern end of Butler Street would require raising to 3.1m AHD as part of the Shirley Street levee, and the levee could be incorporated into further Butler Street road raise for the town centre pump station. Other considerations for the levee are:

- The surrounding land lies at between 1.2 m and 2.2 m AHD requiring levee heights in the order 0.8m to 1.8m high.
- Upgrade of Butler Street has occurred since 2015 which was not previously considered in the scheme. The road has 2/2.1mx1.8m RCBCs connecting to the town drain under Butler Street. The road crest level is approximately 2.3 m AHD with the RCBC base level at approximately 0.50m AHD. This would require raising of about 150m lineal metres of the road by up to 0.8m to achieve the designated 3.1m AHD height.
- Gravity drainage connection for the town drainage to Butler Street Drain is required at an invert level of approximately 0.6 to 0.7m AHD. with potential flood gates required on the new drainage network or retrofitted to the twin RCBC under Butler Street in times of high creek level to prevent backflow into the town centre.
- Consideration of interaction with the old rail line and existing public park and walkway is required and may require relocation of removal of some existing amenities.
- Potential retaining wall levees or similar in some areas may be required due to the limited space for an earth embankment.
- The location of the proposed pump station and levee lies in land owned by Railways NSW and agreement, or license would be required for council to construct and operate new infrastructure on state land.

### 6.3.2.2 Pumping

A large pump station has been nominated to dewater the town centre at flow rates up to 6 m<sup>3</sup>/s to manage flood storage and maintain levels at the outlet of the pipe system low enough to provide a positive hydraulic grade through the network in the 10% AEP. Flood modelling indicates this flow rate may be overestimated, however significant further assessment is required to determine the peak design flow, trade off pump rate, local storage, space requirements and other requirements to develop a feasible pumping arrangement. It is likely inlet screens and management of flood debris would also be required, and suitable pumps to convey sediment laden water (or sewage pumps if water quality is worse) will be required.

A preliminary review of this pump station size has been made with the same criteria as discussed in section 7.1 and the review information is displayed in Table 6.7. An approximate area of 2,500 sqm was nominated previously by SMEC for the location of the pump station, which lies on Railway NSW land. The area is an area of regrowth vegetation which has poor drainage between Butler Street and the old rail line embankment. Assuming the land access can be agreed, there may be adequate area for the facility, and the various other ancillary requirements to support the facility such as power infrastructure, generators, maintenance access similar to the discussion in section 6.2.2. Discharge pipe work of multiple steel DN 900mm pipes (say) will be required to connect from the pump station approximately 150m to the west beneath Butler Street into an outlet structure into the Town drain. Geotechnical investigations will be critical in determining suitability of the site and the conditions encountered are likely to have a significant influence on the cost and constructability of the facility.

The facility will impact on existing resident use of the local cycle path / pedestrian path crossing the area, and Railway NSW utilisation of the land. Design consideration of the impacts on visual amenity and noise should also be considered when developing the concept.

TABLE 6.7: TOWN CENTRE PUMP STATION-

Location	PS1
Peak Flow rate (m <sup>3</sup> /s) (SMEC, 2010)	6.0
Minimum Pump Storage (m <sup>3</sup> ) (max. 8 pump starts/hour)	675
Approx Motor size (kW)	730 (min. 2 pumps @ 365)
Existing ground level at proposed site (m AHD)	2.0 m AHD
Pump well footprint (m <sup>2</sup> )	450m
Pump well depth (m)	7m



On the same basis as discussed in section 7.1.2.1 this pump station may cost in the order of \$5 million to \$7 million for civil works, concrete, pumps, electrical connections, MCC, and pipework. This is before site specific considerations such as additional pump storage requirements, PUP interactions, flood levees or modifications and upgrades to the surrounding stormwater network and road reserves and also does not include land costs or approvals.

### 6.3.3 Summary

The following Table 6.8 outlines the various components of the drainage strategy in Area 2 and summarise the risks, challenges and potential feasibility of each system.

TABLE 6.8: TOWN CENTRE (JONSON STREET) CATCHMENT SUMMARY (AREA 2)

Component	Feasibility	Key Challenges	Relative Cost to the overall scheme t
1:10 underground stormwater system	AEP Likely	Only functions to design capacity by gravity in relatively low tailwater levels (i.e. when Belongil Creek levels are lower than 1.1m AHD, mean sea level) unless pump assisted Low gradients may require maintenance. Kerb inlet pit capture efficiency requires significant road inundation to be effective due to flat topography Large shallow RCBCs are required in existing roads that are likely to have significant utilities conflicts and major construction impacts to CBD	High
Non return outlet to Creek	Likely	One way valve likely to be feasible at outlet headwall into Butler Street Drain. The size of the RCBC outlet will likely require a large automated flood gate with actuators, control logic and power supply. This has inherent risks and may require a high level o f maintenance. Corrosion and blockage of gates may impact function and design life. Maintenance may be required. Channel works downstream in Butler Street drain may be an opportunity to improve drainage function in low tailwater conditions	Medium
Stormwater Pump Station	Marginal. Further investigation required to confirm budget costs. Land tenure investigation required.	Pumping storage of at least 675m3 required to achieve functional pumping at nominated 6.0m3/s max flow rate. Not feasible to construct within existing road reserves. A footprint of 1500-2000 sqm has been nominated for the pump station however this lies in Railway NSW rail tenure. Geotechnical and groundwater investigation required, as significant excavation is likely required below water table for pump station. Required switchboards to be sited above 1:100 AEP flood. Available space may limit pump station and backup generator options. Reliability of mains power requires investigation.	Very High
Flood Levee	Likely	The nominated flood levee surrounding the pump station location lies in Railway NSW rail tenure. The existing boardwalk cycle path will be impacted Geotechnical conditions and groundwater in construction adjacent Town Drain and Butler street. The levee may need to be a Butler Street road raise combined with a masonry or concrete wall around the pump station to minimise land take, noise and visual amenity. Proposed level of 3.1 m AHD.	High (due to utilities impacts).





## 6.4 Middleton and Cowper Street (Area 3)

### 6.4.1 Drainage System Upgrade

The proposed drainage network upgrades in Middleton Street and Cowper Street would provide a substantial increase in capacity to the local road drainage system. The layout of the upgrade in the area is shown in Figure 6.3.

Key issues identified are with the Middleton Street network, which provides a small improvement in road drainage but is heavily constrained. The low topography along Middleton Street and the 'swamp' south of the Courthouse where the system is proposed to outlet. Due to levels in this area of 1.0-1.5m AHD it is not possible to get fall to the Clarks Beach outfall pipe (1.3m AHD) at the end of Middleton street and connection by a swale or channel is not very effective and has marginal feasibility. Therefore, improvement in flooding to this system would potentially rely on:

- Excavation of additional flood storage (noting the outlet swamp is on crown land with potential sensitive environmental conditions).
- Provision of water transfer pumps (already discounted by Council).

Further summary of the road stormwater network requirements for Middleton and Cowper Street is provided in Table 6.9.

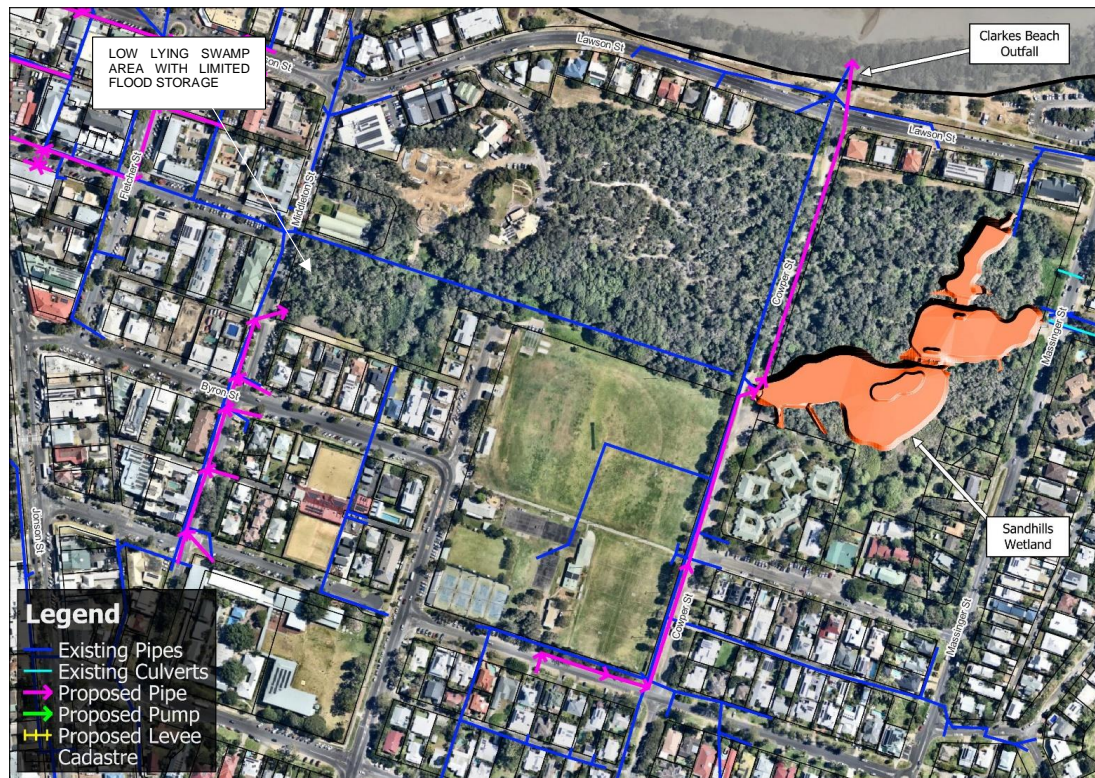


FIGURE 6.3: COWPER STREET DRAINAGE SCHEME (AREA 3)

### 6.4.2 Sandhills Wetland

Sandhills wetland provides significant flood improvement between Cowper Street and Massinger Street. A larger wetland, particularly at a lower level (i.e. the southern cell) would provide an increase in available flood storage at the wetland and could provide additional benefit to flooding in the area, and the southern cell could potentially be further interfaced with overland flow paths or the Cowper Street stormwater upgrade to the south to provide additional (albeit minor) improved local flood performance.



#### 6.4.2.1 Opportunity - Massinger Street Catchment Diversion

The previous drainage strategy did not consider the potential to divert the Massinger Street catchment around the problem flooding area in Cowper Street. There is 21.2 ha of upstream catchment in Massinger Street that currently reports to the Cowper Street area and the Sandhills wetland. This constitutes 25%-30% of the overall area that reports to the Clarkes Beach outfall drain via Cowper Street. As the preferred Byron Bay drainage strategy relies on an increase in outfall capacity to Clarkes Beach, there is an opportunity to divert this catchment to the Clarkes Beach outfall and avoid contributing flow into the Cowper Street area.

The Massinger Street catchment outlets via twin 600mm diameter pipes under Massinger Street into the proposed wetland area at a invert level of 2.41m AHD. Based on the levels, the existing 2/600mm diameter trunk drainage pipes could be intercepted and conveyed 140m north within the road verge to Lawson Street. At Lawson Street the trunk drain could run 50m west and collect the 675mm diameter road drainage that currently also falls south towards the Sandhills wetland. From here the trunk drain could then connect to the proposed Clarkes Beach outfall duplication 175m further west in Lawson Street, or a new outfall could be provided.

This project would remove the catchment from contributing to the flooding in the Cowper Street area and has the advantage that it retains a piped system at a relatively high level compared to much of the drainage system and the storm tide levels.

This would remove significant inflows (up to approx. 1.5m<sup>3</sup>/s based on estimated existing pipe capacity) into the flood prone area around Cowper Street and is likely to provide significant benefits to flooding by freeing up flood storage in the proposed wetland. It would however require reconsideration of the wetland design as the inflows to the area would be modified. An arrangement where low flows from the Massinger Street catchment are allowed to flow through the wetland, and flood flows are diverted down the new trunk main would be feasible and may have combined benefits of achieving water quality improvement objectives for low flows, and additional flood benefits in high flows.

As this option would have tangible flooding benefits to the Cowper Street area, it is recommended a review of the impact on it be undertaken on the sandhills wetland to determine if some wetland benefits can be realised with the reduced inflows, and what the likely change would be to the proposed Wetland. It is noted that this option may result in reduced water quality outcomes.

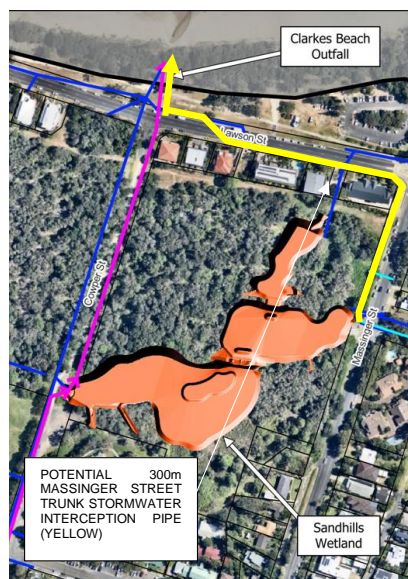


FIGURE 6.4: POTENTIAL MASSINGER STREET TRUNK STORMWATER DIVERSION ALIGNMENT

#### 6.4.3 Clarkes Beach Outlet Duplication

Duplication of the outlet at Clarkes Beach is considered feasible and fundamental to managing flooding across the Cowper Street area, and potentially has benefits to Middleton street and the Town Centre. Inspection of the outlet identified numerous issues for consideration in future design of a duplication as follows:

- The existing outfall appears to be RC flush joint pipe with diameter 1350mm.



- Significant undermining and erosion has occurred around exposed sections of pipe. Stabilisation of new and existing pipes is required to combat beach erosion. This requires consideration of pipe foundations and potential consideration of pile foundations to meet beach erosion requirements.
- There may be merit in investigation HDPE pipes were exposed to saline conditions, and one way flow valves.
- Consideration of duplicating the 1350mm diameter pipe vs a larger single sized outlet should be made considering tendency for sand accumulation on twin outlets.
- Maintenance regime of the outlet is integral to the design and detailed design must consider councils maintenance capability and frequency.
- The possibility was raised of a potential pump assisted outlet under certain high beach level conditions, which would require further investigation and may be an opportunity for further augmentation.

Maximising the capacity and utilisation of the beach outlet should be a key objective of any future flood mitigation work in the catchment.

#### 6.4.4 Summary

The following Table 6.9 outlines the various components of the drainage strategy in Area 3 and summarise key risks, challenges and potential feasibility of each system.

TABLE 6.9: COWPER STREET CATCHMENT SUMMARY (AREA 3)

Component	Feasibility	Key Challenges	Relative Cost
1:10 AEP underground stormwater system (Cowper Street)	Likely	Flat grades and potential tailwater conditions.	Medium
1:10 AEP underground stormwater system (Middleton Street)	Likely	Very flat topography. Internally draining system to low point (swamp north of 15 Marvell Street adjacent the Byron Bay Courthouse).  System function reliant solely on local flood plain storage with no outfall, and likely to perform poorly in medium events and greater when swamp is inundated.	Medium
Channel Works from Middleton Street to Cowper Street	Marginal  Some benefit, but not feasible to freely drain Middleton Street	Inadequate fall is likely to prevent design of a free draining channel for the approximate 300m length as the drainage outlet at Middleton Street lies at approximately 1.2m AHD which is the same level of the Clarkes outfall pipe inlet pit at Cowper Street.  A defined flow path could be constructed from Middleton St to Cowper St to limit the zone of frequent inundation and provide a greater floodplain storage and maintenance access, but this has limited benefit.  Concrete channel lining may provide benefit for flow conveyance, maintenance and integrity of the system.  The nominated channel works from Middleton Street to Cowper Street lies on Crown land.  The defined channel flow path may provide greater connectivity of Cowper Street flooding to the Town centre and has potential to impact the town centre under extreme storm tide conditions	Low
Sandhills Wetland	Likely	Per AWC design and approvals.  May be opportunity to re-route additional overland flow from Cowper Street through southern cell of wetland to improve flooding and water quality performance.	High



Component	Feasibility	Key Challenges	Relative Cost
		Opportunity to divert catchment west of Massinger through new trunk drainage in road reserve around wetland to improve flooding and reduce wetland size. This requires further assessment on feasibility and the potential benefit to flooding vs impact to the wetland.	
Clarkes Beach Outfall Upgrade	Likely	<p>Approximate 315 lineal metres of new RC pipe required for duplication. Opportunity to explore other pipe materials for aggressive coastal environment.</p> <p>Potential rehabilitation of existing outfall is required at the beach, and maybe an opportunity to consolidate into a single larger pipe.</p> <p>Work in road reserve and significant work required in coastal reserve.</p> <p>Geotechnical conditions and utilities impact require consideration at Lawson Street road crossing.</p>	Medium
Outfall non return valve	Likely	<p>Provides some flood benefit in some conditions, and disadvantage in others. Can be a contentious management measure.</p> <p>Non return valve on the critical beach outlet has potential to silt up.</p> <p>Requires additional maintenance.</p>	Low

## 6.5 Alternate Strategic Approaches Considered

### 6.5.1 Rationalisation of Pump Stations

Significant issues have been identified with the feasibility of proposed location of pump station 3 and 4 in the Shirley Street area. Investigation is recommended into the potential to relocate these stations to adjacent road reserves (Milton or Wordsworth streets), or consolidate them in a single location. A feasibility and trade off assessment of local topography, flood levels and likely pump station depths would be required prior to concept design to identify the feasibility of consolidating these pump stations.

### 6.5.2 Additional Pump Stations

Additional locations for pumping within the scheme was considered to endeavour to reduce reliance on major centralised pumping systems. Due to the topography and development within the town catchments, the only feasible additional pump location was nominated as the low lying area east of Middleton Street, which was previously identified by SMEC (2010) as a potential pumping location. Since this proposed pump location has been removed from the scheme by Council, further technical assessment has not been undertaken.

Another alternative that could warrant future investigation would be booster pumping of flows in the Clarkes Beach outfall in storm tide conditions where tailwater levels prevent gravity drainage of the area. Potential inline pumping could be augmented to this outfall depending on the final pipe arrangement to provide positive flow to the ocean during storm surge conditions.

### 6.5.3 Private Property Resumption for Drainage Reserves

A review of private property flood impacts should be undertaken in concept design to identify worst impacted properties and if there is any potential for resumption or buy back of land in severely flood prone locations. Areas of particular interest may be properties with boundaries adjacent the Butler Street drain. Due to the widespread nature of the low lying areas across the town centre there may not be significant potential to address specific issues through resumption in the town centre, however a review of properties at risk of the most severe flooding could be considered and a cost /benefit assessment undertaken.

Resumption may also be required for drainage easements relating to the upgraded drainage scheme. At this stage no specific easement requirements have been identified to date, however depending on the concept design it is possible these will be required. Refer also to section 7.5.3 relating to land tenure and potential easements.





#### 6.5.4 Northern Rivers Reconstruction Corporation Resilient Homes Program

On behalf of the NSW State Government, the Northern Rivers Reconstruction Corporation (NRRRC) are currently implementing the Resilient Homes Program (RHP) for flood affected properties throughout the Northern Rivers region. The program will offer eligible landholders one of the three available measures, based on expert property assessments, flood impact severity data, safety risks and potential future flood levels:

- Home buybacks – the homeowner receives a payment for the purchase of their house and land, or
- Home raising – funding is committed to elevate liveable areas above a property-specific flood level, or
- Home retrofit – funding is committed to retrofit and/or repair liveable areas to improve the resilience of these areas for future floods.

A review of current plans for the RHP in the areas of this study is required to identify where raising, retrofit or buyback is proposed. This presents an opportunity to integrate the Preferred Byron Bay Drainage strategy into the RHP and develop a streamlined program of upgrades and prioritised benefits across the catchment for both Council and State government. This could provide cost benefits to both parties and ensure minimal overlap of priorities in the study area.

### 6.6 Costs

Updating the project cost estimate is not within the scope of this strategy review, and the costs proposed in the previous work (BMT, 2015 and SMEC, 2010) are shown in Figure 6.5. These were estimated to a preliminary level of accuracy and cover other scope items not included in the strategy review scope. If the items not pertaining to the project capital expenditure are removed (Western Industrial area and pump maintenance costs) the 2015 estimate is in the order of \$9 Million for the scheme (including \$1.6M for the Sandhills wetland).

Based on the high level technical review undertaken in this report, as well as consideration of scope growth in the pump stations, wetland, levee works, possible road raises and recent construction industry cost escalation, it would be expected that overall costs of the scheme have increased significantly from what was proposed in 2015. At this stage it would not be unreasonable to assume costs of the entire scheme may be up to two (2) to three (3) times the 2015 estimate, however this requires a more rigorous review. This does not consider land acquisition costs.

Costs are likely to be significantly impacted by the following factors:

- Preferred drainage alternatives selected.
- Land tenure constraints and acquisition requirements.
- Geotechnical conditions.
- PUP impacts.
- full costing and assessment following concept design.
- Schedule of works.
- Project Staging.
- Contracting strategy.

Following design development and a revised concept cost estimate for the project, it is recommended to revisit the potential flood benefits and determine which components have the greatest cost / benefit ratio to determine project feasibility and prioritisation. If there is significant escalation of costs following concept design, it is possible some elements of the scheme may not remain feasible in the current strategy.



Item	Comment	Cost
Detailed design		\$300,000
Town Centre		\$2,783,800
Shirley Street	Partial flooding 100 year ARI events	\$2,729,100
Western Industrial	Upgrade Ewingsdale Road culverts	\$163,900
Cowper and Marvell	Wetland (including inlet structure)	\$1,585,800
	Clarks Beach Drain Upgrade	\$298,000
	Street Drainage	\$1,028,260
Pump Maintenance	Annual maintenance - 5 pumps (\$8,000 per pump per year)	\$40,000/year Total = \$552,000
	Pump replacement – All pumps (5)	\$1,200,000 (SMEC, 2010) <i>note: not included in estimated total cost</i>
Estimated Total Cost		\$9,440,100

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BMT WBM

FIGURE 6.5: PREVIOUS SCHEME COST ESTIMATE (BMT, 2015)



## 7. BASIS OF CONCEPT DESIGN

The following outlines the proposed basis of design for the concept design of the drainage scheme for Council review and endorsement, including consideration of further options and feasibility assessments.

### 7.1 General

TABLE 7.1: GENERAL BASIS OF DESIGN

Item	Requirement
Design Life	80 years
Land tenure	All infrastructure on council land
Objective	Provide 1:10 AEP drainage system; or where not feasible, provide significant flooding improvements to nominated areas of Byron Bay township.
Client Requirements	BSC Local Environmental Plan, BSC Development Control Plans, Floodplain Management Plans NSW Flood Risk Management Manual Northern Rivers Development Guidelines and Standard drawings

### 7.2 Flooding Basis of Design

The flooding basis of design is per industry guidelines using ARR 2019, and Byron Bay LEP Climate Change Strategic Planning Policy 14/006. A detailed basis for the development of the new hydrological and hydraulic flood models is attached in Appendix E.

TABLE 7.2: BASIS OF DESIGN – RAINFALL, FLOODPLAIN AND STORM TIDE

Parameter	Present Day Scenario (2010)
Rainfall	Per ARR 2019
High tide level (HAT) – low tailwater design scenario	1.1 m AHD
Storm Tide - high tailwater design scenario (envelope approach)	1:100 AEP event with 1:20 AEP (2.20 m AHD) ocean level 1:20 AEP event with 1:100 AEP 2.60 m AHD ocean level

TABLE 7.3: CLIMATE CHANGE SENSITIVITY TESTING

Parameter	2050 Scenario	2100 Scenario
Rainfall	10% increase in ARR2019 design rainfall	30% increase in ARR2019 design rainfall
High Tide level (HAT) - Low TWL scenario	1.5 m AHD (assuming 0.4m sea level rise)	2.0 m (assuming 0.9m sea level rise)
High TWL scenario (envelope approach)	1:100 AEP with 2.40 m AHD 1:20 AEP event with 2.6 m AHD	1:100 AEP event with 2.90 m AHD 1:20 AEP event with 3.1 m AHD

#### 7.2.1 Stormwater Network

The stormwater network is required to be designed to Northern rivers local government specification, specifically *Development Design Specification, stormwater drainage design D5*. Specific requirements are shown Table 7.4.



TABLE 7.4: STORMWATER NETWORK BASIS OF DESIGN

Item	Requirement
Design Level of service	10 % AEP flood contained below ground (desirable). 10 % AEP flood contained in road reserve (minimum).
Outlet conditions	Water level at outlet pipe obvert level.
Pipe Type	RCP min pipe class 3 or per Australian standard. RCBC to meet standard traffic loading. Saltwater cover for headwalls and pipes directly exposed to Belongil Ck Estuary or Clarkes Beach.
Pit Type	Per Northern Rivers local government standards. Side entry pits to be kerb in line for existing roads. Junction pits to be custom, as required based on RCBC sizes.
Minimum grade	To meet self-cleansing or per QUDM minimum grades.
Blockage	Standard Inlet gully relationships incorporating blockage for pits. Blockage assessment to be made based on catchment type to inform any additional blockage factors and additional pit or pipe capacity required. Standard culvert lockage factors (QUDM)
Roof Drainage / kerb adaptors	Like for like. Where possible provision for connection directly to new drainage network
Backflow prevention	Gated outlet headwall for all drainage outlets interface into Belongil Creek. Floodplain to prevent backflow into the network. Duckbill (or similar) non return valve consideration for Clarkes Beach outfall (new and existing pipes).
Existing Stormwater Network Interaction	Existing network to connect into new network with new manhole at clash locations. Downstream existing pipe to be capped where networks intercept.

### 7.2.2 Pump Station Basis of Design

There are five nominated pump stations in the scope of the project. The peak flow rate for these was nominated by SMEC (2010) however this requires further assessment and testing to determine the performance and effectiveness of these pump rates, and optimum design pump flow rates coupled with number of pump units and standby requirements. Initial basis of pumping is minimum two duty pumps and one standby at each station for redundancy and maintenance, however this may be optimised based on actual pump availability.

TABLE 7.5: PUMPING GENERAL BASIS OF DESIGN

Item	Requirement
Desirable Level of service	10 % AEP flood contained below ground (desirable). 10 % AEP flood contained in road reserve (minimum).
Outlet conditions	Pump to Belongil Creek above level 2.6m AHD.
Pump storage	Based on maximum 8 starts/ hour (WSAA).
Storage arrangement	Pump storage provided below obvert of incoming pipe. Excavated wet well / tank storage.
Pump Arrangement	1 duty pump, at least 1 duty assist pump, 1 standby pump (min desirable). To be optimised based on pump station location constraints, efficiency and council requirements.



Item	Requirement
Levee heights	Based on upgraded 1:100 AEP flood level (storm tide) with pumps operating, plus freeboard allowance. Consideration and provision for future raising of levee height.
Freeboard	0.5m (desirable) 0.3 (absolute min)
Primary power supply	Mains power.
Secondary power supply	Diesel generator backup and fuel storage for 4 hours.
Pump Failure	Assessment of failure scenario required. No worsening from existing flooding scenario when pumps fail (desirable)
Pump Efficiency (min)	80%, with 20% non-overloading factor (NOL).

The locations and nominated flow rates from the previous design (SMEC, 2010) compared to the updated modelling in this report are listed in Table 7.6. These require further design development and optimisation based on review of storage available, drainage network optimisation and pump location.

TABLE 7.6: PEAK PUMP DESIGN MODELLED OUTFLOW RATE ESTIMATES

Location	10% AEP (m <sup>3</sup> /s) (ENGEMY)	10% AEP (m <sup>3</sup> /s) (SMEC 2010)
PS1	1.0	1.7
PS2	1.3	1.3
PS3	0.8	0.8
PS4	0.3	1.2
PS5	3.6	6.0

Critical levels identified to target to achieve 10% AEP flood level of service for each pump station have been defined as per Table 7.7. Adopting a level based criteria will allow optimisation for pump storage and flow rate in concept design.

TABLE 7.7: PUMP STATION TARGET LEVELS TO REDUCE FLOODING IN 10% AEP

Location	Road Flooding (m AHD)	Property Flooding Level / Address (m AHD)	Floor Level Flooding / Address (m AHD)
PS1	1.40	56 Shirley St: 1.55 58 Shirley St: 1.81	56 Shirley St: 3.16 58 Shirley St: 2.24
PS2	1.75	6 Dryden St: 1.54	6 Dryden St: 2.04
PS3	1.75	4 Shirley St: 2.17	4 Shirley St: 2.75
PS4	2.00	Lot 388 on DP728537: 2.41	Lot 388 on DP728537: 2.63
PS5	2.10	54 Jonson St: 2.07	54 Jonson St: 2.33



TABLE 7.8: PUMPING POWER CONSIDERATIONS BASIS OF DESIGN

Item	Requirement
Primary power supply	Mains power.
Secondary power supply	Diesel generator backup and fuel storage for 8 hours.
Pump Efficiency (min)	80% assumed, with 20% non-overloading factor (NOL).
Arrangement	Switchboards and generators located above 1:100 AEP flood level plus freeboard.





## 8. SUMMARY AND RECOMMENDATIONS

The preferred Byron Bay drainage strategy has been reviewed from a high level taking into consideration the following:

- Changes in the catchment.
- Ongoing project progress (i.e. Sandhills Wetland).
- Latest industry guidance on flood and drainage assessment.
- Updates to other studies such as coastal hazards and Belongil Creek outlet management strategy.
- Consideration of practical constraints such as pump sizing, storage volume, land requirements and land tenure.

The review has found significant parts of the strategy are likely to be feasible from an engineering perspective, however all components of the drainage strategy require further concept design to better define the technical requirements and costs. This will inform prioritisation and staging of the strategy and develop the scheme feasibility.

Key review outcomes are summarised as follows.

### **Flooding Assessment**

The flood model rebuild (1D/2D TUFLOW) has demonstrated reasonable validation to the 2022 historical event, however key deficiencies in model data have been identified.

- The use of old 2010 LiDAR and poorly defined drainage network database requires update with more recent survey and LiDAR when available.
- Significant improvements can be achieved to flooding in various flood prone areas of Byron Bay by implementation of the preferred drainage strategy, subject to refinement and optimisation of the scheme.
- Sensitivity testing of the scheme for a range of tailwater conditions can be undertaken to inform benefits under a range of creek and ocean flooding scenarios.
- Sensitivity testing of the scheme to climate change in the 2100 horizon is recommended per the LEP (2014) to identify potential risks and issues for the scheme based on its proposed 80-year design life.
- A combination of design methods is recommended to develop the drainage scheme into a robust design including 1D pipe drainage modelling, 2D direct rainfall modelling and traditional 1D/2D point input hydrology and hydraulic modelling.

### **Drainage Networks**

- Optimisation of drainage networks may be possible in some areas to reduce sizing of trunk stormwater systems.
- Middleton Street drainage network provides limited benefit due to its low levels and constrained outlet.
- An opportunity exists for a new trunk stormwater interception pipe in for the Massinger Street catchment that should be investigated to improve Cowper Street flooding.
- Additional consideration of drainage network extensions or changes is required at Milton Street, Wordsworth Street and Butler Street to enable stormwater pumping and levee implementation adjacent the town Drain. This was not considered in the original preferred drainage strategy.
- Early engagement with PUP providers and impacted parties (including business owners and the community) is required following concept design to identify major constraints. PUP impacts require further definition in Concept design.
- Drainage network upgrade provides drainage and flooding benefit independent to the proposed levee and pump station components of the system.

### **Levees**

- The proposed flood levees are likely to be feasible but impose significant impacts to existing road reserves and require raising of Ewingsdale Road at Kendall Street, Butler Street and the Byron Street Cycle path.
- Drainage crossings of levees require gated pipe /culvert outlets. Reliance on one-way flow gates to prevent creek or ocean backflow in the pipe system is fundamental to the implementation of the scheme. This will require significant design consideration and significant ongoing Council maintenance depending on the need for passive, automated or manual gate operation.
- Geotechnical considerations for levee design is required to ensure embankment stability, integrity and public safety. A particular risk may be sandy geotechnical conditions.



#### **Pump Stations**

- Stormwater pump stations are likely to be feasible but costly to build, operate and maintain. The new pump stations potentially require dedicated operation and maintenance personnel in Council.
- Provision of the levee and pump station system provides a major barrier around the study area to Belongil Creek flooding and potential storm tide and sea level rise. Significant flood improvements are realised across the township if the scheme can be implemented successfully.
- Proposed pump station locations are all space constrained. Pumps will typically require to be submersible with significant below ground pump storage wells, pipework, access, mains power and backup power.
- Peak pump flow rates previously identified can likely be optimised and reduced, however provision of pump storage wells is required. Pump stations will require significant deep excavations and consideration of geotechnical and groundwater risks.
- Stormwater pumping may create significant noise and visual amenity impacts at the proposed pump station locations.
- Council do not own the land proposed for the town centre pump station (PS5). Agreement or purchase of land would be required with Railways NSW.
- Pump stations 3 and 4 are not considered feasible in their original proposed location and should be investigated to determine if a consolidated alternative pump station could be implemented in Wordsworth Street.
- Pump station outlets to the floodplain may pose a safety risk due to high flow rates and potential local flood afflux. This requires appropriate design and public safety measures.
- Power demands for pump station operation may be significant with initial operating power estimates ranging between 6-8% of Council's current annual electricity usage.

#### **Ocean Outfall**

- Additional outlet capacity to the ocean is fundamental to improving flooding within the township. Duplication of the Clarkes Beach outlet with a 1350mm pipe consolidation of the twin pipes into a single larger pipe is recommended and could be undertaken as an improvement measure regardless of the other components of the scheme.
- One way flow valves should be considered on the outfall to prevent storm tide impacts.
- Review of the beach outlet function, maintenance practices, coastal management objectives and capacity should be undertaken as part of the design of the outlet.

#### **Sandhills Wetland**

- The Sandhills wetland provides an improvement in flooding at Cowper Street as it creates significant flood storage away from the road reserve and private property.
- The wetland likely provides tangible water quality improvements to the urban runoff it receives.
- Integration of any road drainage measures in Cowper Street should consider interface and integration to the wetland where possible.
- Diversion of the upstream Massinger Street catchment could be considered to reduce flood inflows to the wetland and further relieve flooding in the Cowper Street area.

#### **Costs**

- Further design development is required to inform costs, however it is expected that scheme costs are significantly higher (potentially 2x to 3x) than the approximate \$9M budget estimated in 2015.
- Following better definition of costing, an updated cost benefit assessment is required to rank the individual elements of the scheme and determine project feasibility and prioritisation.

#### **Other Constraints**

Consideration of other constraints that have potential to significantly change or fatally flaw components of the scheme is required. These include:

- Land tenure.
- State and Federal approvals pathways.
- Power supply.
- Geotechnical investigations.



## 8.1 Forward Work Plan

It is recommended further design definition be undertaken of the holistic scheme. Proposed forward work in order of priority is:

- Undertake ground and drainage survey of the existing areas.
- Commence approvals pathway and land tenure planning work.
- Update flood modelling with survey to confirm benefits and impacts.
- Undertake technical trade off and feasibility assessments into:
  - Massinger Street catchment diversion and wetland benefits/impacts.
  - Middleton Street swamp flood storage expansion.
  - Investigate the feasibility and impacts of road raises at Ewingsdale Road/Kendall Street intersection and Butler Street.
  - Feasibility of consolidating PS4 and PS5 in Worsdworth Street.
  - Pump station arrangements to define space, depth requirements in more detail to inform feasibility.
- Commence engagement with electrical utility (Essential Energy) to determine likely network capacity and impacts of pumping.
- Undertake drainage network design based on detailed survey.
- Undertake concept design of the scheme including levee and pump station layouts.
- Develop costing of the scheme and cost benefit ranking of individual scheme components.
- Develop a geotechnical investigation plan for field investigation.
- Consider prioritisation of the various components of the scheme and consider project staging (following concept design).



## 9. REFERENCES

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- NSW OEH (2015) Floodplain Risk Management Guidelines
- Rienco Consulting (2019) WBNM Theory Behind Model.
- QUDM (2016) 4<sup>TH</sup> edition IPWEA 2016
- SMEC (2010a) *Belongil Creek Flood Study* 2010
- SMEC (2010b) *Byron Bay Drainage Strategy* Rev 2 14 April 2010 Ref 3001042
- TUFLOW (2018) TUFLOW Classic/HPC User Manual



## 10. QUALIFICATIONS

- (a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.
- (b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.
- (c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:
  - (i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or
  - (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.
- (d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.
- (e) This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this Report.
- (f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.
- (g) This Report does not provide legal advice.

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## APPENDIX A: AR&R 2019 DATA OUTPUT





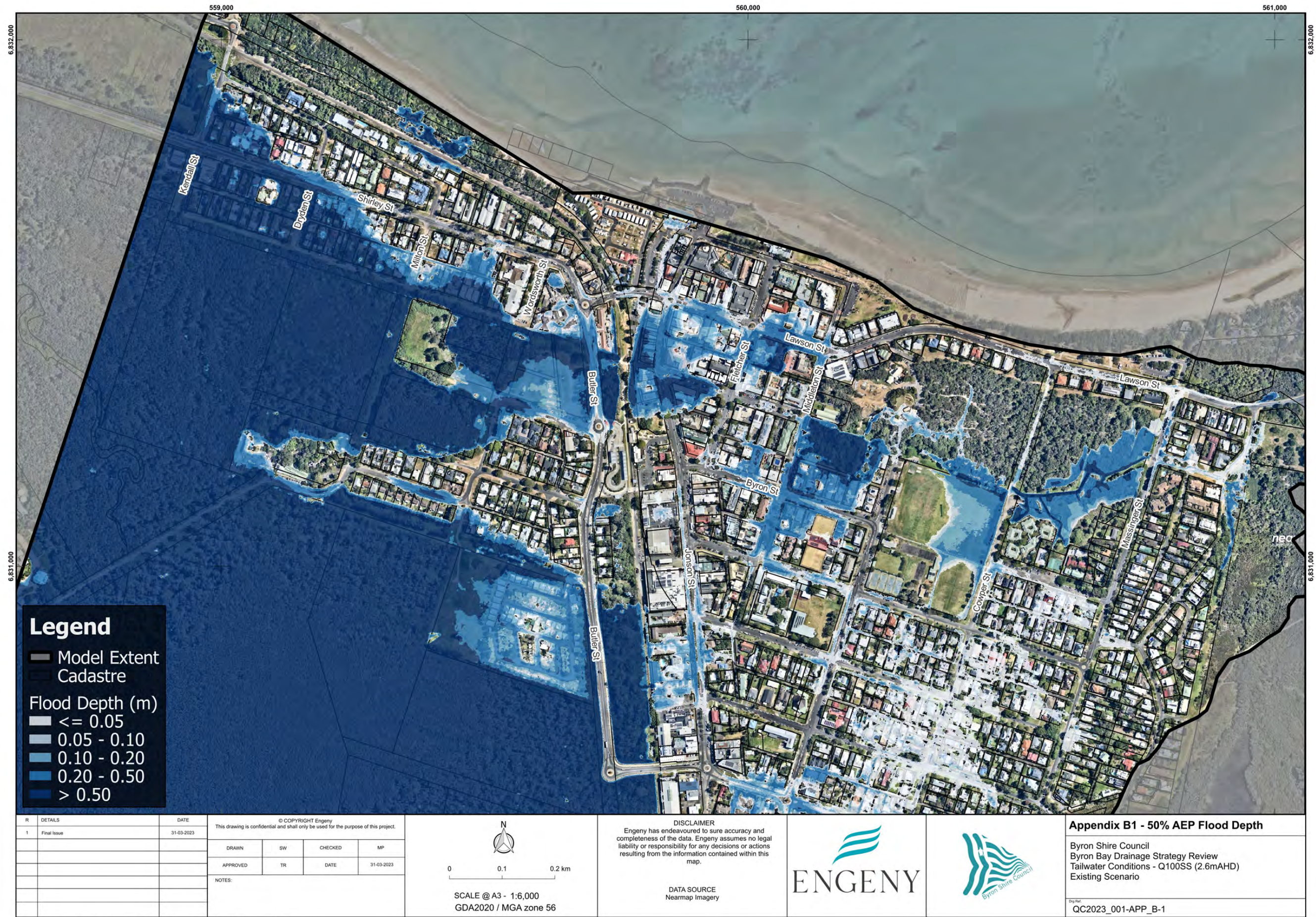
TABLE A.1: INTENSITY-FREQUENCY-DURATION DEPTHS (MM)

Duration	Duration in min	63.20%	50%	20%	10%	5%	2%	1%
1 min	1	2.58	2.88	3.81	4.43	5.03	5.8	6.38
2 min	2	4.35	4.86	6.49	7.63	8.76	10.4	11.7
3 min	3	6.1	6.82	9.1	10.7	12.2	14.4	16.2
4 min	4	7.71	8.62	11.5	13.4	15.4	18	20
5 min	5	9.18	10.3	13.6	15.9	18.1	21.1	23.4
10 min	10	14.9	16.6	21.9	25.4	28.8	33	36.1
15 min	15	18.8	21	27.7	32.1	36.2	41.5	45.3
20 min	20	21.8	24.3	32.1	37.2	42	48.2	52.7
25 min	25	24.2	27	35.7	41.4	46.8	53.8	59
30 min	30	26.2	29.3	38.8	45	51	58.8	64.6
45 min	45	31	34.6	46	53.7	61.2	71.1	78.7
1 hour	60	34.6	38.7	51.7	60.6	69.4	81.1	90.3
1.5 hour	90	40.2	45.1	60.9	71.8	82.7	97.7	110
2 hour	120	44.7	50.3	68.3	81.1	93.8	112	126
3 hour	180	52	58.8	80.8	96.6	113	135	153
4.5 hour	270	61	69.2	96.3	116	136	163	185
6 hour	360	68.5	78	109	132	155	187	212
9 hour	540	81.2	92.9	132	159	188	226	256
12 hour	720	91.8	105	150	182	214	258	292
18 hour	1080	109	126	180	218	257	307	346
24 hour	1440	123	142	203	246	289	344	387
30 hour	1800	134	155	222	269	315	374	419
36 hour	2160	144	167	238	287	336	398	445
48 hour	2880	160	185	263	317	369	436	486
72 hour	4320	181	209	297	356	413	486	539
96 hour	5760	195	225	318	380	441	518	574
120 hour	7200	205	236	332	397	461	541	599
144 hour	8640	212	243	343	410	477	559	619
168 hour	<b>10080</b>	217	249	351	421	491	574	636

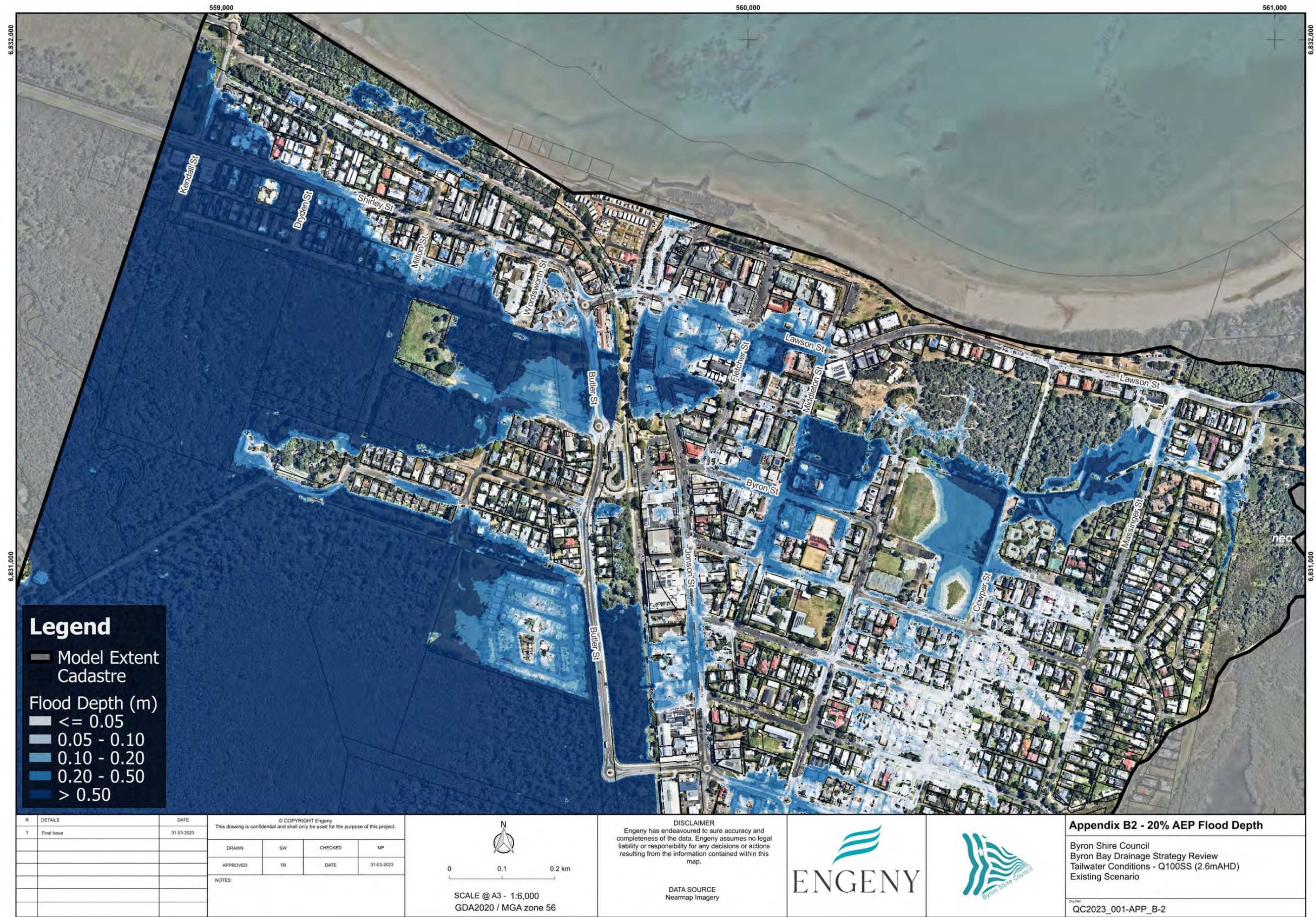
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## APPENDIX B: DESIGN EVENT RESULTS, 1:100 AEP STORM SURGE (2.6 M AHD)

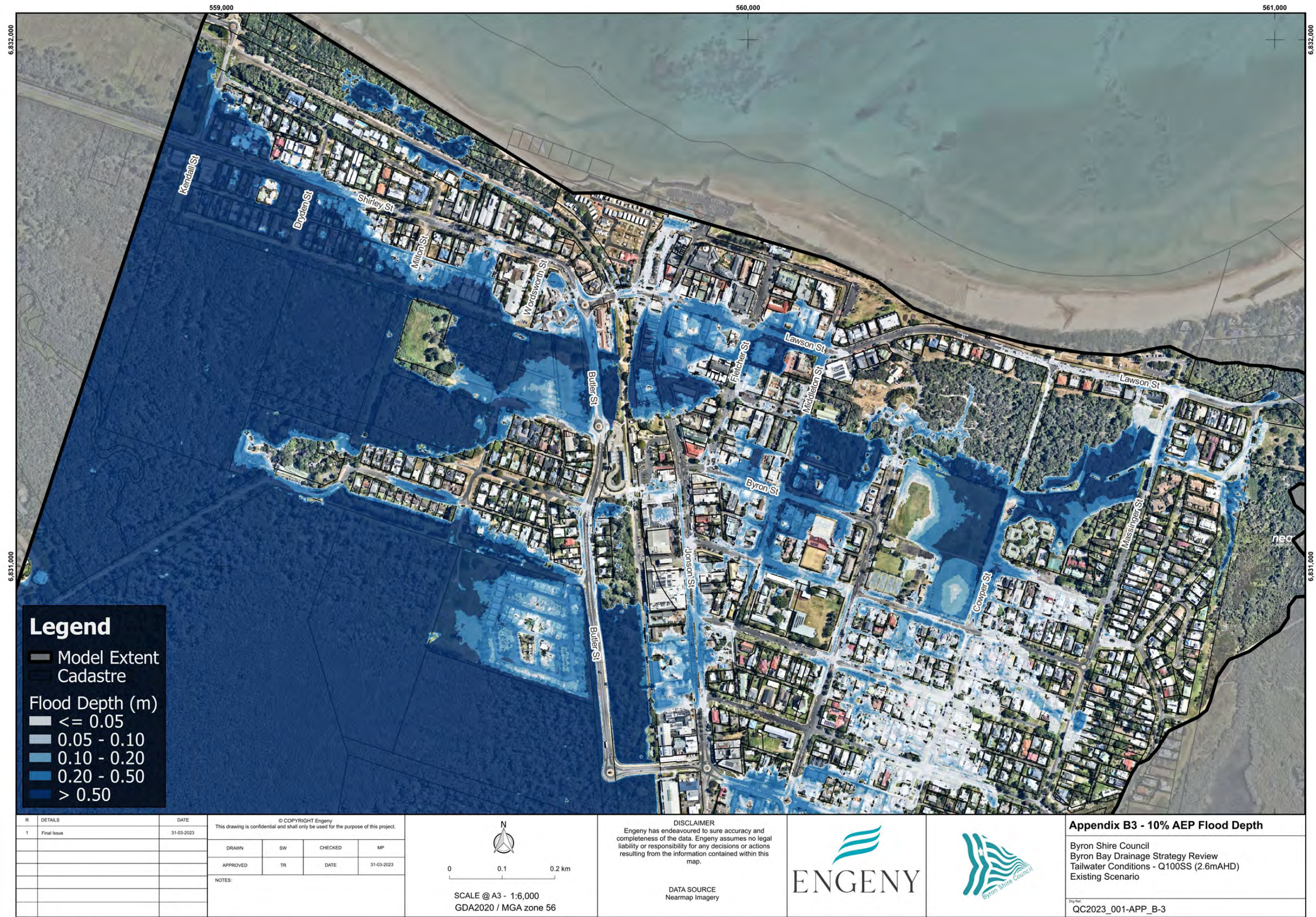




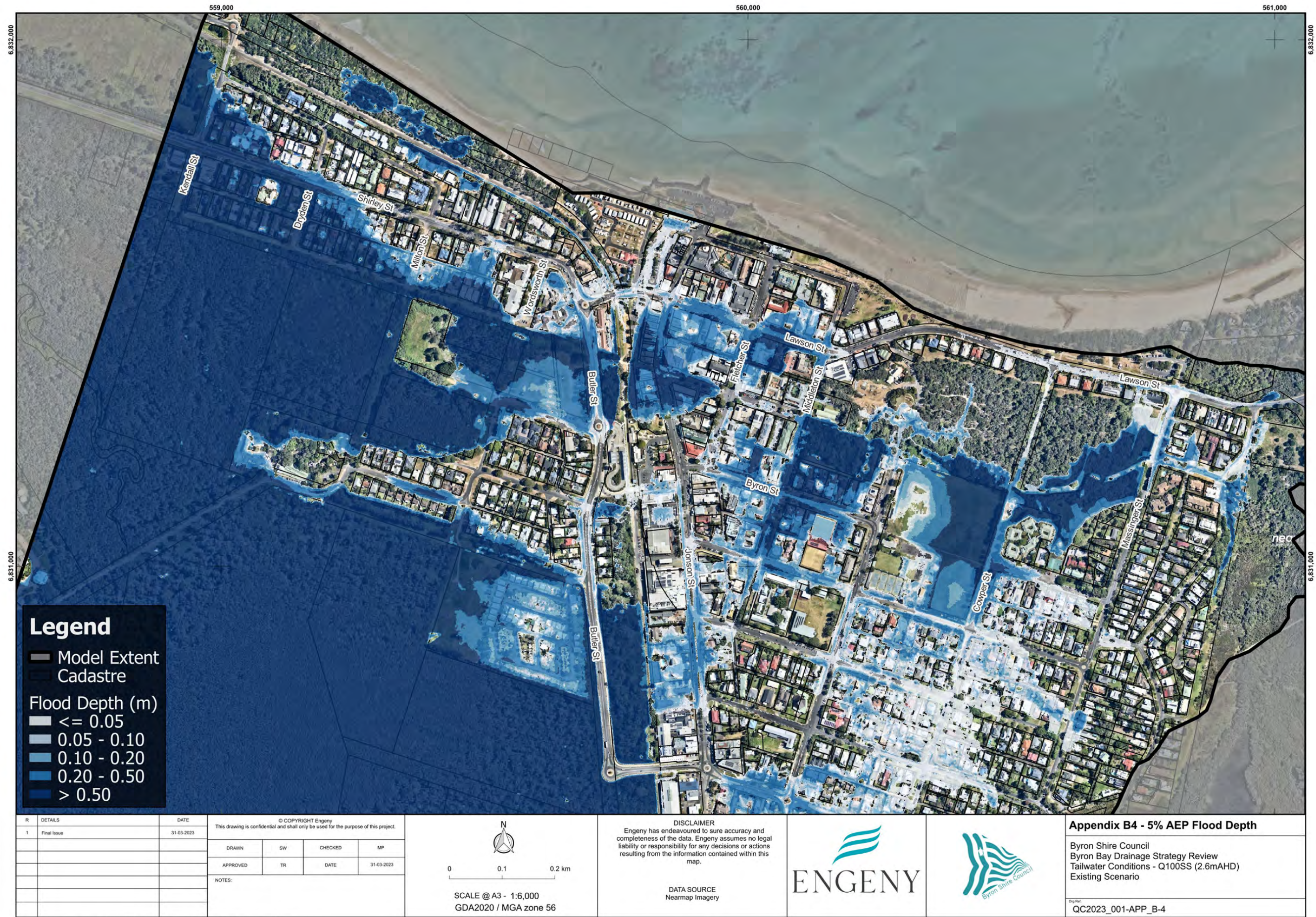




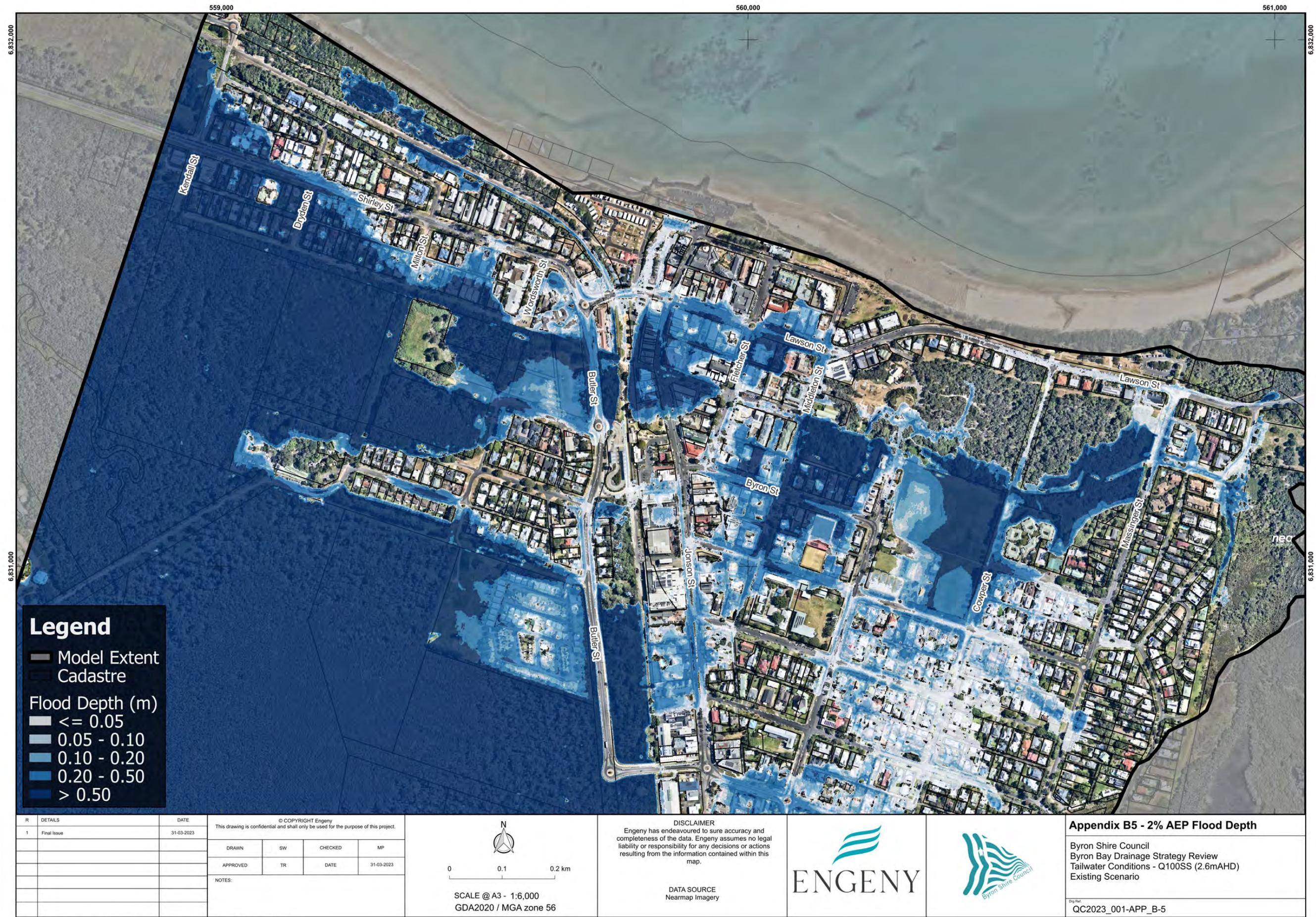




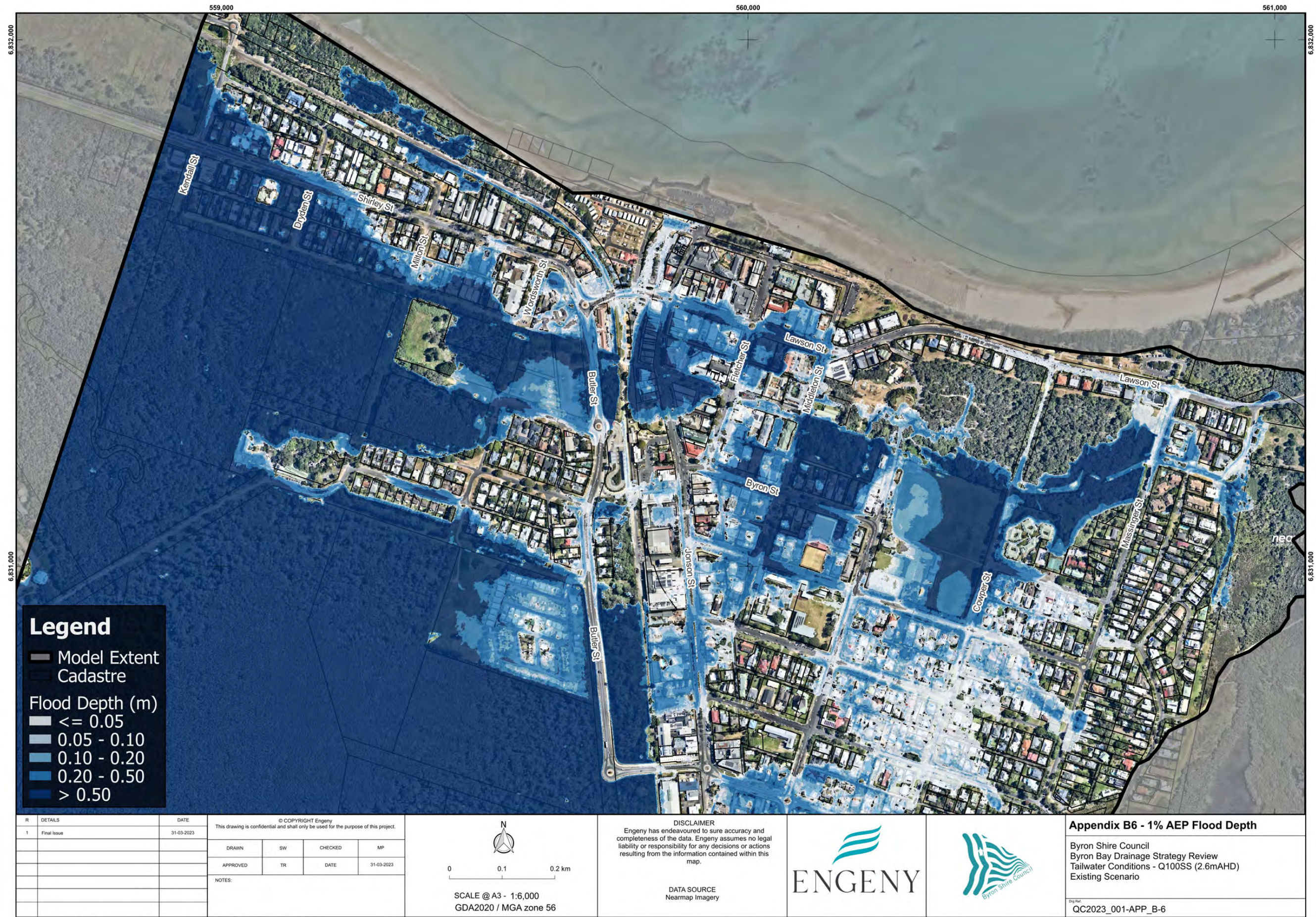




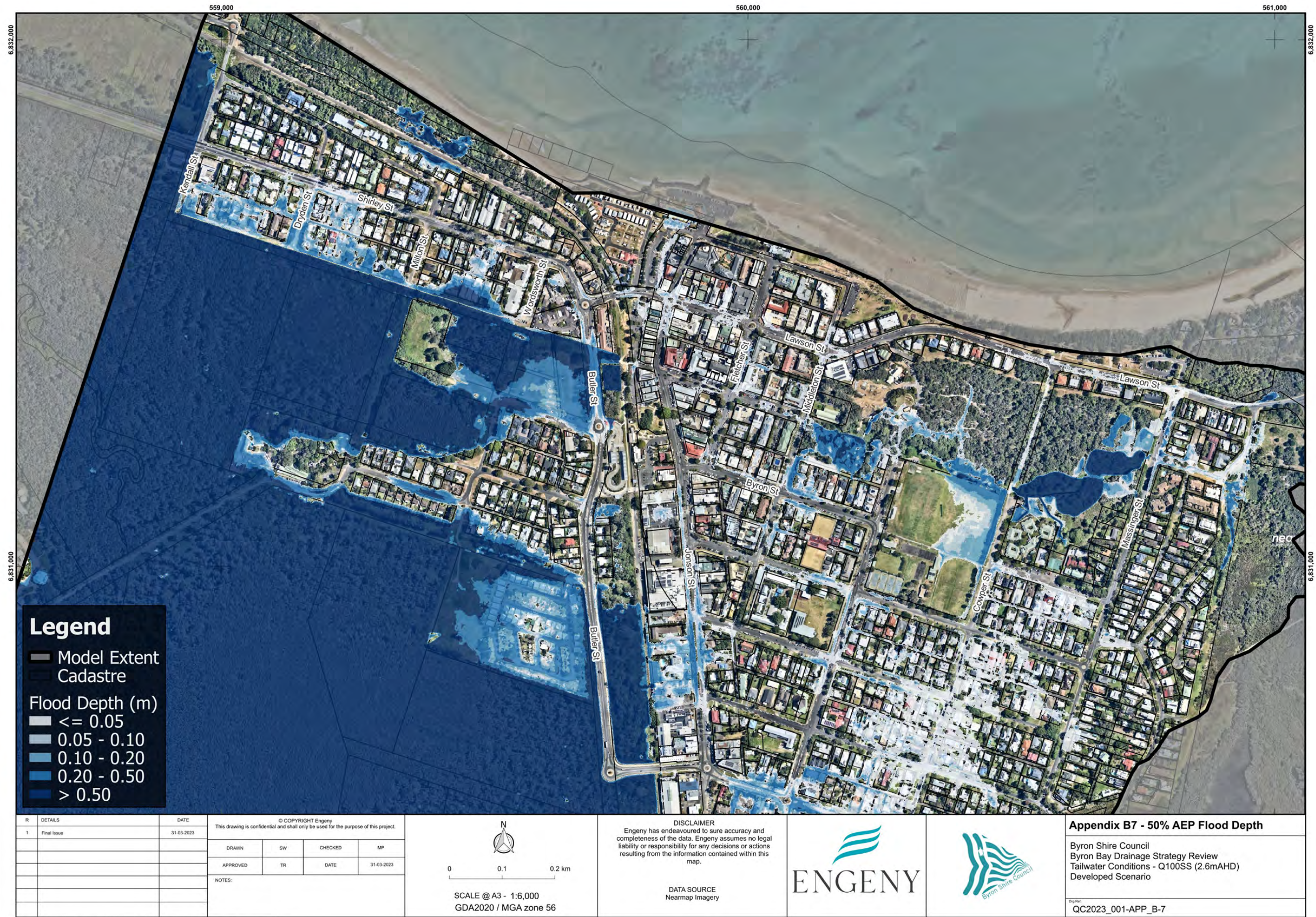




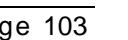




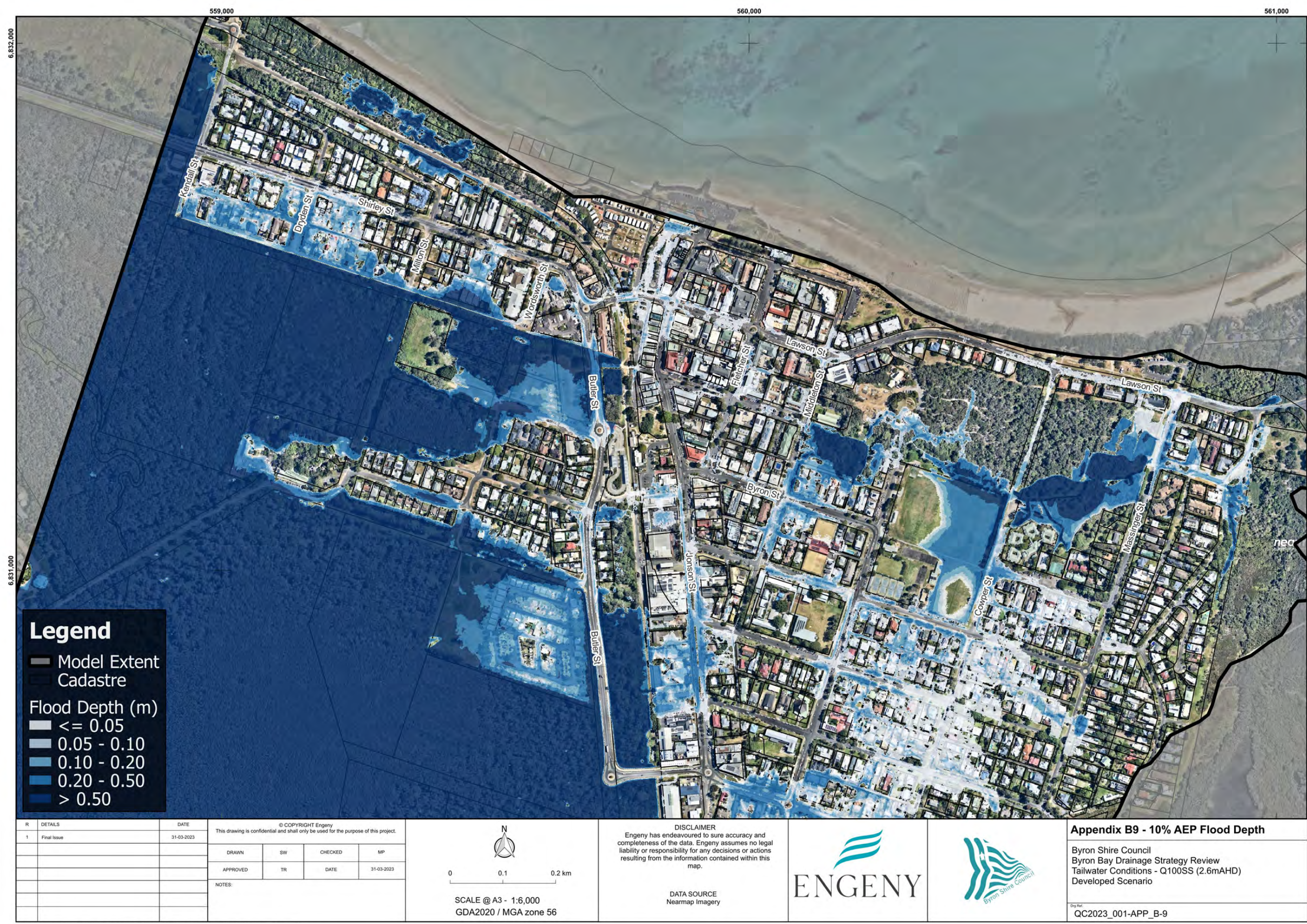




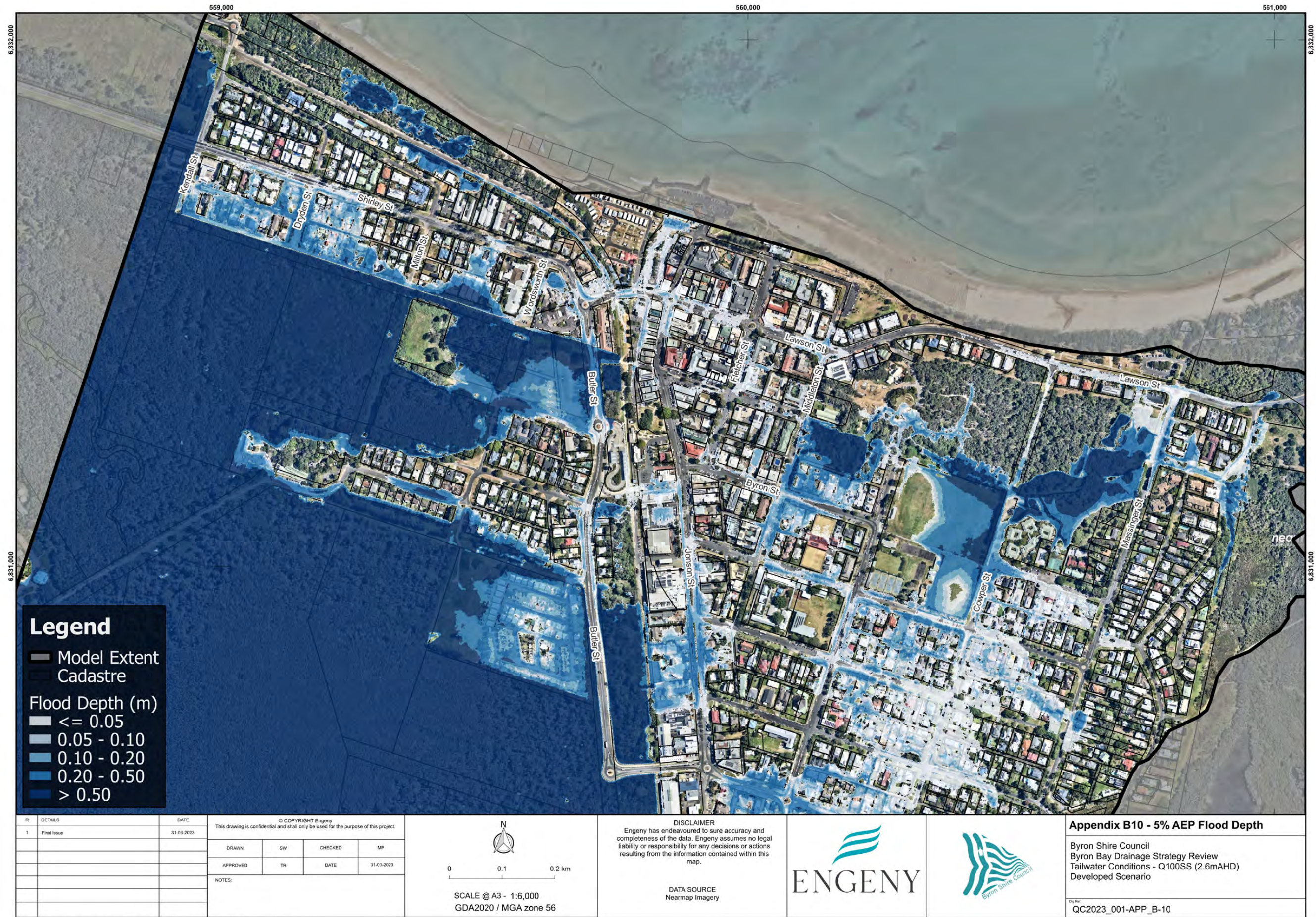




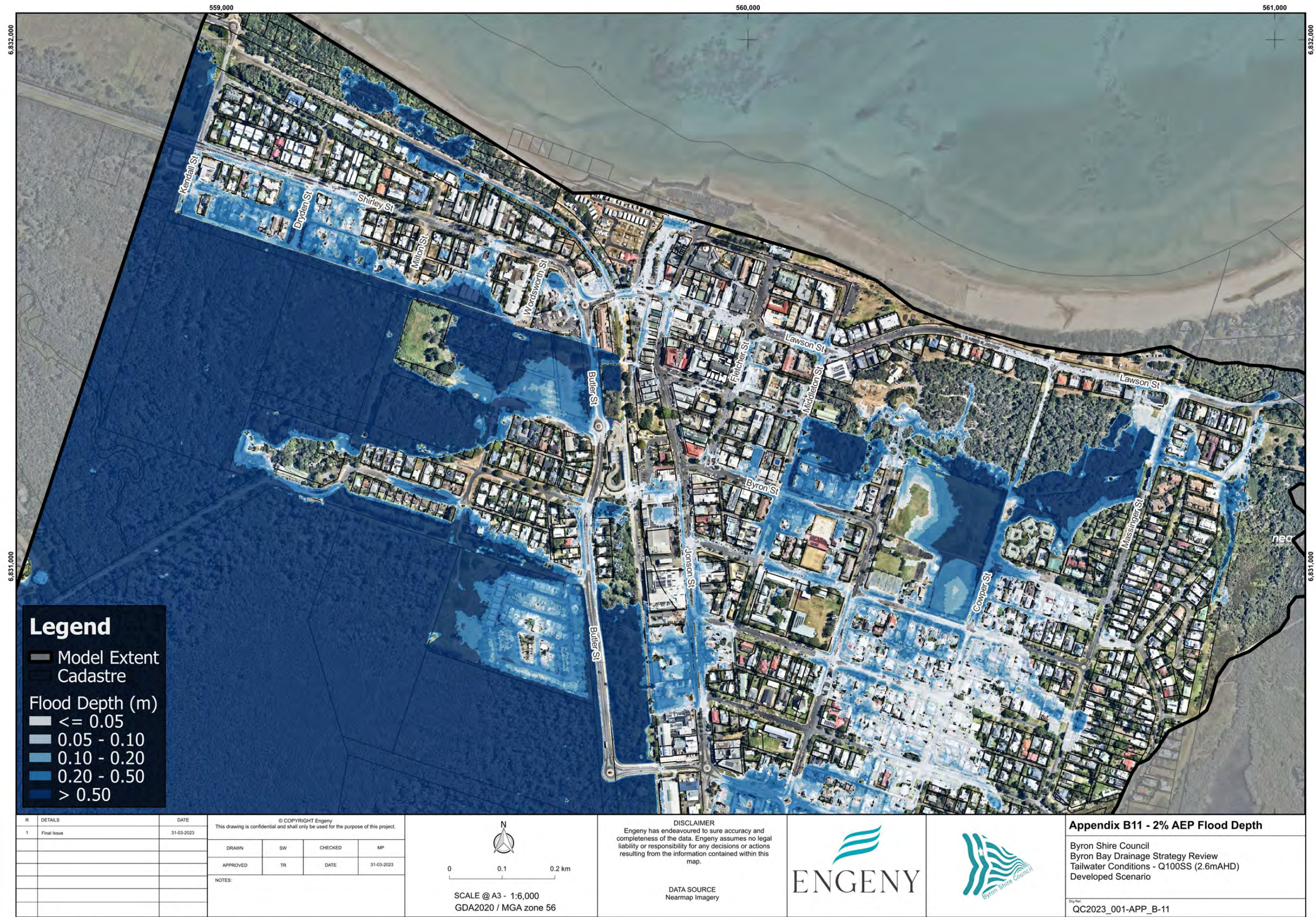




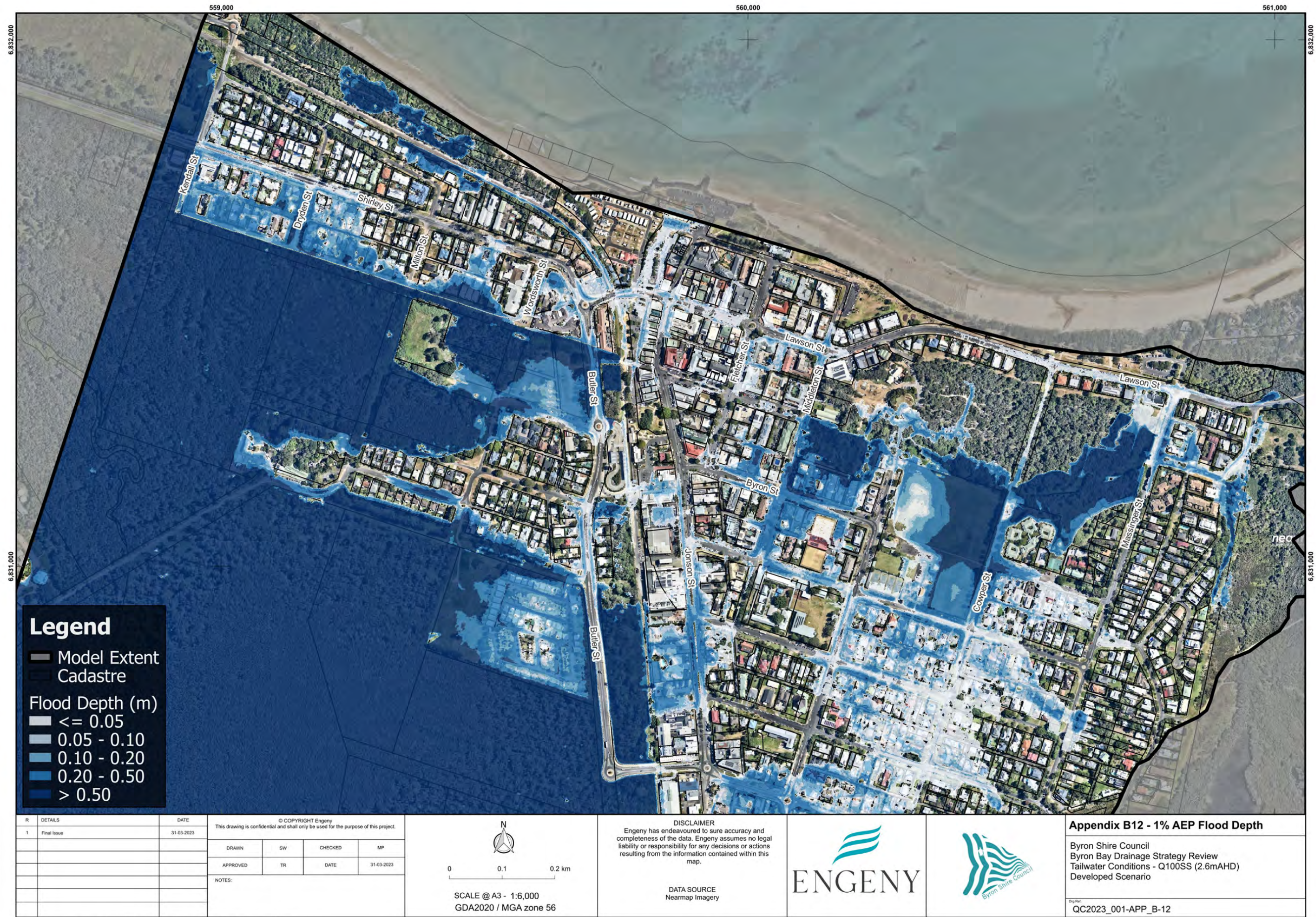




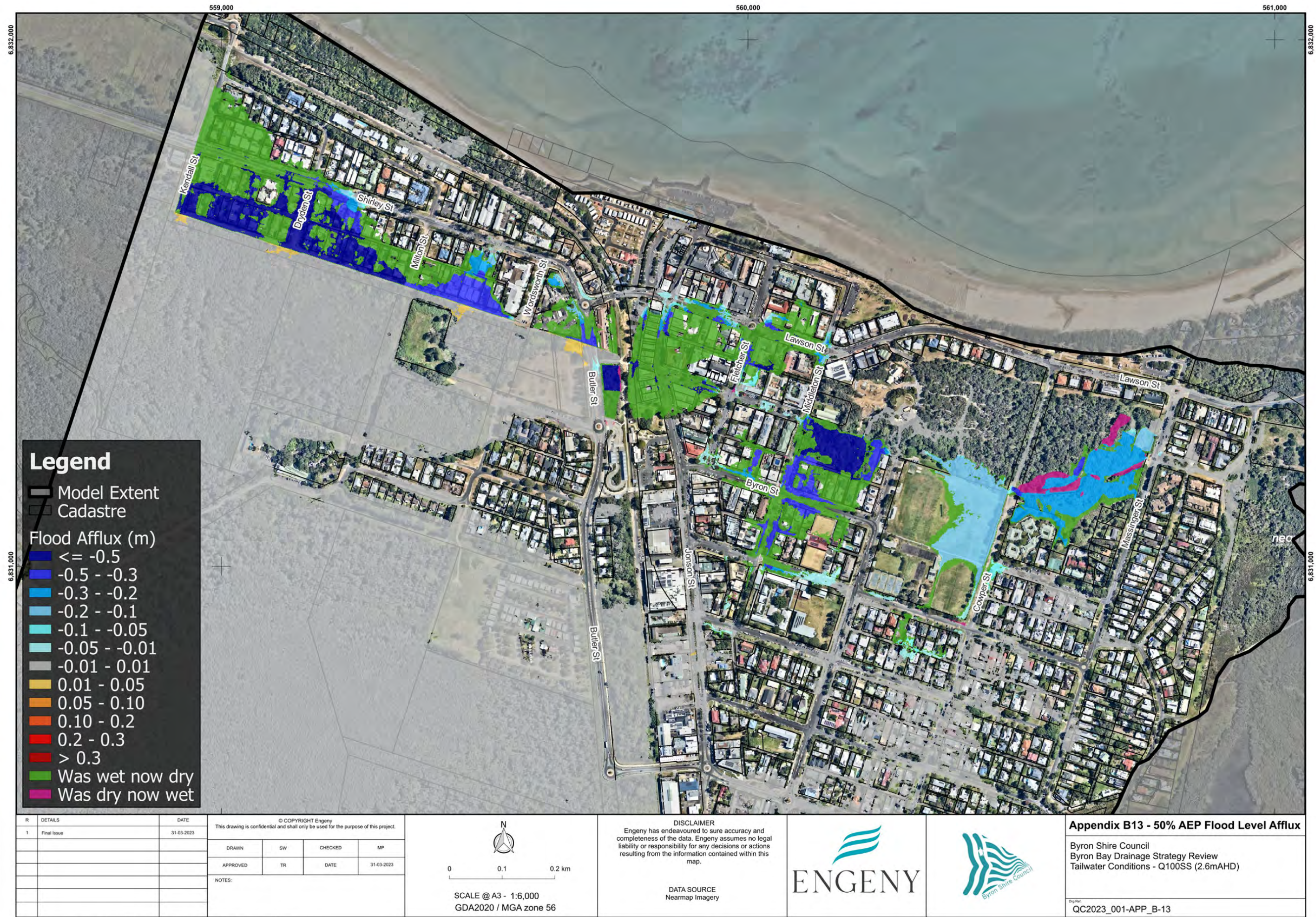




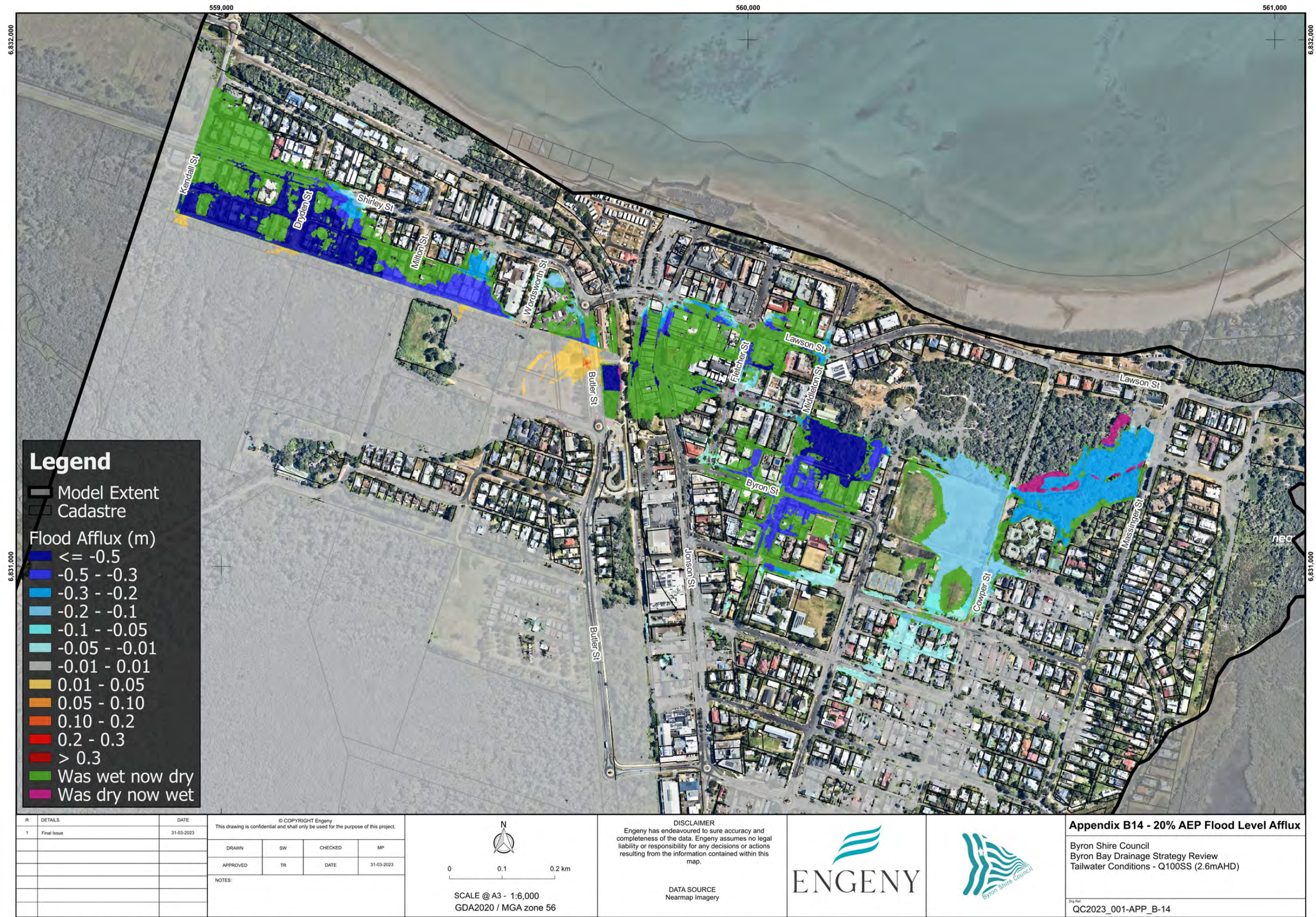




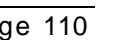




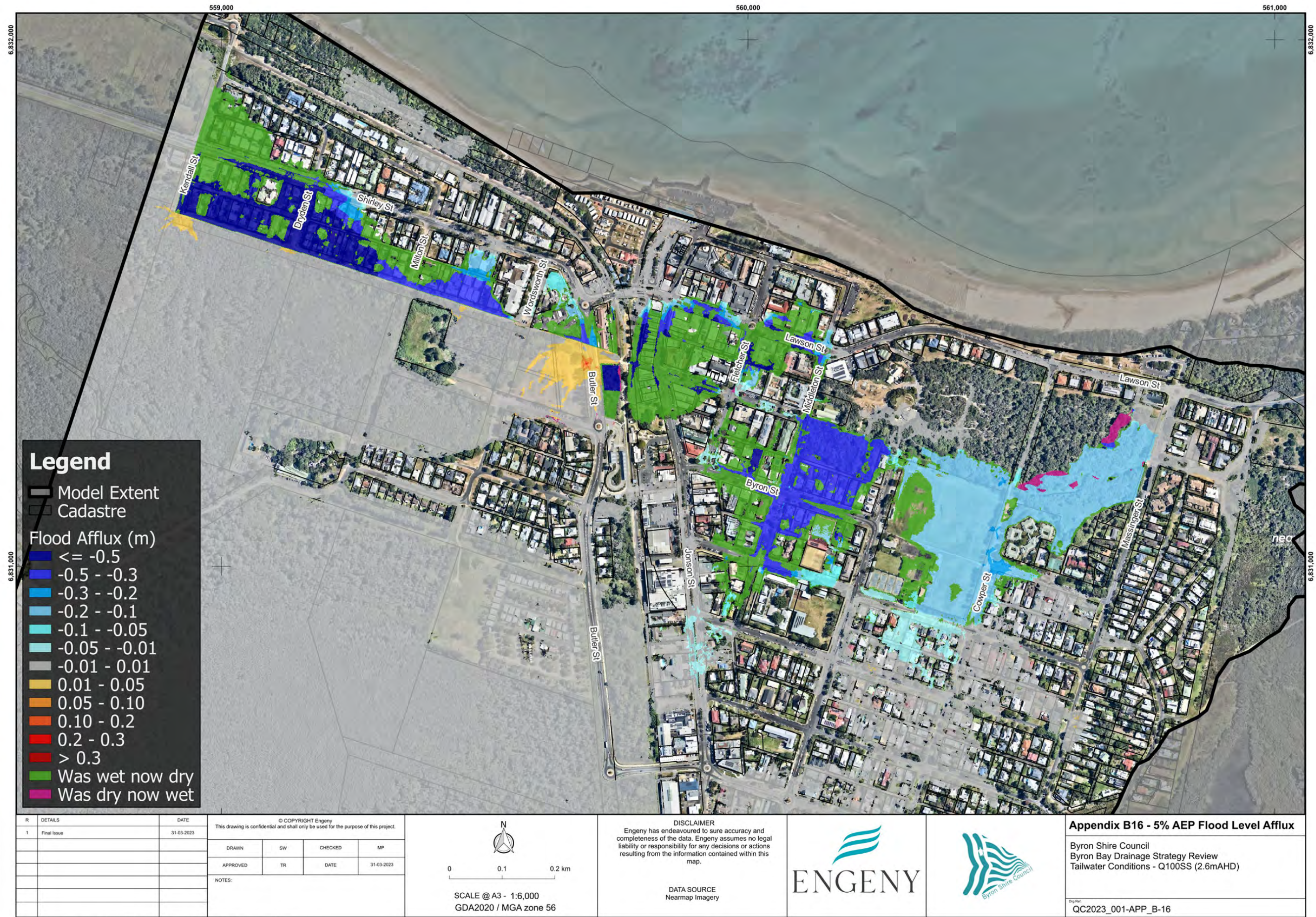




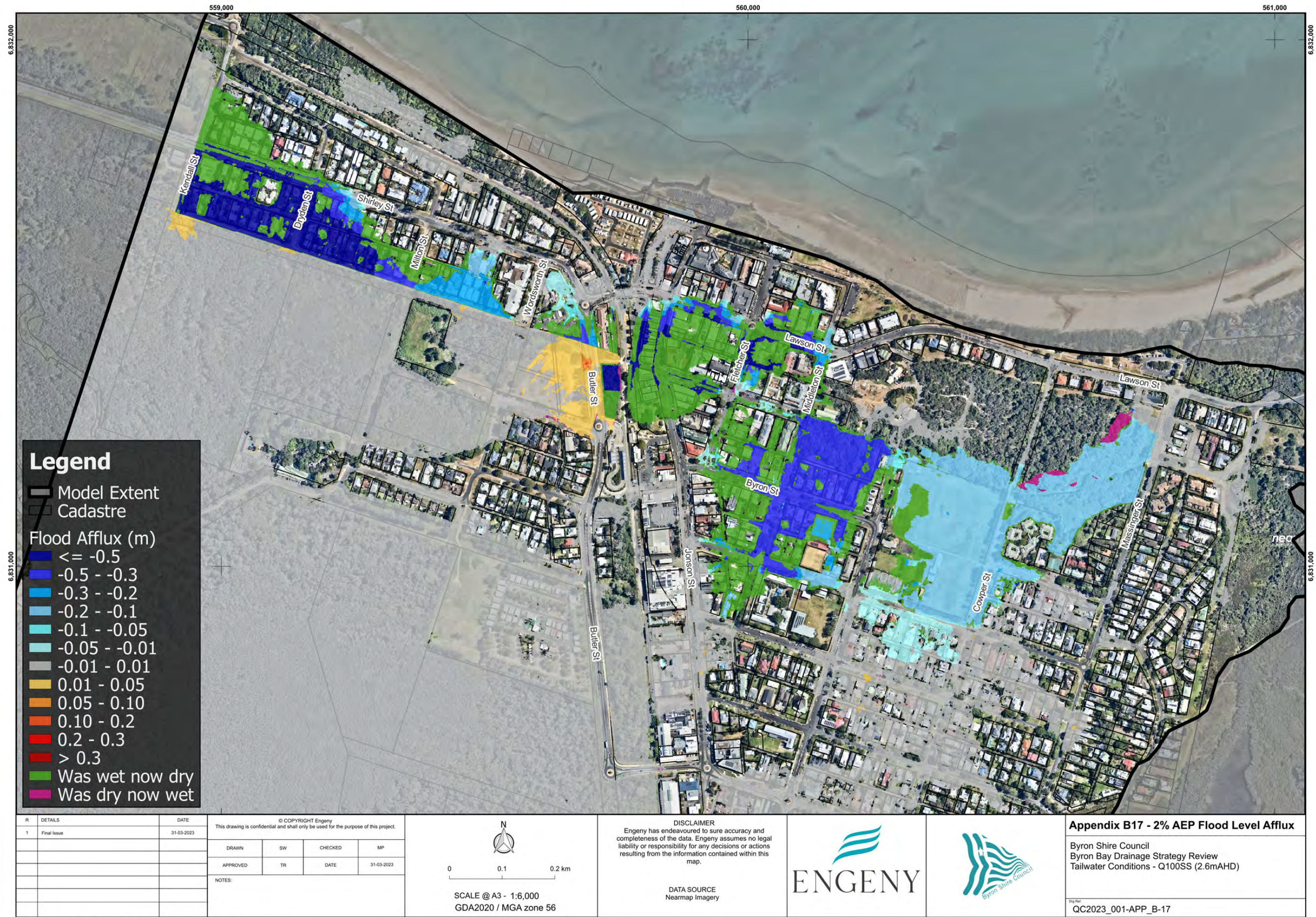




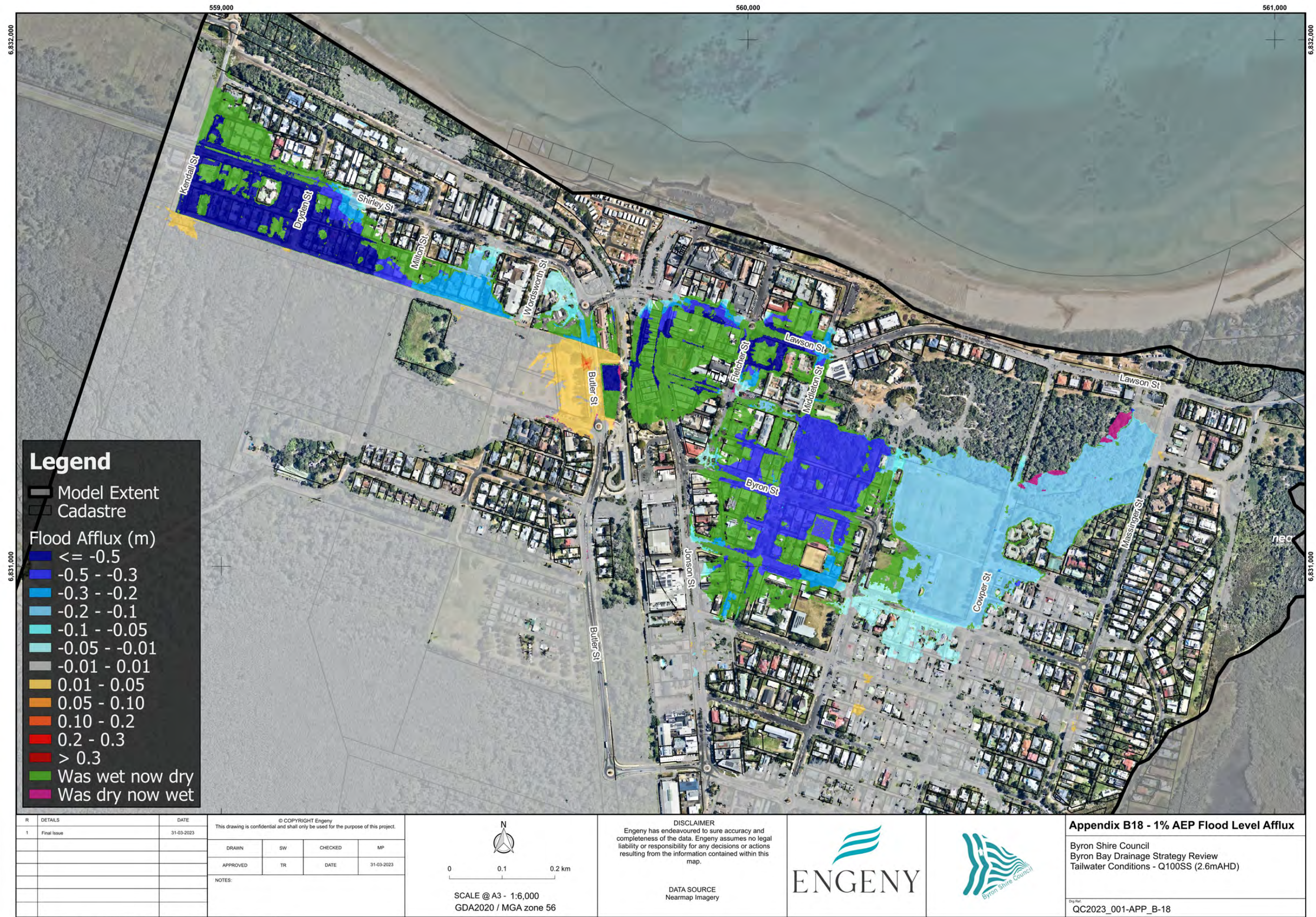










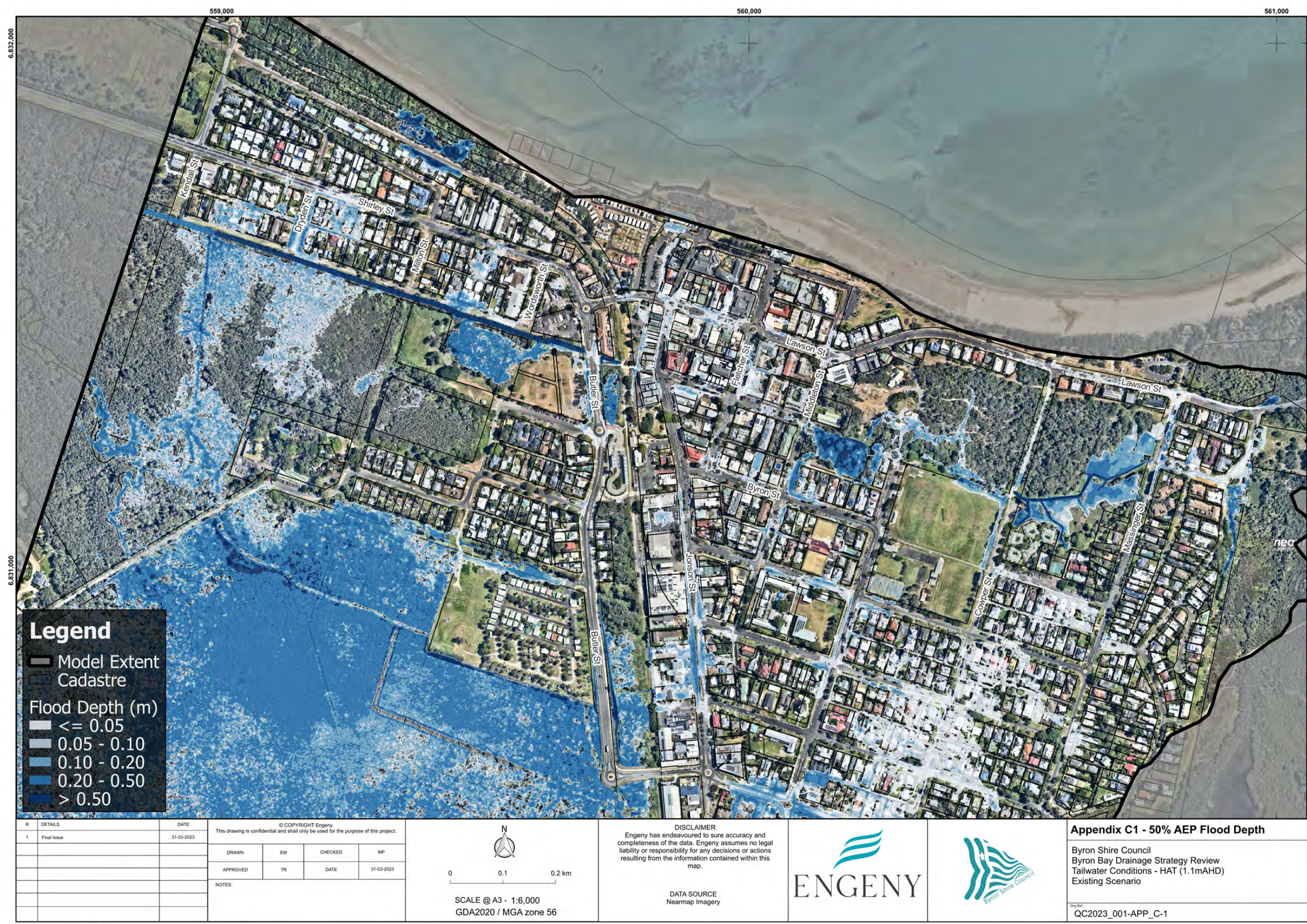




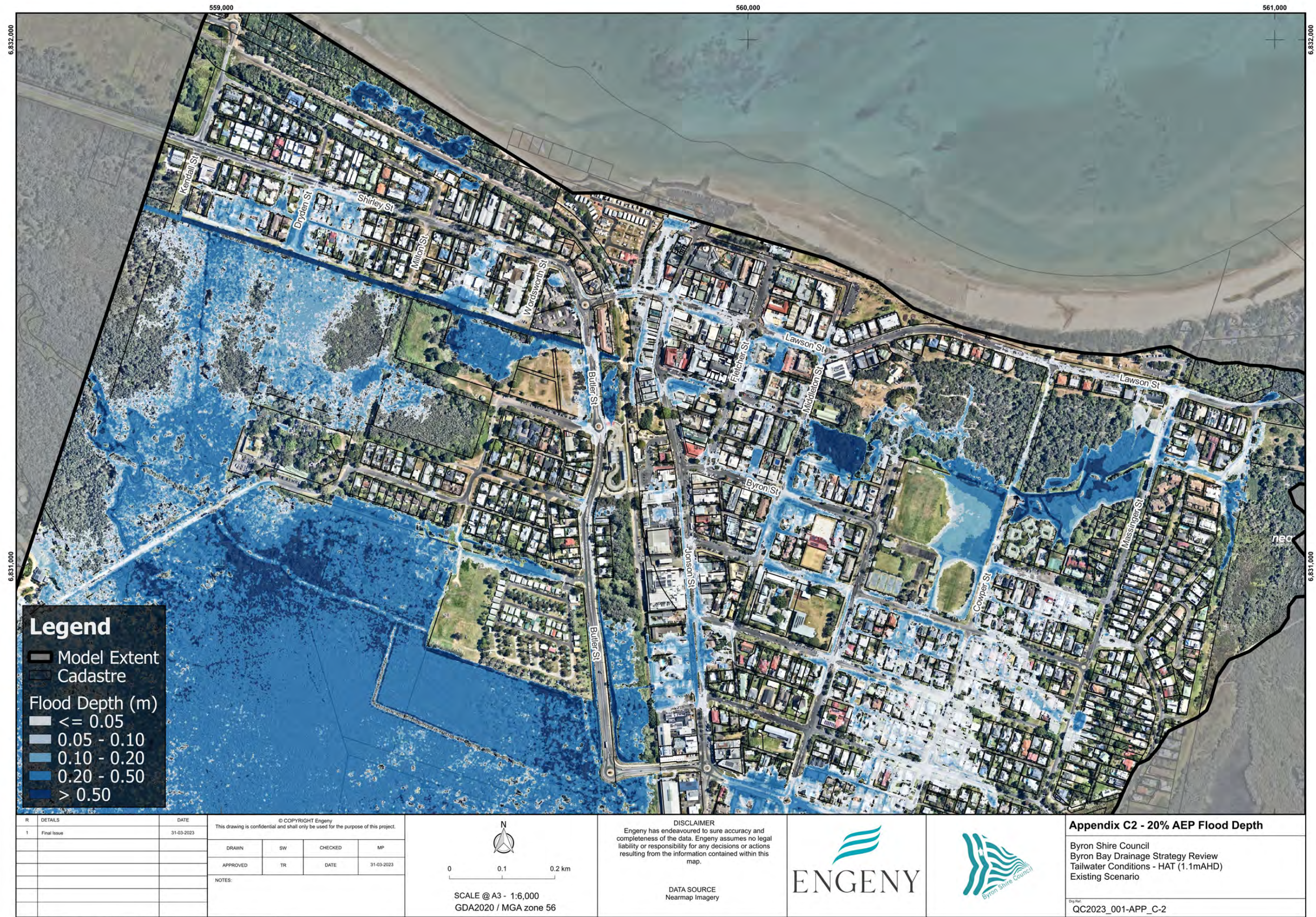
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## APPENDIX C: DESIGN EVENT RESULTS, HIGHEST ASTRONOMICAL TIDE (1.1 M AHD)

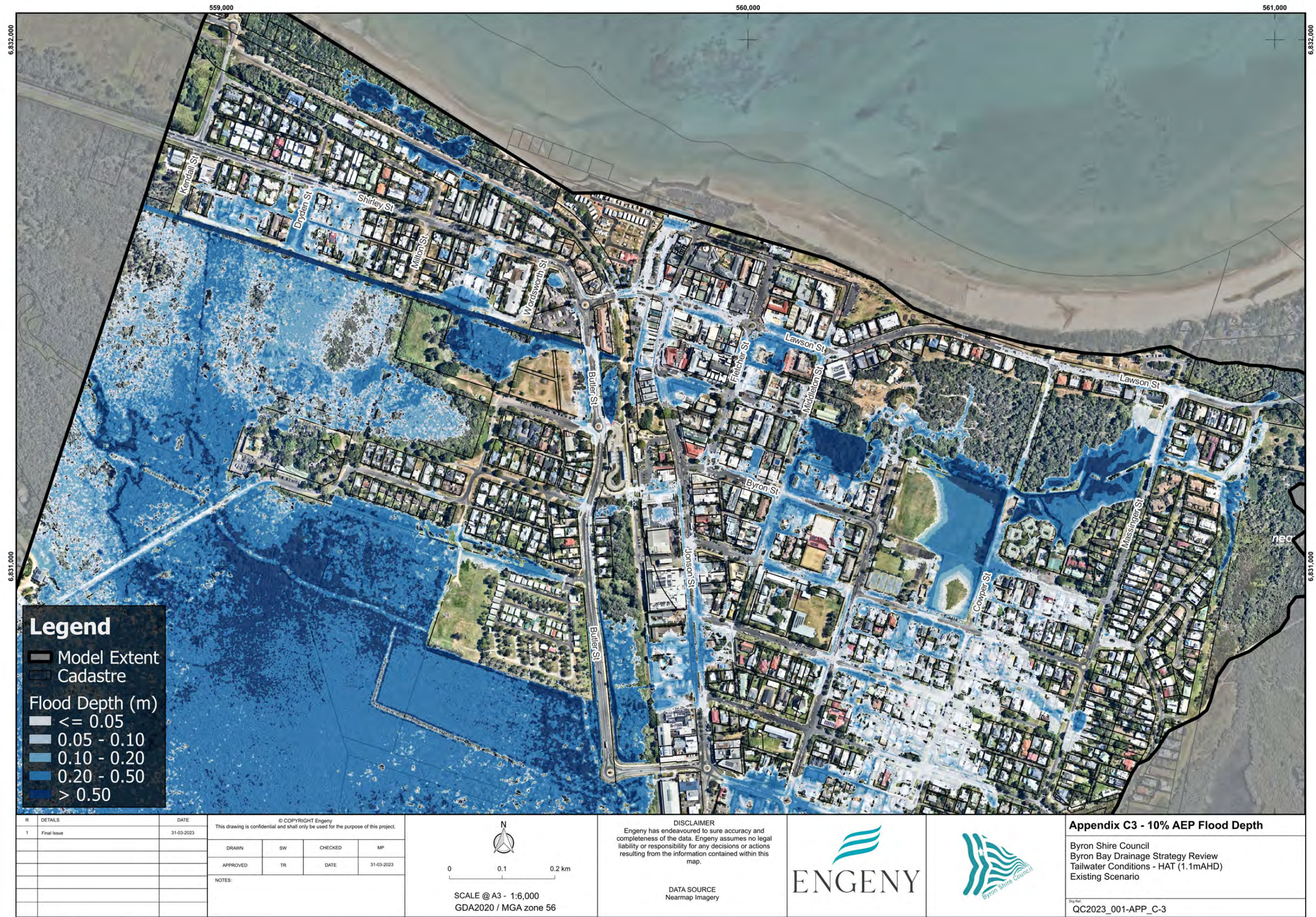




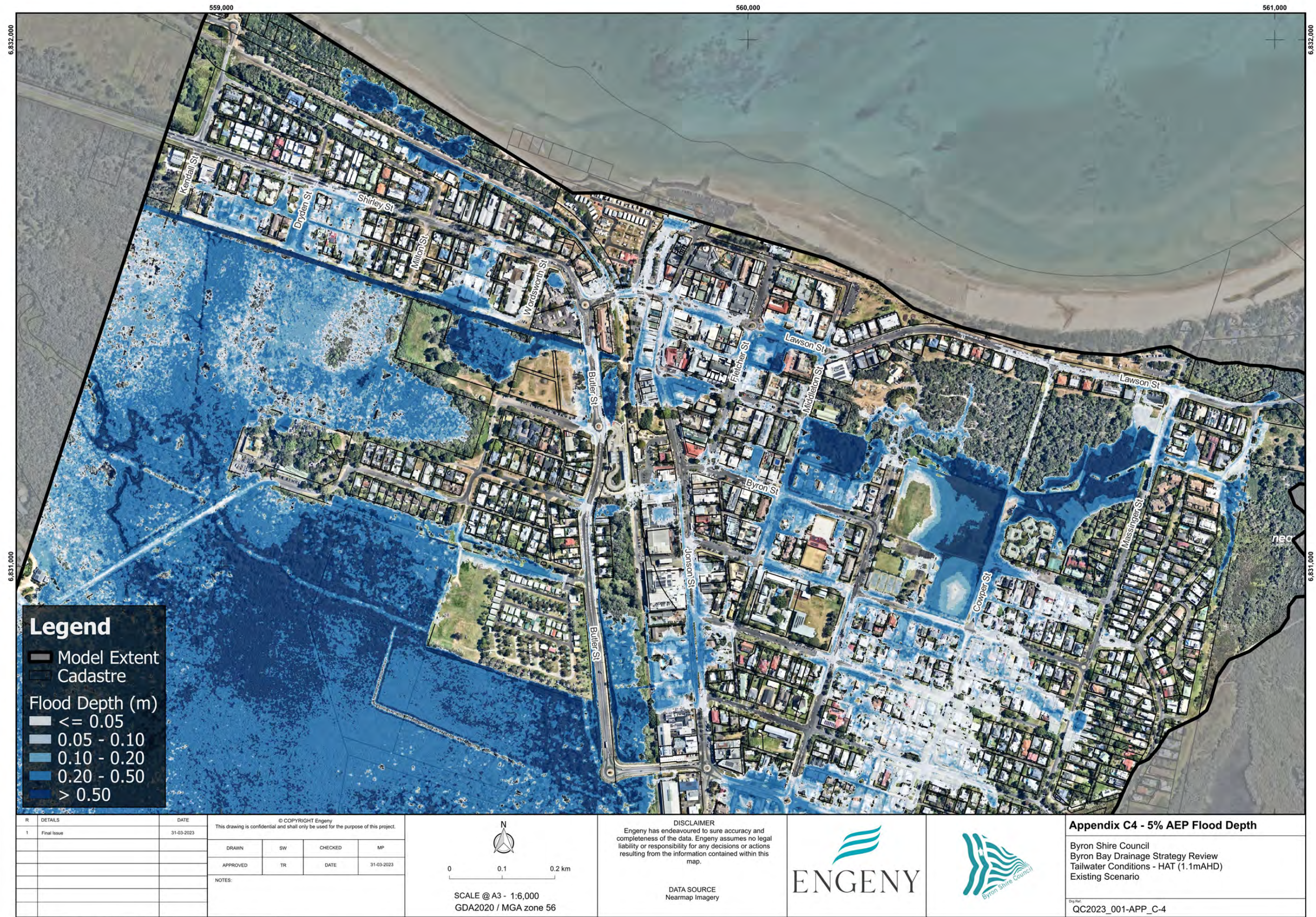




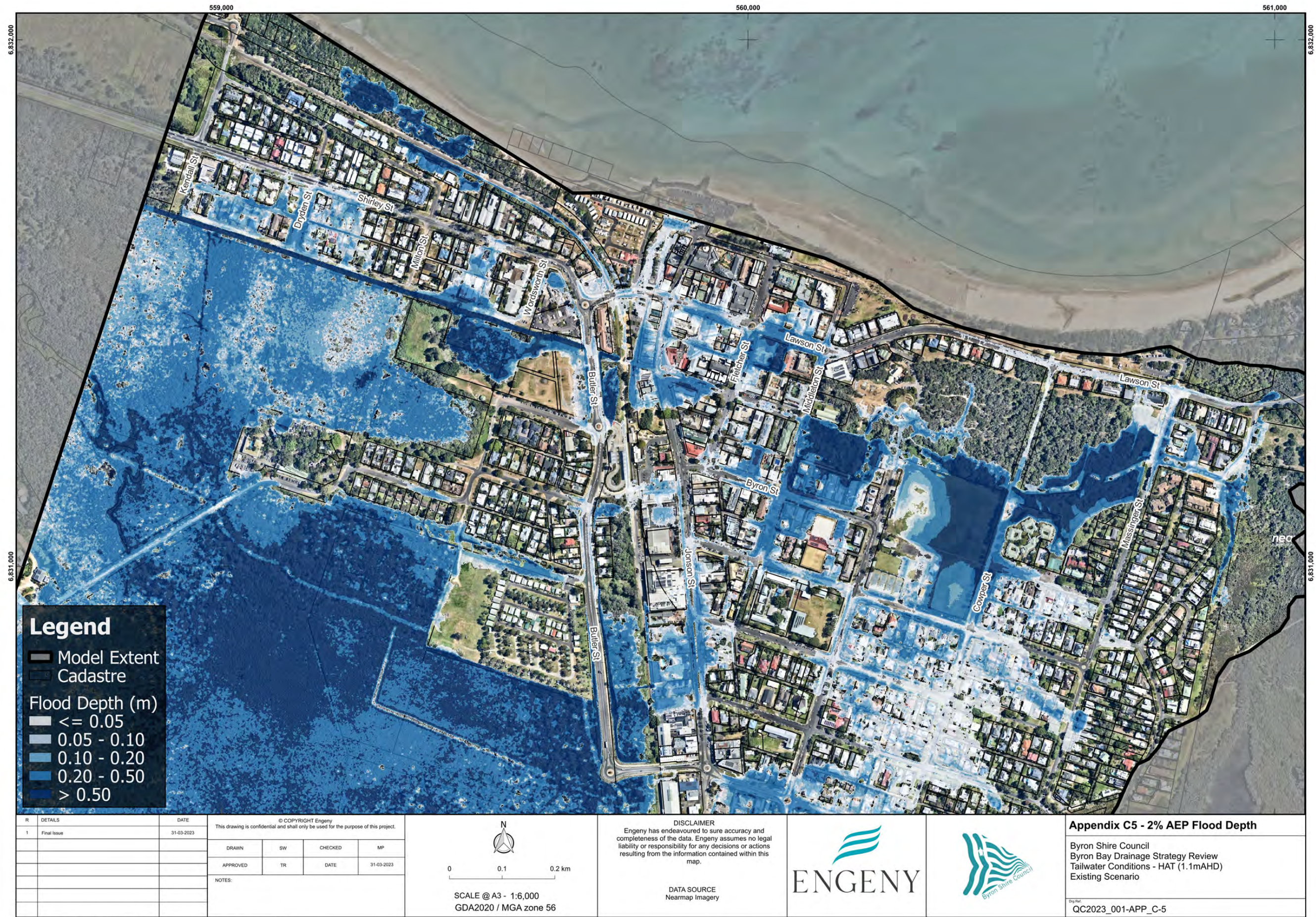




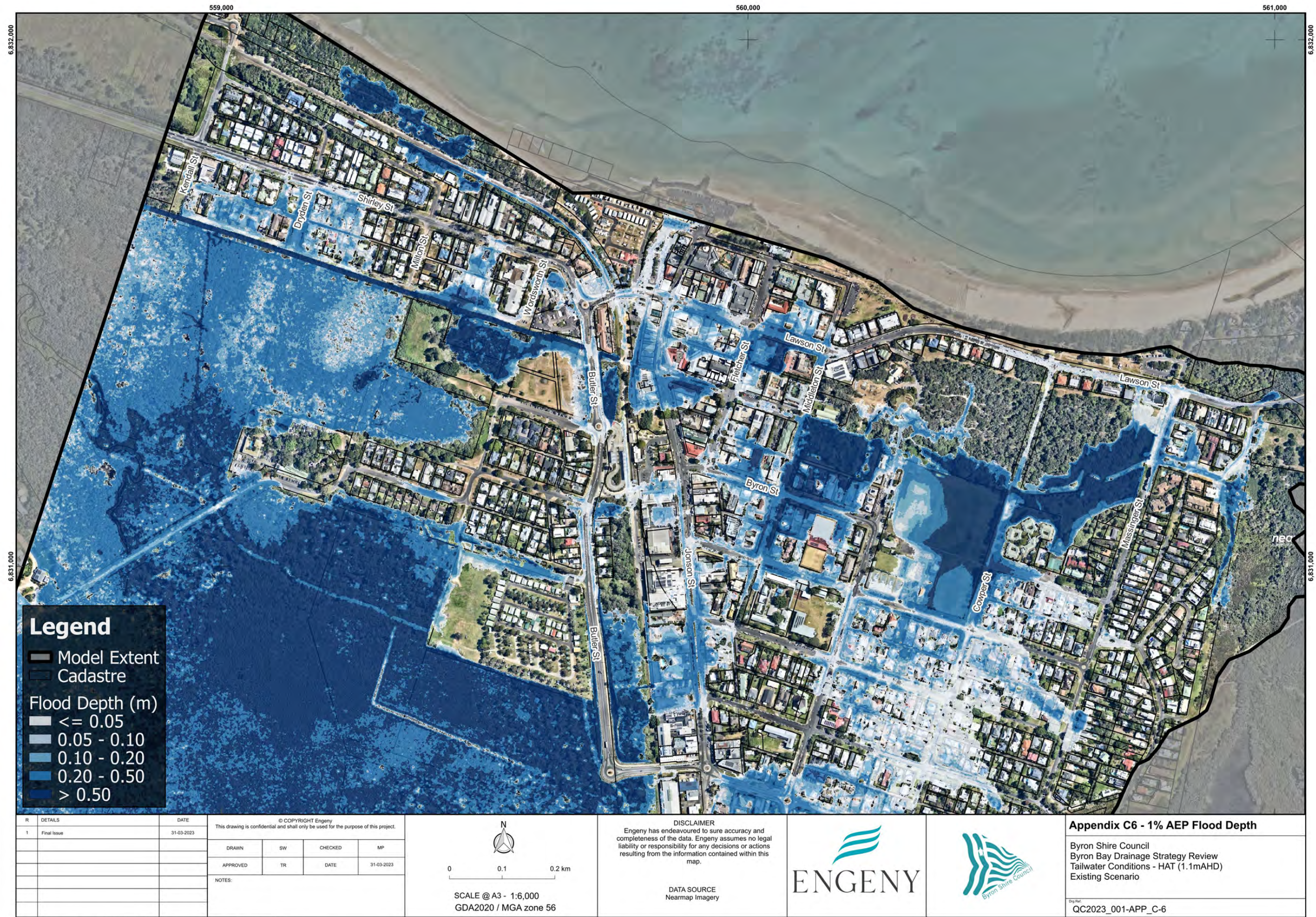




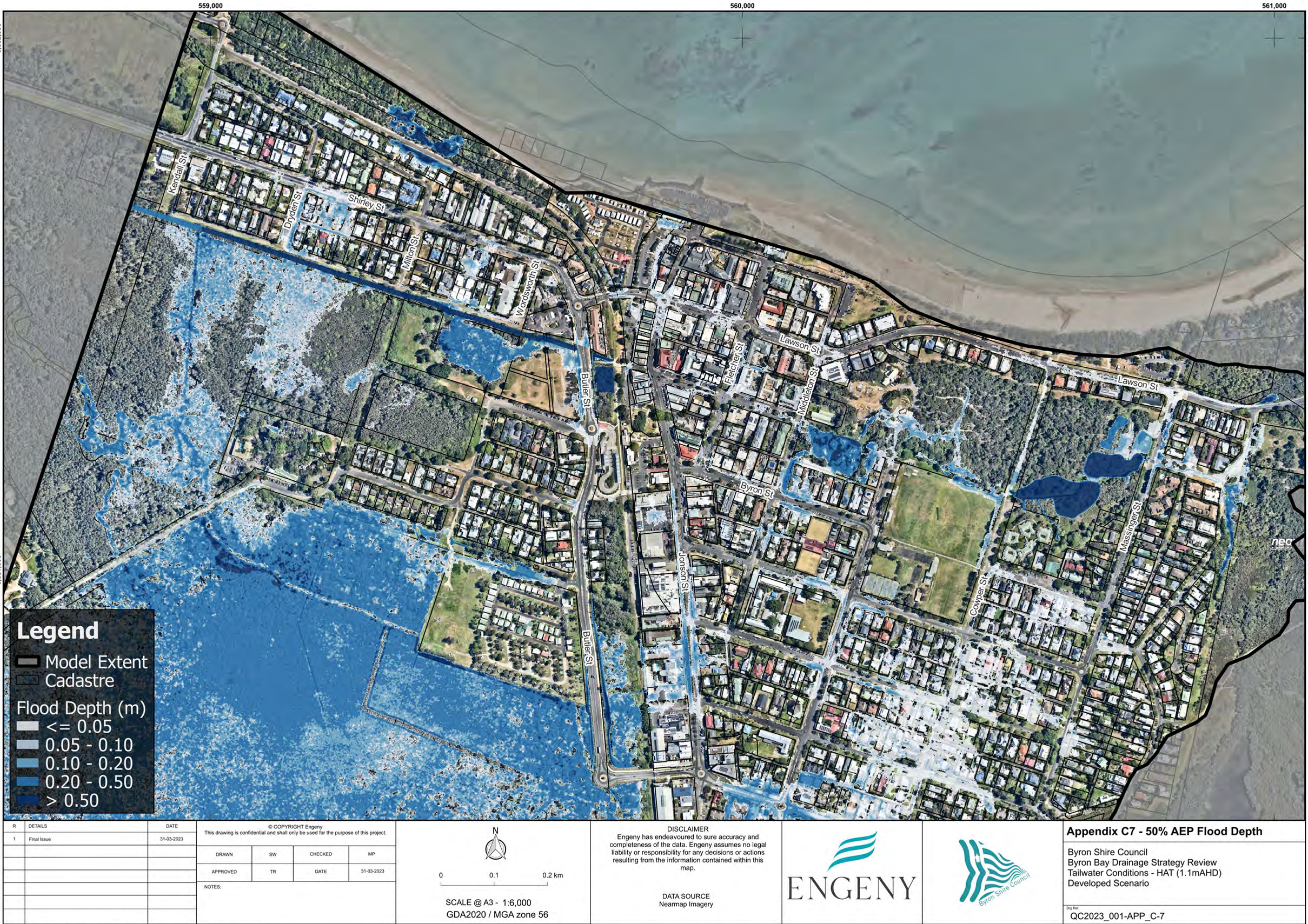




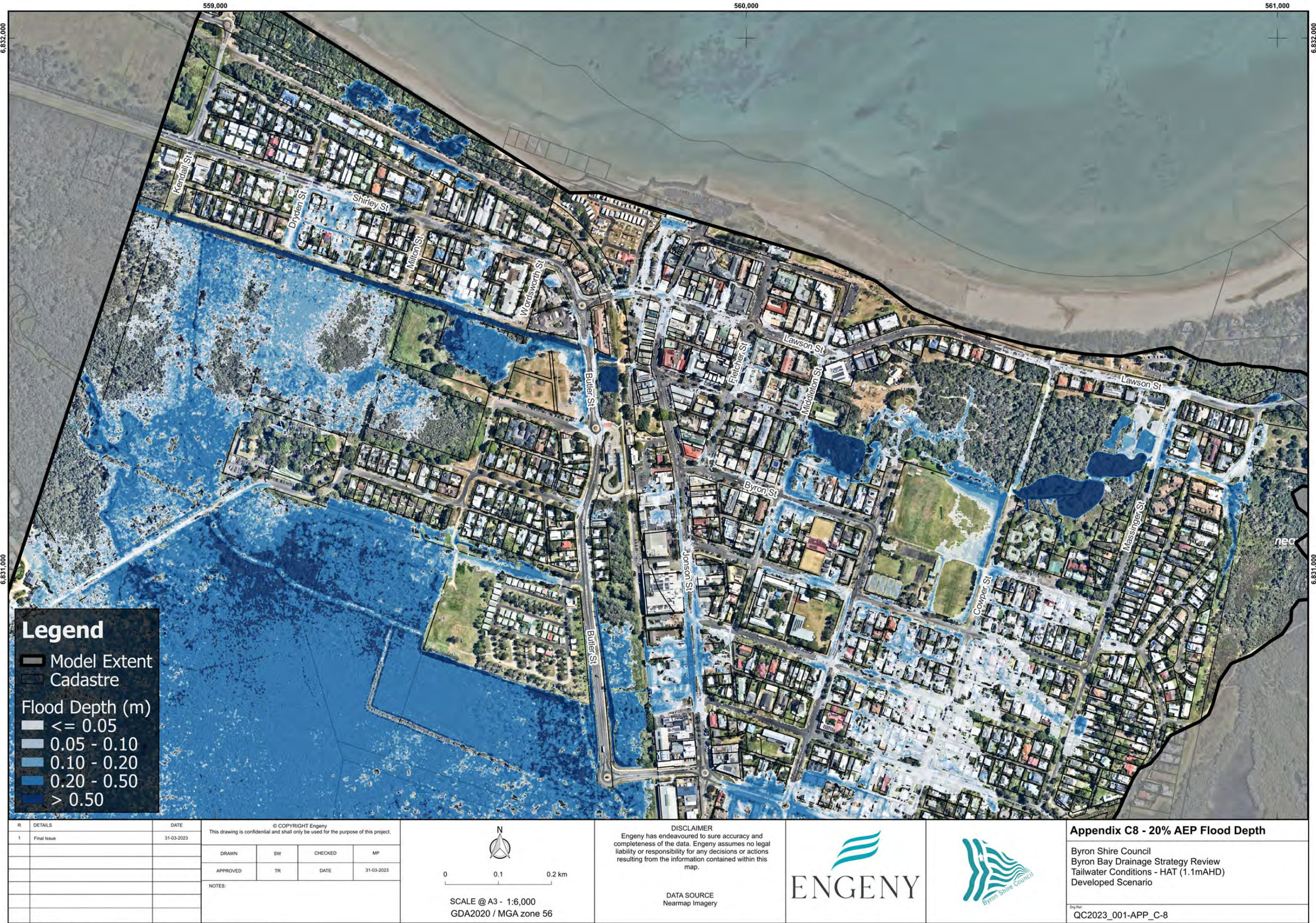




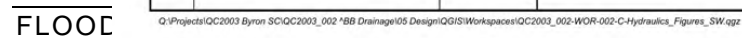




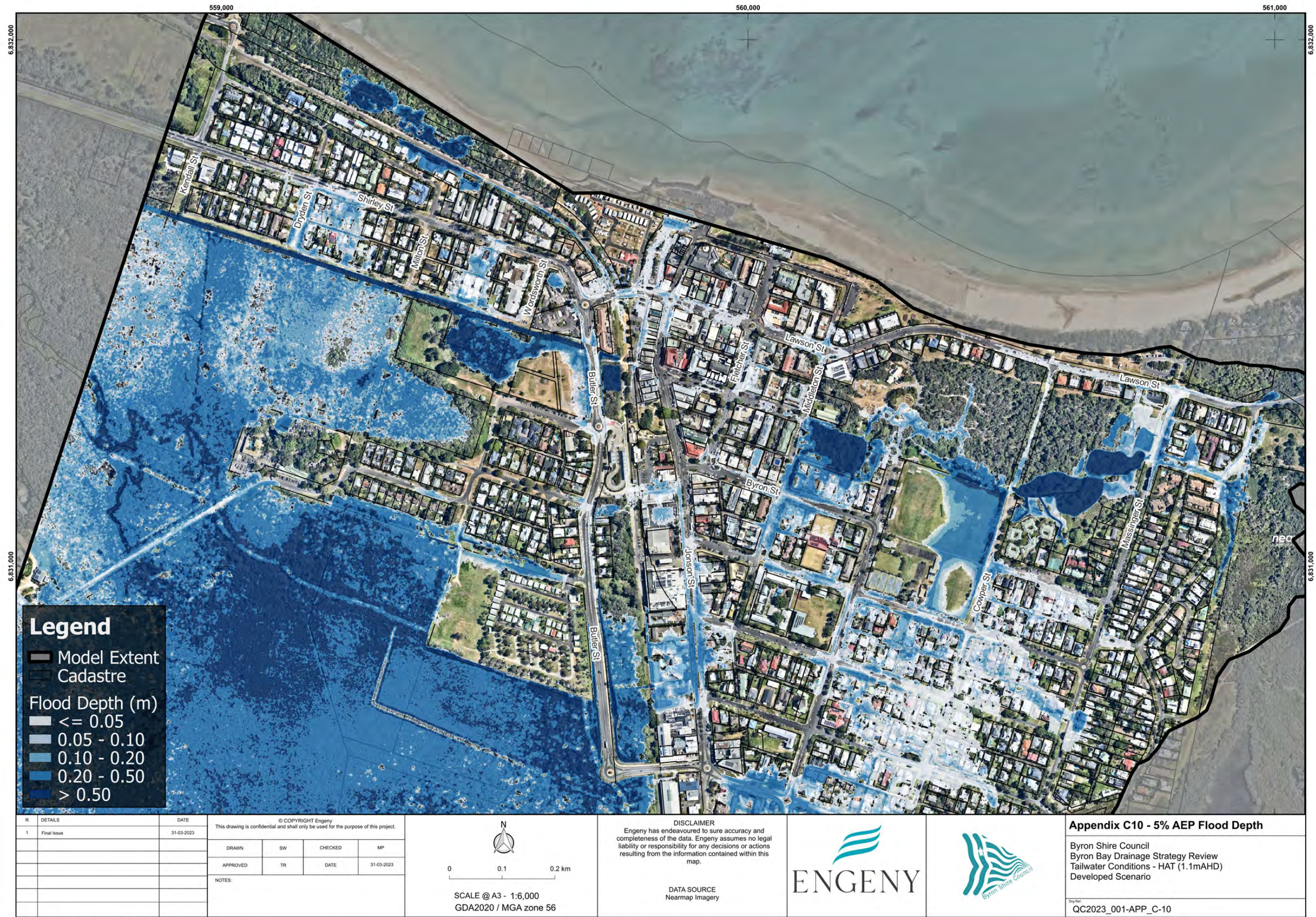




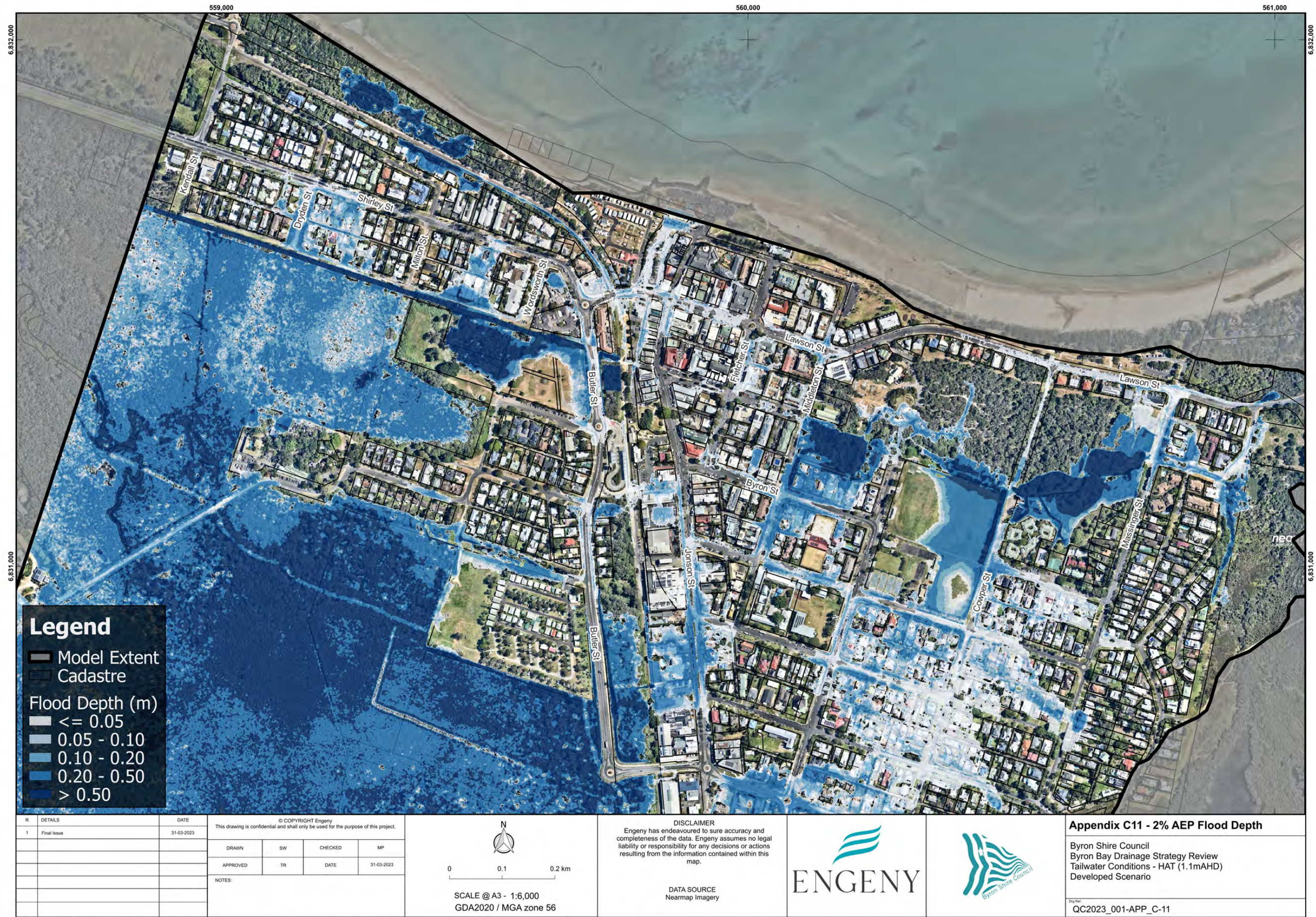




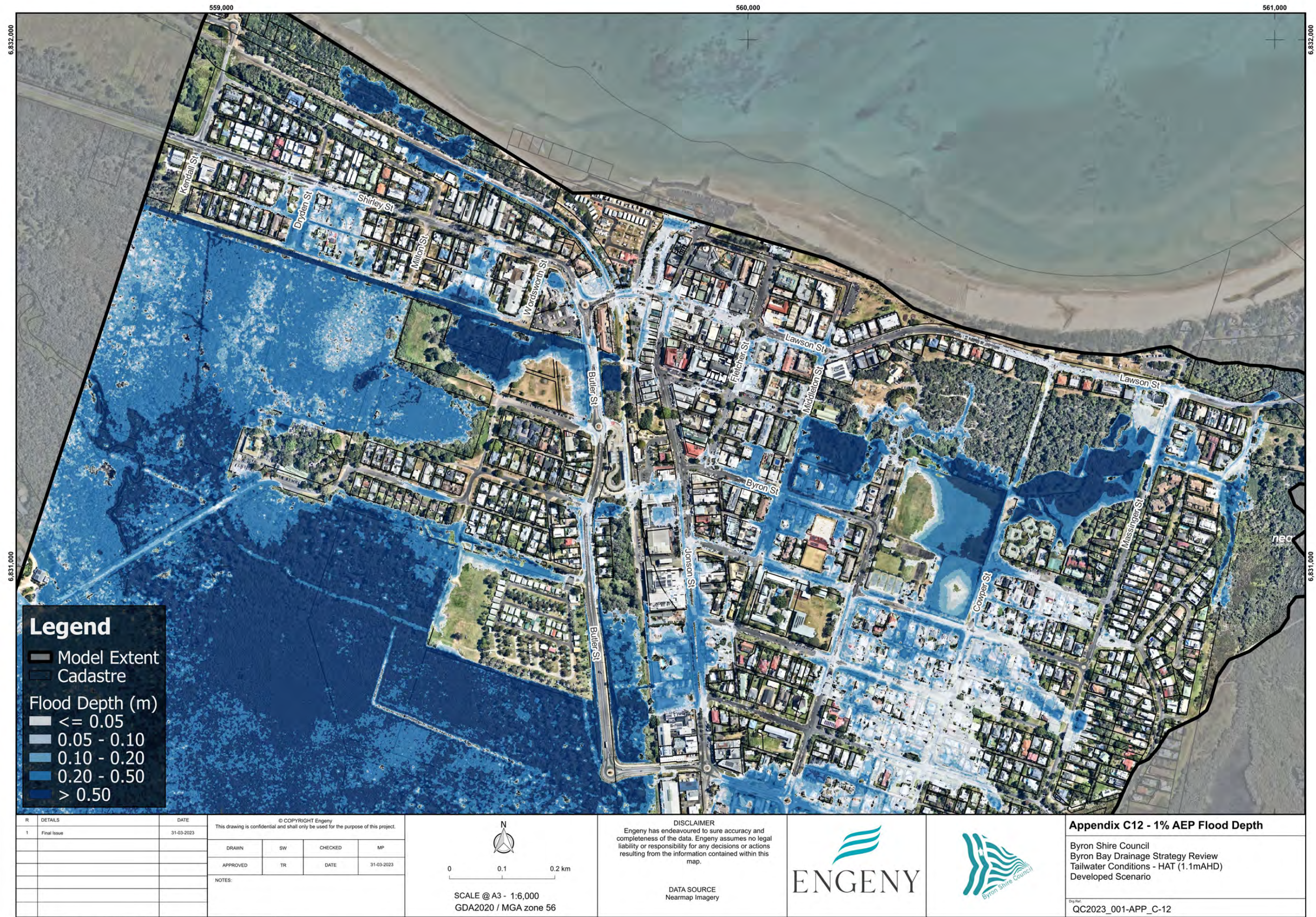




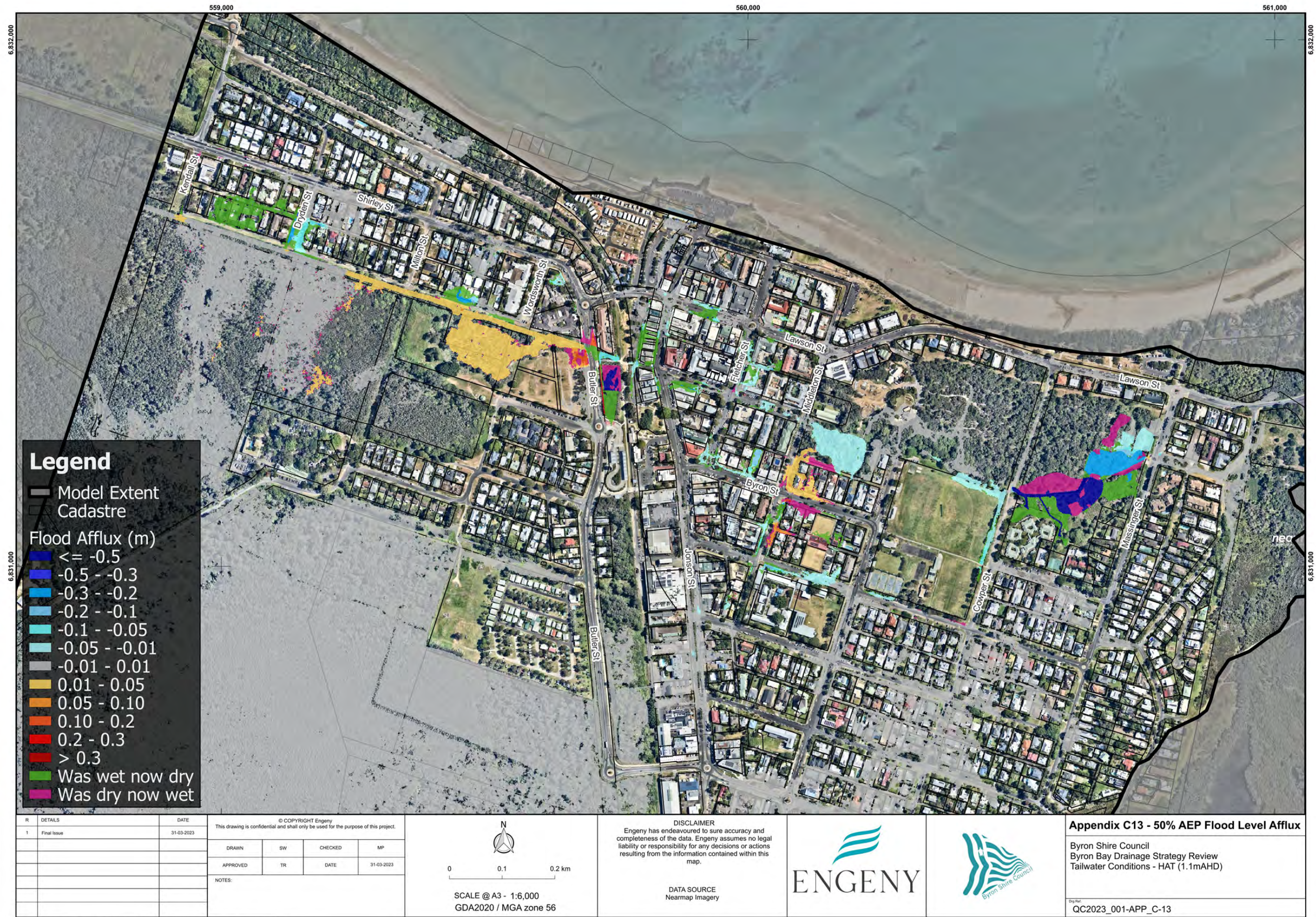




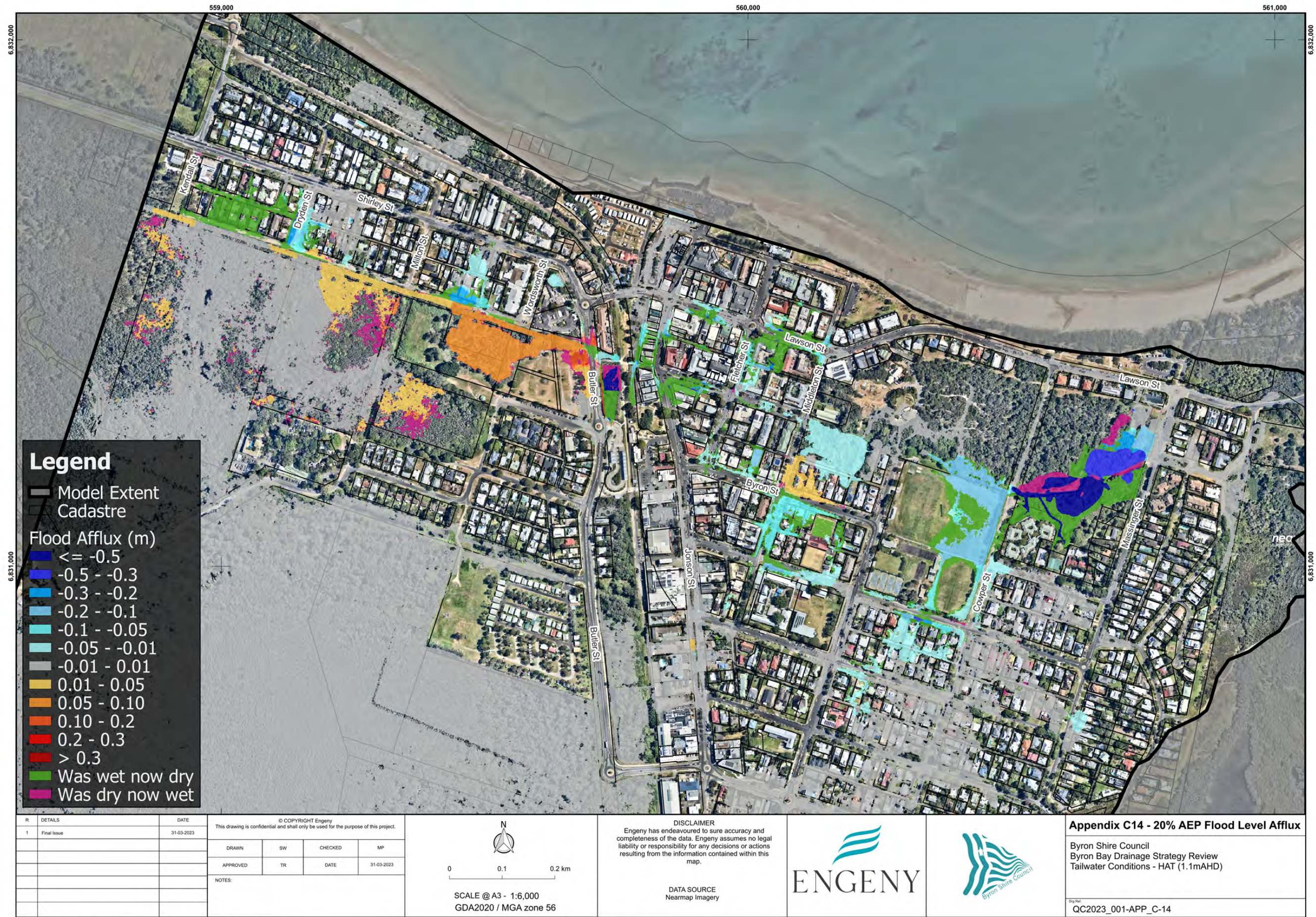




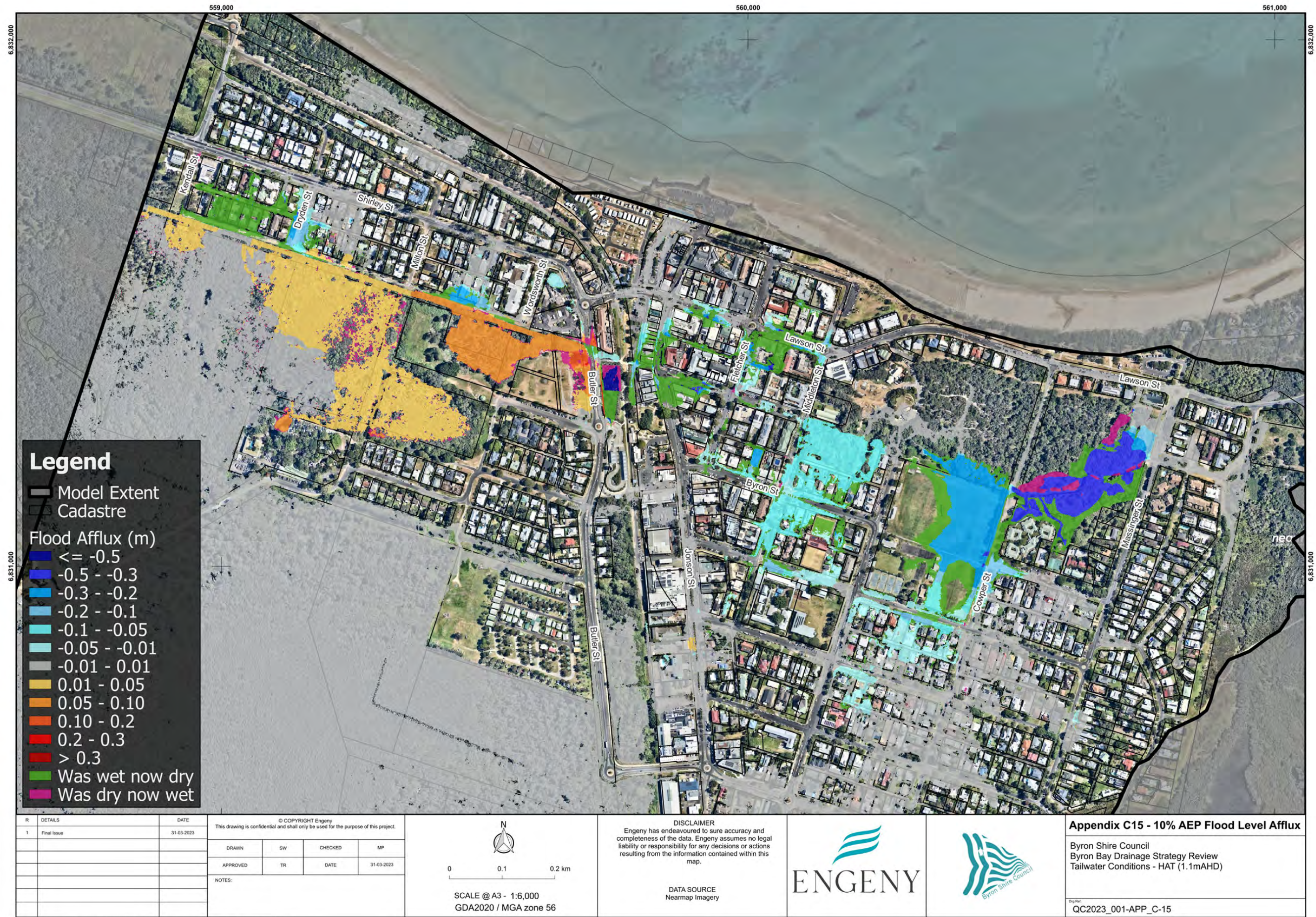




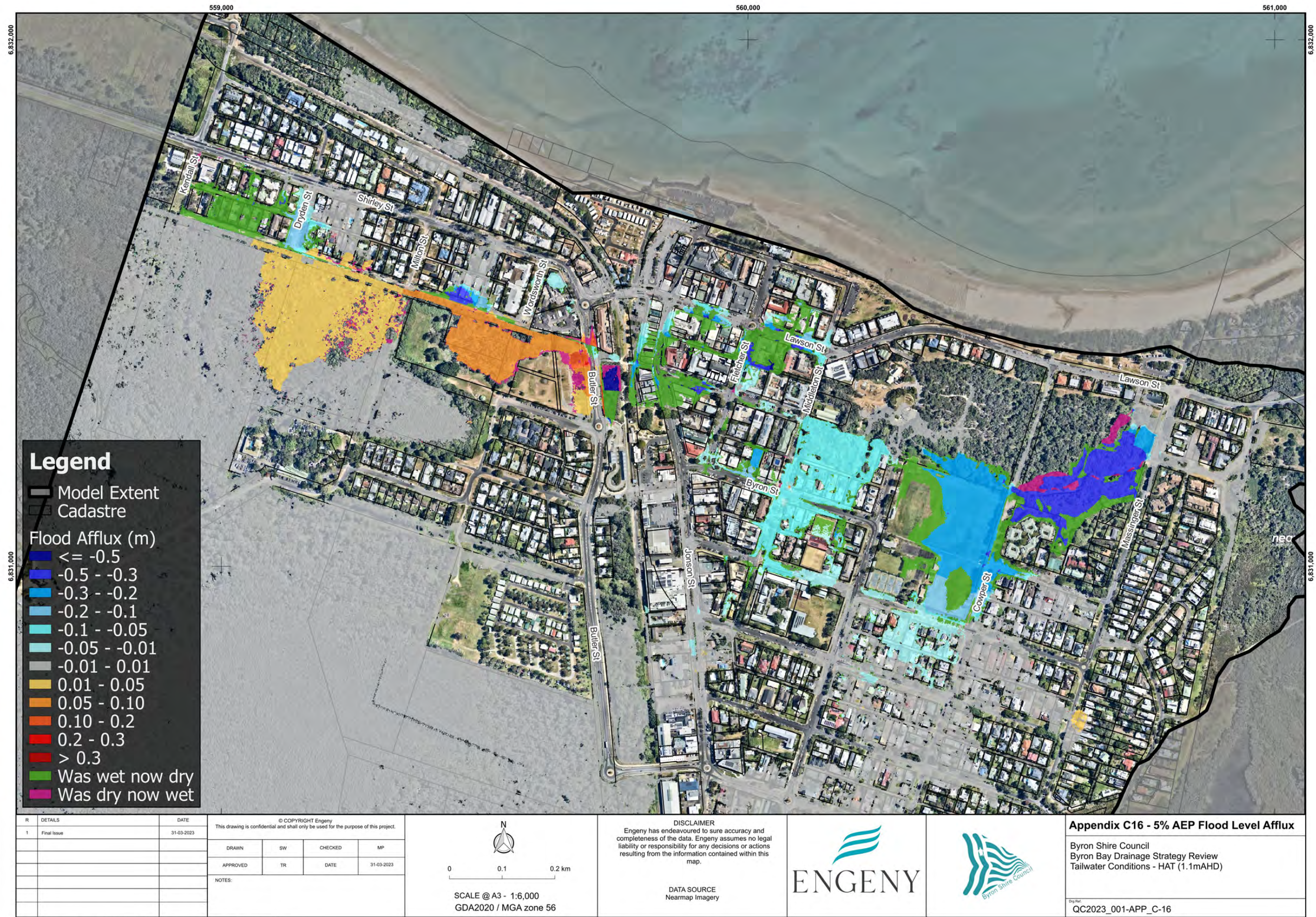




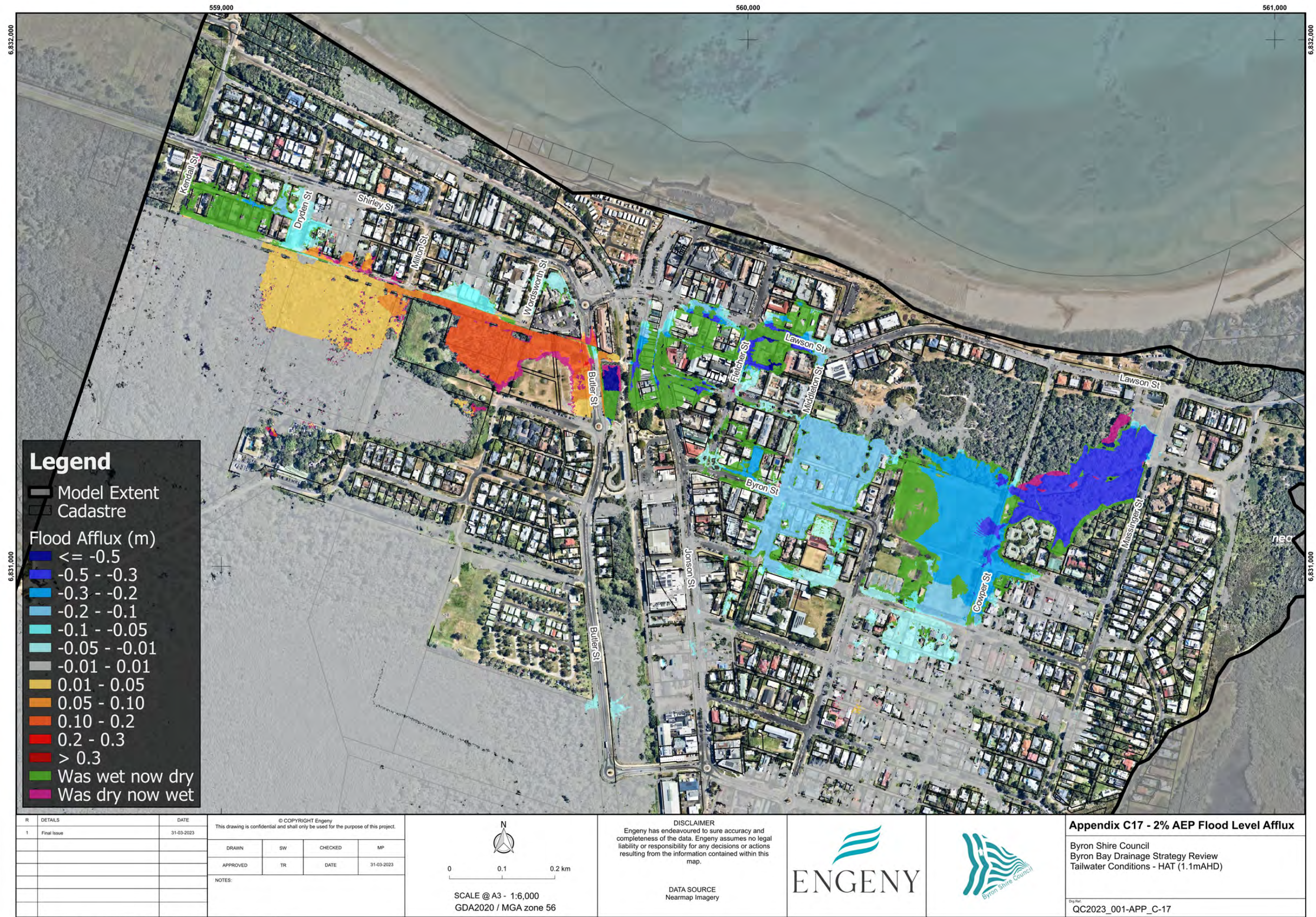




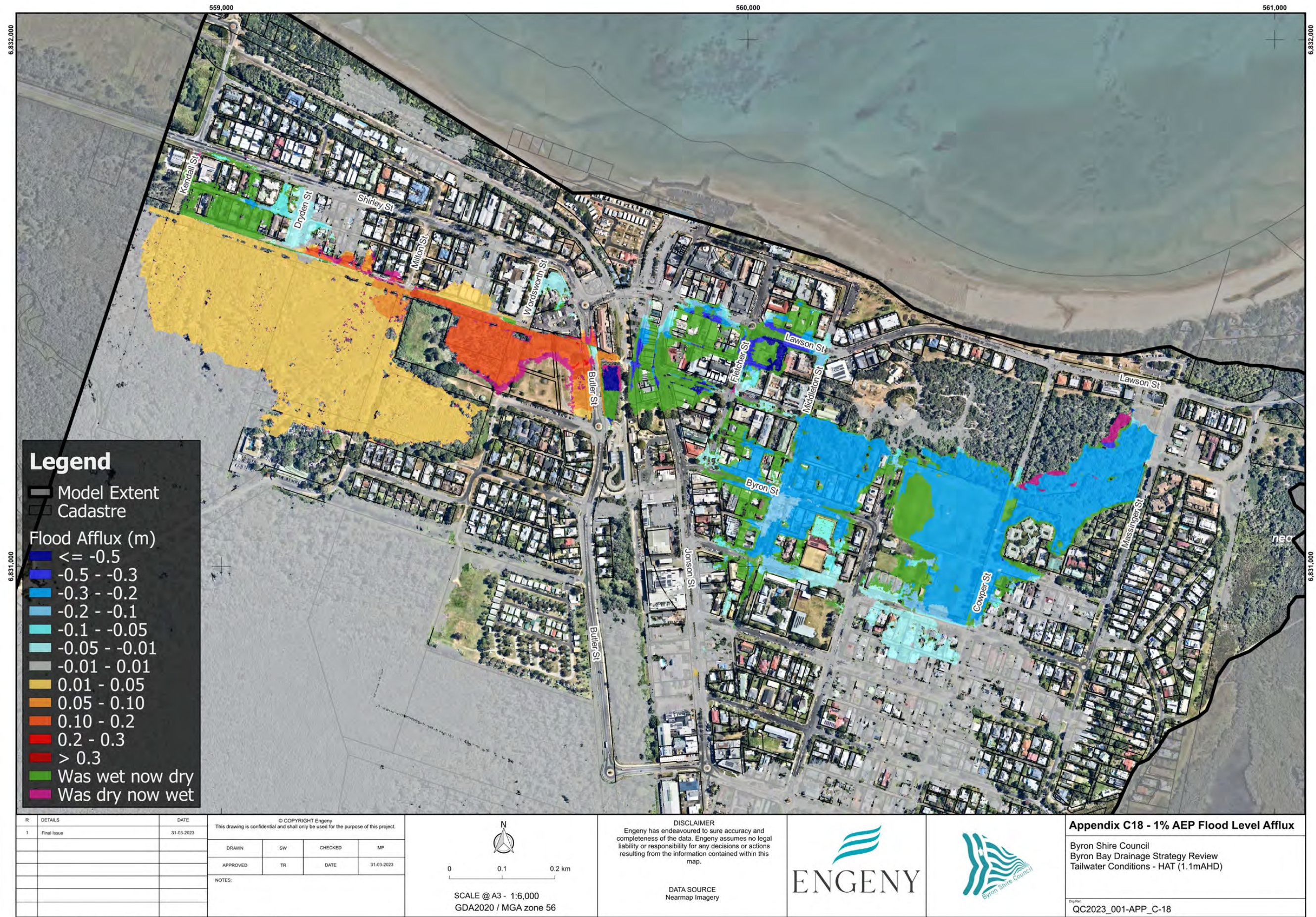










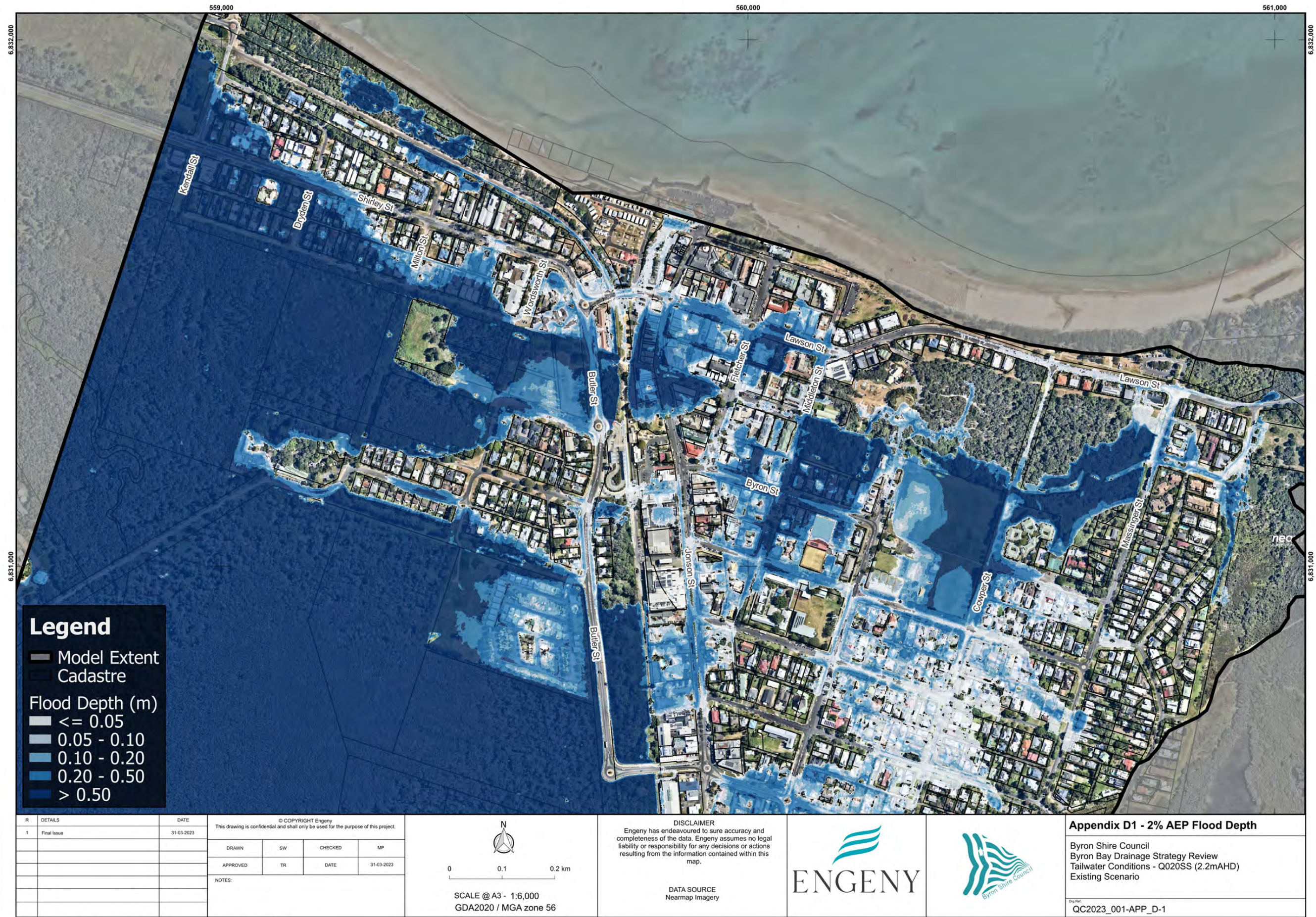




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## APPENDIX D: DESIGN EVENT RESULTS, 1:20 AEP STORM SURGE (2.2 M AHD)

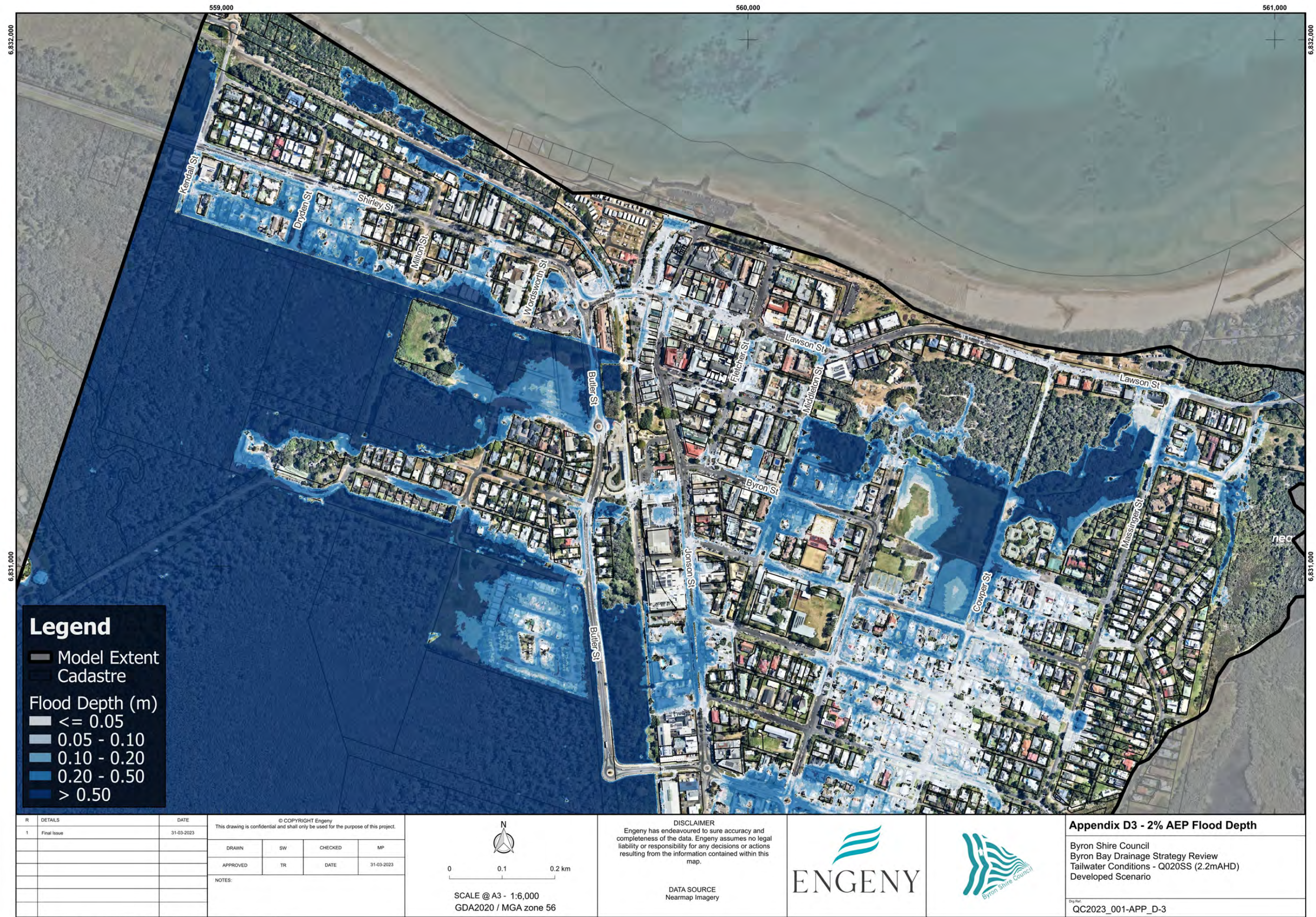




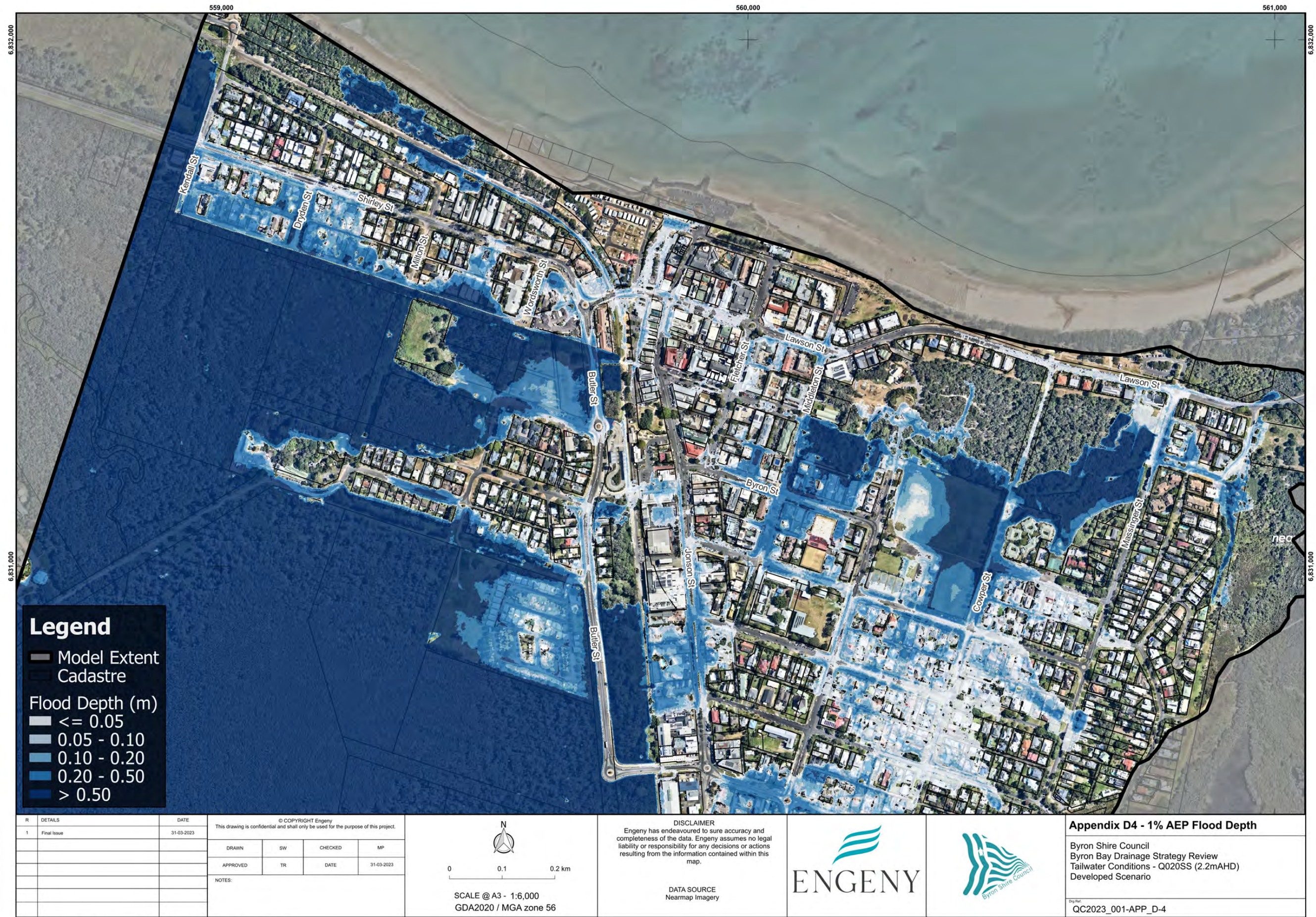




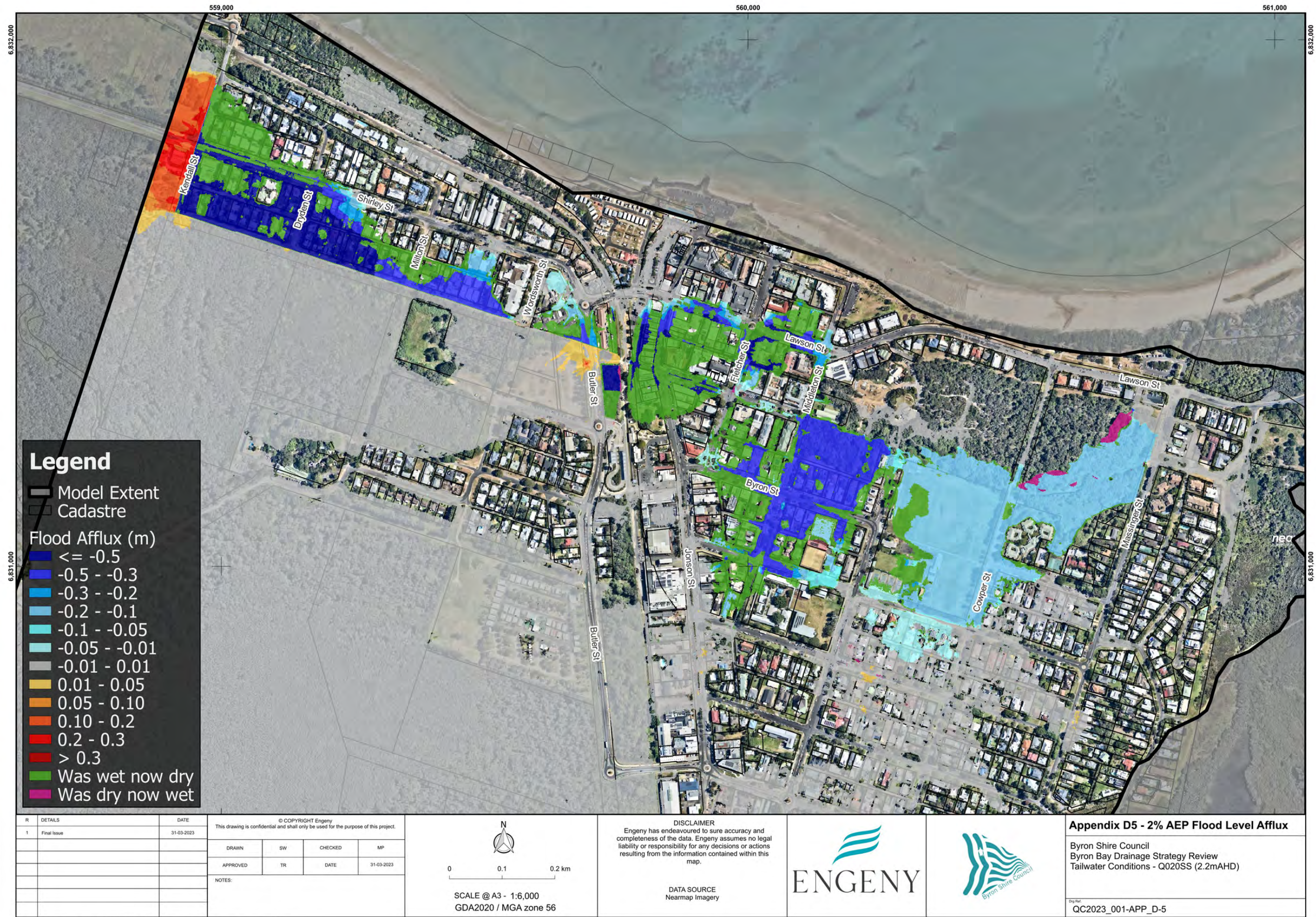




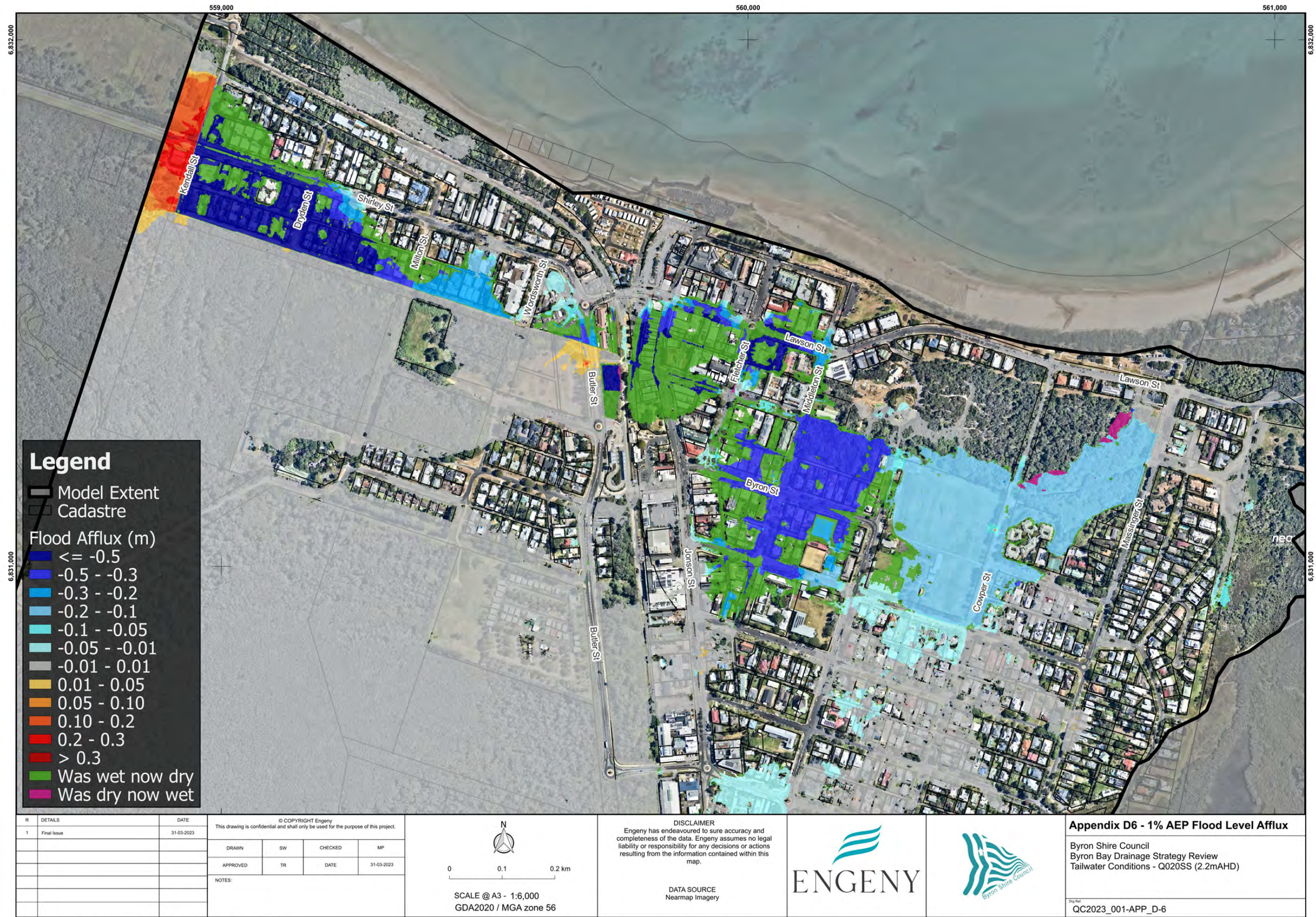














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## APPENDIX E: FLOOD MODELLING BASIS




# BYRON SHIRE COUNCIL

## STAFF REPORTS - SUSTAINABLE ENVIRONMENT AND ECONOMY

## 4.2 - ATTACHMENT 1

QC2003\_002-REG-601-E-Model BoD.xlsx

Hydrology Basis of Modelling			
Date	27/02/2023	Revision	A
Project Number	QC2003_002	Project Manager	TR
Project Name	BB Drainage	Project Director	MP
		Author	SW
		Client	Byron Shire Council
		Client Contact	Scott Moffett
			
Item No.	Parameter	Value	Comment
1	Catchments		
1.1	Topography Data	-	Completed using ELVIS 1m 2010 LIDAR
1.2	Catchment Extent	-	Extent provided in <i>Hydrology BOM Supporting Doc - 1.2 Catchment Extent</i>
1.3	Catchment History	-	The catchment configuration is based of the initial catchment extent used for the Belongil Creek XPRAFTS model developed by SMEC, but has been reduced to only catchments relevant to the study area, and further refined in the township. Refer to <i>Hydrology BOM Supporting Doc - 1.3 Catchment History - SMEC Catchment Extent</i>
2	Impervious Fraction		
2.1	Aerial Inspection	-	The impervious fraction value applied to each catchment is based of a visual inspection of the latest available aerial photography. This is inline with the approach of the original Belongil Creek Flood Study. This does not consider future land use value (i.e. significant increases in urban density).
2.2	AR&R Inputs		
2.3	AR&R Approach & NSW Specific Info	-	AR&R 2016 Guidelines have been utilised for the purposes of this assessment which is the latest industry standard for hydrological studies.  It is noted that NSW Office of Environment and Heritage has developed an independent guide to assists undertaking of studies within NSW in relation to AR&R 2016. It was observed during review of the AR&R 2016 update the a serious under-estimation of peak flow was occurring when using default AR&R data hub information, with CL being observed to be over-estimating losses. The specifics of NSW guideline is provided in <i>Hydrology BOM Supporting Doc 3.1 NSW Specific Info</i> , but the key output is the multiplication of the Datahub provided CL by 0.4, and the replacing of the IL and pre-burst with the Probability Neutral Burst Loss.
2.4	General Metadata	-	The relevant metadata is provided in <i>Hydrology BOM Supporting Doc 3.2 AR&amp;R 2016 Datahub MetaData</i> .
3	Coordinates	-28.6581, 153.6048	
3.1	IL, CL	27mm, 2.10mm/hr	Datahub output, as discussed above. Both IL and CL have been factored according to the relevant guidelines
3.2	Temporal Pattern Label	East Coast South	All temporal patterns for selected durations are to be assessed
3.3	Other Hydrological Inputs		
3.4	Areal Reduction Factors	N.A.	Whilst the entire modelled catchment area is approximately 10.26 km <sup>2</sup> , the areas of interest for this model (Byron Township) is far smaller than this, with each of the key drainage
3.5	Impervious IL, CL	1 mm, 0 mm/hr	
4	Pre-Burst Conditions	-	Pre-burst rainfall depths have not been inserted, instead the pre-burst values have been directly subtracted from the IL as per the Probability Neutral Burst Loss discussion in the NSW guidelines.
4.1	Modelled AEP Events	50pct, 20pct, 10pct, 5pct, 2pct & 1pct	Based on Scope of works and proposal documents
4.2	Modelled Durations	10min - 12hr	H058216,-28.6399,153.6358,Cape Byron ,Cape Byron Aws,NSW,NSW,,BRUNSWICK RIVER,202,,brunswick,,rain gauge,,data,,H058216-02,Preferred,,default,,
4.3	Historical Events	March 2022	The March 2022 rainfall event will be run through WBNM for input into the hydraulic model. The rainfall for this assessment will be sampled from gauge H058216 - Cape Byron. This gauge has 1 minute interval rainfall data from the 14 of February to the 11 of April.
4.4	Climate Change scenarios	None	No hydrological climate change scenarios included at this stage. CC scenarios proposed in hydraulic model (i.e. sea level rise tail water). No CC proposed to be included in the minor storm design event (10% AEP).
4.5	Modelling Software		
4.6	Software	-	Watershed Bounded Network Model (WBNM) & Storm Injector have been selected for the purposes of this assessment. WBNM is a software package designed for flood hydrograph studies on natural or urban catchments.
4.7	Pervious Lag	1.6	WBNM recommended value
5	Impervious Lag	0.1	WBNM recommended value
5.1	Routing Parameter	1	WBNM recommended value

Hydrology BOM




# BYRON SHIRE COUNCIL

## STAFF REPORTS - SUSTAINABLE ENVIRONMENT AND ECONOMY

## 4.2 - ATTACHMENT 1

QC2003\_002-REG-601-0A-Model BoD.xlsx

Hydraulic Basis of Modelling			
Date	QC2003_002	Revision	A
Project Number	BB Drainage	Project Manager	TR
Project Name		Project Director	MP
		Author	JH
		Client	Byron Shire Council
		Client Contact	Peter Brown / James Moffatt
			
Item No.	Parameter	Value	Comment
1	Model Inflows & Boundaries		
1.1	Inflows	Per Engeny validated WNBH hydrology model subcatchments	Urban catchments applied as 2d_sa regions directly to 1d domain stormwater pits (pit capture capacity included). Upstream urban catchments (external to model code) and rural catchments applied as 2d_sa regions to 2d domain.
1.2	Boundary Conditions	consistent with the BMT Flood Study Model (2015) and Sandhills Flood Impact Assessment (2023)	<p><b>Design:</b> HAT (1.1mAHD) for all events up to the 1% AEP.</p> <p><b>Sensitivity:</b> 5% AEP Storm Surge (2.2mAHD) for the 2% and 1% AEP, 1% AEP Storm Surge (2.6mAHD) for all events up to the 1% AEP.</p> <p><b>March 2022:</b> Time-varying based on Ewingsdale Bridge recording applied for Belongil Creek, HAT levels applied at Clarke Beach Outlet as no historical tidal data exists at this location.</p> <p>Creek opening conditions (1.0m AHD water level exceeded at Ewingsdale Bridge and 20mm forecast rainfall in 24 hours) are considered to be satisfied as the tailwater conditions exceed the level threshold upstream and the 63.2% AEP 25min storm exceeds the forecast rainfall condition. It is unlikely that the catchment will have a critical duration of less than 25mins, so both conditions are satisfied for all TUFLOW model simulations.</p>
2	2D Domain		
2.1	Model Extents	-	2d_code to cover township and contributing western catchments
2.2	Cell Size	1m	
2.3	Z-Shapes	-	Apply 2d_zsh thin lines to road centrelines and creek banks, extracted elevations from DEM. Inspect DEM, apply crest line if DEM "broken through" over culverts.
2.4	Initial Water Levels	-	Apply IWL based on static ocean tailwater levels.
2.5	Plot Output	-	2d_po applied at all cross drainage locations and key drainage locations to inform design
3	Hydraulic Roughness		
3.1	Road Reserve	0.025	Based on road reserve cadastre
3.2	Open Water Bodies & Ocean Outfall	0.03	
3.3	Low-Density Residential	0.15	Visual - Detached dwellings on single lots
3.4	Medium-Density Residential	0.2	Visual - Townhouses, units and apartments
3.5	Commercial	0.25	Visual - Shopping districts, industrial estates - commercial lots with large open space to be split off and set as open space materials
3.6	Open Space	0.04	Visual - Sports field, maintained grass, residential lots with no dwelling
3.7	Light or Scrubby Vegetation	0.06	Visual - sparse trees and veg cover
3.8	Medium Dense Vegetation	0.08	Visual - moderate tree cover and thick shrubbery
3.9	Swamp/Wetland	0.05	Visual - veg with standing water, mossy
3.10	Community Facilities	0.1	Education centres, sports facilities, etc.
4	1D Domain		
4.3	Pits	-	Represented as Q-type (specified depth-flow curve) if data available, otherwise 1x1m R-type.
4.4	Pipes	-	All pipe sizes included based on detail survey, Council data and BMT model. C and R type, standard height and width contraction coefficients and entrance and exit loss.
4.5	Culverts	-	No blockage for design. C and R type, standard height and width contraction coefficients and entrance and exit loss.
5	Model Validation		
5.1	Historical Event Validation	March 2022	Modelled flood levels will be compared to the 14 flood debris survey markers collected throughout the Byron Township following the March 2022 event.
6	Output		
6.1	Grids	Max	Produce for maximum only, utilising these commands: Store Maximums and Minimums == ON MAXIMUMS ONLY Maximums and Minimums Only For Grids == ON
6.2	Map Output Format	FLT, ASC	Raw TUFLOW model outputs stored as FLT, processed flood result grids stored as ASC
6.3	Map Output Interval	3600s	
6.4	Output Types	d, h, V, Z0, ZQRA, ZAEM1, TMax (0.0m, 0.3m & 0.5m), TDur (0.0m, 0.3m & 0.5m)	
6.5	Design Events	50%, 20%, 10%, 5%, 2% and 1% AEP	Simulate a range of storm durations (up to the 3-hour) and middle-loaded temporal pattern
6.6	Historical Events	March 2022	
6.7	Sensitivities	-	Sensitivity to alternate ocean levels will be tested for minor storm event design of pipe networks, if relevant.
6.8	TUFLOW Engine	2023-03-AA	
6.9	Solution Scheme/Solver	HPC GPU	

Hydraulic BOM



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## APPENDIX F: ENVIRONMENTAL CONSTRAINTS AND APPROVALS DESKTOP REVIEW





## MEMORANDUM

Project:	Byron Bay Drainage Upgrade Design	Date:	21 March 2023
To:	Byron Shire Council	From:	Engeny Australia Pty Ltd – Tim Randell
ATT:	Scott Moffett	CC:	Samantha Breslin
Subject:	Environmental and Cultural Heritage Risk Review for the Byron Bay Drainage Upgrade Design		

### INTRODUCTION

This desktop environmental and cultural heritage risk review has been prepared for Byron Shire Council (BSC) for the proposed Byron Bay Drainage Upgrade. The purpose of the desktop risk review is to identify environmental and/or culturally significant features within the footprint of the proposed drainage upgrade across the Byron Bay township. This information can be used by BSC, concurrently with the Drainage Strategy Review Report, to assist with determining the risk and likelihood of the proposed drainage upgrade triggering environmental permits and approvals. It will also inform the next phases of work which are to identify approvals pathways and commence on supporting studies or consultation required to commence approvals.

### PROJECT DESCRIPTION

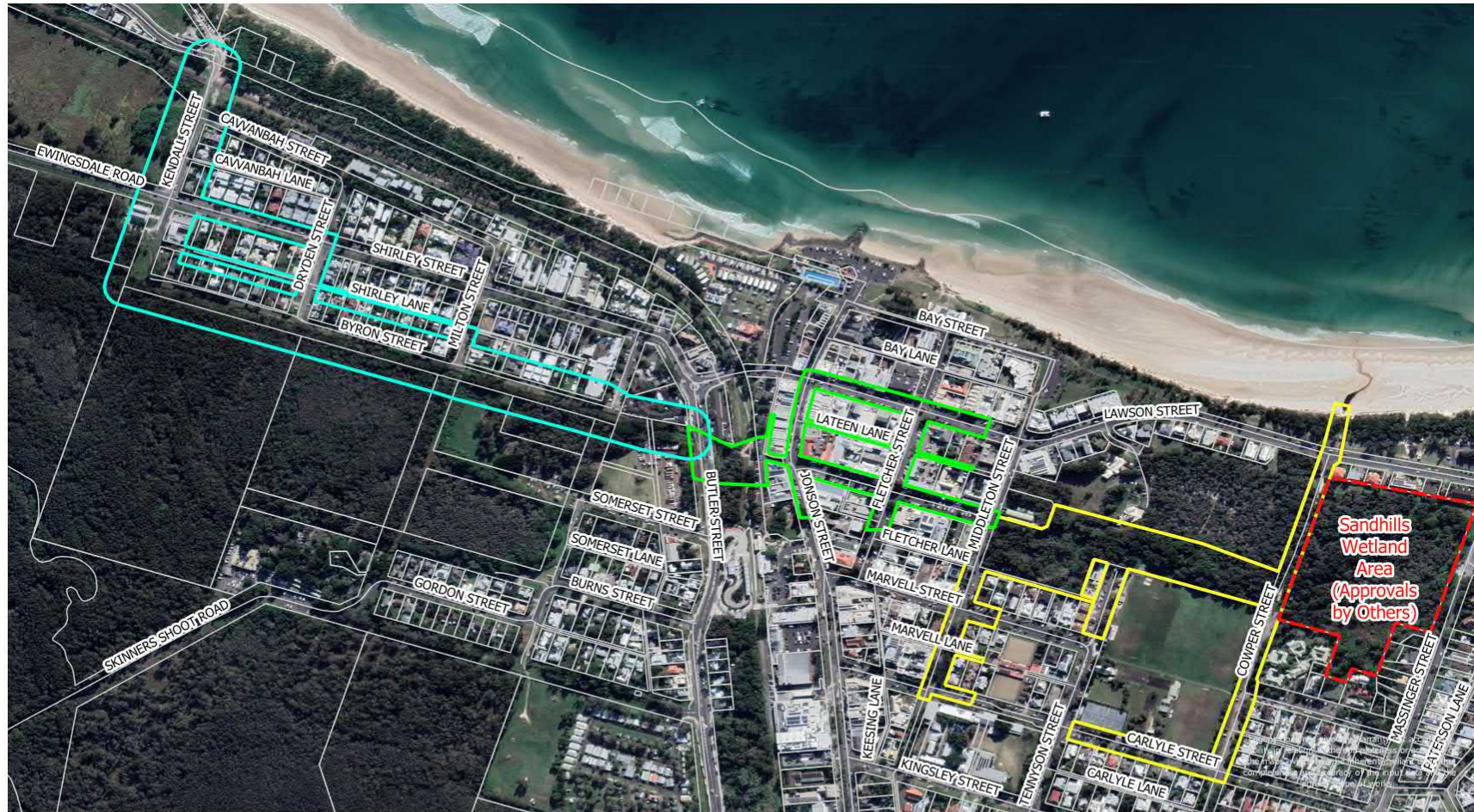
BSC currently intends to implement new drainage systems in the Byron Bay township to mitigate the adverse effects of flooding. These systems include the use of flood pumps (and associated power infrastructure), levees, an upgraded stormwater network and new ocean outfall pipe to capture and transfer runoff to the Belongil Creek estuary or Clarkes Beach outfall. The drainage upgrade project extends from Kendall Street on the east of the town near Belongil Creek to Cowper Street in the centre of the town. For the purposes of the study, it has been divided into the following areas (hereby referred to as the project areas):

- Shirley Street (area 1);
- Town Centre (area 2); and
- Middleton to Cowper Street (area 3).

Figure 1 outlines the extent of each area. Due to the potential for the project extent to vary and the proximity of environmental receptors, for the purpose of this assessment, a 30-metre buffer has been applied area the drainage project footprint area select locations to endeavour to capture potential direct and indirect impacts from the project.

This assessment does not cover the Sandhills Wetland area, which is understood to already have commenced the environmental assessment and approvals process. Refer also to 'Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay' (Planit Consulting, 2021) and 'BDAR – Sandhills Precinct, Byron Bay' (Planit Consulting, 2022).





**Figure 1**

Project Area Overview  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment

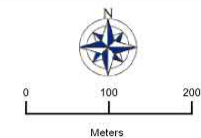


### Legend

- Cadastre
- Assessment Exclusion Zone

### Project Footprint

- Area 1 Boundary
- Area 2 Boundary
- Area 3 Boundary



Scale @ A4 1:5,500  
Date: 8/3/2023  
Drawn By: MB  
Project Number: QC2003\_002





## ENVIRONMENTAL AND CULTURAL HERITAGE REVIEW

The scope of this environmental and cultural heritage review is limited to the Area 1, Area 2, and Area 3 locations, hereby referred to as the 'project areas'. Findings of the review are outlined below.

### Commonwealth Matters

- The *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool (PMST) (Appendix A) was used to identify Matters of National Environmental Significance (MNES) that may, or are likely to occur, within a 5 km radius of the project areas. The following MNES were identified:
  - 62 migratory species (including birds, marine mammals, turtles, and sharks / manta rays);
  - 7 threatened ecological communities (TEC); and
  - 100 threatened species.

If the project works is assessed as having, or likely to have, a significant impact on a MNES, it must be referred to the Australian Government Department of Climate Change, Energy, the Environment and Water for a decision on whether assessment and approval is required under the EPBC Act. To inform this assessment an ecology survey is usually required to determine the presence/absence of MNES within the project areas. Following the ecology survey, a 'self-assessment' can be completed against the MNES significant impact criteria, for any areas requiring clearing as a result of the project. Area 3 has been surveyed for MNES during 2019 and 2022 assessments. Findings from these assessments are provided within 'Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay' (Planit Consulting, 2021) and 'BDAR – Sandhills Precinct, Byron Bay' (Planit Consulting, 2022).

- The Byron Bay Post Office, located adjacent to the southern portion of Area 2, is registered on the Commonwealth Heritage List (Figure 2).
- No places nominated to and included in the National Heritage List exist within the proximity of any of the project areas (Figure 2).
- All project areas are overlaid by the Cavanbah (Byron Bay) Arakwal Indigenous Land Use Agreement (ILUA) and the Bundjalung People of Byron Bay ILUA, the Bundjalung People of Byron Bay Native Title Determination, and have NTSCORP Limited as the Native Title Service Provider. Area 1 is also overlaid by the Bundjalung of Byron Bay Aboriginal Corporation (Arakwal) Registered Native Title Bodies Corporate (RNTBC) (Figure 3).

### State Matters

The following state matters were assessed for the project areas via desktop searches of online mapping services:

- Belongil Creek Catchment Issues Study (Draft Report) (Alluvium, 2019);
- Biodiversity Development Assessment Report (BDAR) – Sandhills Precinct, Byron Bay (Planit Consulting, 2022);
- BioNet Atlas of NSW Wildlife;
- ePlanning Spatial Viewer mapping;
- Essential Energy – Network Information Portal mapping;
- Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay (Planit Consulting, 2021); and
- The Central Resource for Sharing and Enabling Environmental Data (SEED) in NSW mapping.

### Land and Land Use

- Both Area 1 and Area 3 intersect with Council managed Crown Land under the *Crown Lands Act 1989* (NSW Government, 2023) (Figure 4). Area 1 intersects with three areas of Crown Land, with two of those areas being dedicated to public recreation (Byron Bay Beach and an unnamed reserve surrounding the Butler Street Reserve), and one of those areas being dedicated to environmental protection (Butler Street Reserve). Butler Street Reserve provides an important coastal wildlife corridor between Belongil estuary, Cumbebin Swamp, and eventually further west into *State Environmental Planning Policy (Coastal Management) (2018)* coastal wetlands. Area 2 exists within proximity to Crown Land dedicated to parking. Area 3 intersects with an area for public recreation. Information regarding





Crown Land has been obtained from online mapping resources, including Byron Shire Council and SEED NSW mapping. Crown Land areas within Area 3 are described in more detail in 'Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay' (Planit Consulting, 2021), including tenure associated with the Sandhills Wetland currently under ownership/management negotiation with BSC and the Crown.

- Under the State Environmental Planning Policy (SEPP), no State and Regional Development Subject Land (SEPP (Planning Systems), 2021), State Significant Development Sites (SEPP (Planning Systems), 2021), Major Infrastructure Corridors (SEPP, 2020), or State Significant Precincts (SEPP, 2005) exist within proximity to any of the project areas.
- Overhead powerlines owned and operated by Essential Energy exist along all streets within all project areas excluding Lateen Lane and Byron Street in Area 2.
- A railway corridor exists for the Casino to Murwillumbah Railway Line in the eastern portion of Area 1 and the northern portion of Area 2. The line has been out-of-service since 2004 (Arup, 2014), however Bryon Bay Railroad Company currently hold a non-exclusive licence from Transport for NSW to use the railway corridor and railway infrastructure, and are required to maintain both of the state-owned assets (Byron Bay Railroad Company, 2023).
- The following land zones are included within the footprint of each project area (Figure 5):
  - Area 1 intersects with the categories of national parks and nature reserves (associated with the Cumbebin Swamp Nature Reserve to the north of Kendall Street and the west of Byron Street), environmental conservation (to the north of Kendall Street), low density residential, medium density residential, rural landscape, deferred matters, infrastructure (railway infrastructure), and public recreation zones.
  - Area 2 includes infrastructure (rail infrastructure and carpark), public recreation, and local centre zones.
  - Area 3 includes low density residential, deferred matter, mixed use, and local centre zones.
- Land uses within the area include urban and industrial areas, agricultural areas, and high value ecological areas, including the Cumbebin Swamp Nature Reserve (Alluvium, 2019)

### Native Title and Cultural Heritage

- The Byron Bay Railway Station and Yard Group is listed on the State Heritage Register and intersects Area 2 (Figure 2). If works occur within the protection area of the Railway Station and Yard Group, approval may be required under the *Heritage Act (1977)*.
- No Aboriginal Places listed on the State Heritage Register exist within the vicinity of any of the project areas (Figure 3).
- An ILUA exists between the Budjalung people of Byron Bay and the NSW Government (Figure 3).

### Water

- None of the project areas intersect the Cape Byron Marine Park.
- All areas intersect a Coastal Wetland Proximity Area, however, only Areas 1 and 3 intersect a Coastal Wetland Area mapped under the *State Environmental Planning Policy (Coastal Management) 2018* (Figure 6). Information regarding the ground-truthing of the wetland within Area 3 is presented within 'Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay' (Planit Consulting, 2021) and 'BDAR – Sandhills Precinct, Byron Bay' (Planit Consulting, 2022).
- A high ecological value waterway and water dependent ecosystem area is overlaid by Area 1 and Area 3 (Figure 7). The area overlaying Area 1 is believed to be associated with Belongil Creek (located approximately 300 m from Area 1) and Cumbebin Swamp, which also intersects Area 1 (Figure 8). It is not clear from the online mapping why an area overlays Area 3. It should be noted that this area is not ground-truthed and it is recommended that field assessments and / or a comparison to local mapping be undertaken prior to any decisions being made (NSW Government, 2023).
- A mapped watercourse traverses through Area 3, however upon ground-truthing, it was determined this watercourse is a constructed drainage line (Planit Consulting, 2022).





## Flora and Fauna

- None of the project areas intersect a Littoral Rainforest or a Proximity Area for Littoral Rainforest mapped under the *State Environmental Planning Policy (Coastal Management) Act (2018)* (Figure 9). Ground-truthed data concerning Littoral Rainforest areas within Area 3 can be found within 'Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay' (Planit Consulting, 2021).
- The north-western and western extent of Area 1 overlays the Cumbebin Swamp Nature Reserve, a NSW National Parks and Wildlife Service (NPWS) Managed Estate (*National Parks and Wildlife Act (NPW Act) 1974*) (Figure 9). Areas of NPWS Estate include National Parks, Nature Reserves, Regional Parks, State Conservation Areas, Aboriginal Areas, Historic Sites and Karst Conservation Reserves.
- Six threatened fauna species and two threatened flora species listed as vulnerable under the *Biodiversity Conservation Act 2016* were recorded during targeted surveys within Area 3 (Planit Consulting, 2022). Further information can be found within 'BDAR – Sandhills Precinct, Byron Bay' (Planit Consulting, 2022).
- No areas are mapped as occurring within Koala Habitat Protection zones (*State Environmental Planning Policy (Koala Habitat Protection) 2019*), however, Koalas are regularly recorded within areas of suitable habitat (including Swamp Mahogany trees) within the Belongil catchment area (Alluvium, 2019). Koala preferred habitat is present within bushland sections of Area 3, between the Butler Street Reserve and the railway line in Area 2, and within the Butler Street Reserve and on Lot 1 on Deposited Land 781473 in Area 1 (Alluvium, 2019). Ground-truthed information regarding koala habitat within Area 3 is presented with 'Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay' (Planit Consulting, 2021) and 'BDAR – Sandhills Precinct, Byron Bay' (Planit Consulting, 2022).
- Biodiversity Areas were identified using the Biodiversity Values Map and Threshold Tool. Area 1 intersects with land mapped as containing threatened species or communities with potential for serious and irreversible impacts and wetlands under the *State Environmental Planning Policy (Coastal Management) Act (2018)*, while Area 3 intersects with land mapped as containing wetlands under the *State Environmental Planning Policy (Coastal Management) Act (2018)* (Figure 10).
- Multiple Saving our Species (SoS) Management Sites overlay the entirety of Byron Bay, including 49 flora and fungi sites, 2 fauna sites, but no threatened ecological community sites. The three project areas are included within each of these mapped sites. These areas overlay the northern coast of NSW, with fauna sites extending as far north as Tweed Heads and as far south as the Victorian state border. Flora sites typically encompass the area between Lennox Head, Nightcap National Park, and Crabbes Creek, however, some sites are noted to extend significantly further.
  - It should be noted that although an SoS Management Site for the Fleay's Barred Frog overlays all project areas, this species is unlikely to occur due to the lack of elevation in the Byron area (Alluvium, 2019).
- The BioNet Atlas of NSW Wildlife (NSW Government, 2023) was used to identify species and groups within the greater Byron Bay region (BioNet Atlas has a minimum search area of 100 km<sup>2</sup>). The BioNet Atlas Map is provided in Appendix B. Findings of the BioNet Atlas are outlined below, however, it should be noted that no category 3 sensitive species (within ~1 km rounded) or category 2 sensitive species (within ~10 km rounded) are mapped as occurring within any of the project areas. Also it should be noted that Area 3 has been surveyed in order to confirm the presence of species listed in the BioNet Atlas database. Information from this survey is presented within 'Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay' (Planit Consulting, 2021) and may supersede the desktop findings below.
  - No endangered populations were identified;
  - 37 threats were identified, including but not limited to, clearing of native vegetation, competition and habitat degradation by exotic animal species, invasion and establishment of exotic plant species, removal of dead wood and trees, and the loss of hollow-bearing trees;
  - 17 plant communities were identified;
  - No fungi species were identified;
  - 1,131 plant species were identified; and
  - 427 animal species were identified.
- The Belongil Creek catchment supports a diversity of vegetation community types typical of low-lying and seasonally inundated coastal areas of the NSW north coast, including but not limited to, coastal swamp forest dominated by Broad-leaf Paperbark, coastal swamp forest dominated by Swamp Oak, Littoral Rainforest, Saltmarsh, Mangrove Swamp, coastal dune mixed scrub, maritime grasslands on coastal dunes, and coastal freshwater lagoons (Alluvium, 2019). The clearing of native vegetation is regulated under the *Local Land Services (LLS) Act (2013)* and clearing of vegetation is regulated under the *State Environmental Planning Policy (Vegetation in Non-Rural*





*Areas) Act (2017).* Areas of High Environmental Value Vegetation relevant to the project areas are outlined in the Local Matters section of this report.

- Under the *Local Land Services Act (2013)*, Sensitive Regulated Land is mapped as occurring within the footprint of Area 1 and Area 3 (Figure 9). Within Area 1, Sensitive Regulated Land exists to the northern end of Byron Street, adjacent Ewingsdale Road, and to the west of the Byron Street and Milton Street intersection. In Area 3, Sensitive Regulated Land exists to the south of Lot 440 on Deposited Plan 800268. Sensitive regulated land is land where clearing is not permitted under the Land Management (Native Vegetation) Code 2018, and a limited range of allowable activities is permitted.
- Under the Department of Planning and Environment (DPE) Environmental Planning Instrument (EPI) (*Environmental Planning and Assessment Act 1979*), no Environmentally Sensitive Land is mapped as occurring within or in proximity to any of the project areas.
- Exotic flora species have been identified in the western road reserve of Byron Street and are likely to exist within other project areas (Alluvium, 2019). For Area 1 and 2, it is unknown what these species are and therefore whether these species are listed under the *Biosecurity Act (2015)*. Ground-truthed exotic vegetation data for Area 3 can be found within 'Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay' (Planit Consulting, 2021).
- There is the possibility of encountering contaminated leachate from an old landfill in Area 1, to the west of Byron Street in the vicinity of the Butler Street Reserve and the Butler Street drain (Alluvium, 2019). Any work potentially resulting in pollution must comply with the *Protection of the Environment Operation (POEO) Act (1997)*.

## Local Matters

Local environmental or culturally significant matters were identified using the Byron Shire Council online mapping tool. Constraints at a local scale include:

- All project areas intersect with Koala Habitat under the Byron Shire Council Koala Plan of Management. In Area 1, Lot 1 on Deposited Plan 781473 is mapped as Koala Habitat, likely due to the mapped Area of High Environmental Vegetation. In Area 2, the area to the north of Butler Street is mapped as Koala Habitat. In Area 3, Lot 440 on Deposited Plan 800268 and the surrounding area to the east and south is mapped as Koala Habitat, likely due to the mapped Coastal Wetland (*State Environmental Planning Policy (Coastal Management) Act 2018*).
- Area 1 also intersects the mapped West Byron Koala Management Precinct, to the north-west and west of Byron Street.
- The entirety of Byron Bay is mapped as existing within a Koala Planning Area.
- A Flying Fox Camp, overlaid by Area 1, exists to the west of the Byron and Wordsworth Street intersection (Alluvium, 2019). A second Flying Fox Camp, overlaid by Area 3, exists to the south of Middleton Street and to the west of Lot 440 on Deposited Land 800268 (Alluvium, 2019).
- All project areas intersect mapped Areas of High Environmental Value Vegetation. For each of the project areas, the following was identified:
  - In Area 1, Areas of High Environmental Value Vegetation are aligned with the unnamed Environmental Conservation area to the north of Byron Street, the Cumbebin Swamp Nature Reserve, Lot 1 on Deposited Land 781473, the eastern portion of Kendall Street, and the Butler Street Reserve and the surrounding unnamed reserve. High Value Vegetation within Area 1 consists of Swamp Oak, Paperbark Rainforest, Forest Red Gum, Coast Banksia, Wattle, Tuckeroo, and Brush Box. In Area 2, the Area of High Environmental Value Vegetation consists of Paperbark and is located within Lot 2 on Deposited Land 1289363, to the east of the Byron Motor Lodge Motel (Lot 60 on Deposited Plan 1290080). This is likely associated with the Butler Street Wetland, which lies between Butler Street and the railway line (Alluvium, 2019).
  - In Area 3, Areas of High Environmental Value Vegetation are associated with the bushland area between Middleton Street, Lawson Street, and Massinger Street. High Value Vegetation within Area 3 consists of Paperbark Rainforest, Swamp Oak, Swamp Mahogany, Paperbark, Coast Banksia, and Fernland. Ground-truthed vegetation data for Area 3 can be found within 'Preliminary Ecological Assessment – Sandhills Precinct, Byron Bay' (Planit Consulting, 2021) and 'BDAR – Sandhills Precinct, Byron Bay' (Planit Consulting, 2022).
- Under the Byron Shire Council Local Environmental Plan (2014), the following environmental aspects were identified:





- There is no significant probability of acid sulfate soils (ASS) occurring within the most easterly portions of each project area, and a low probability of ASS occurring in the most westerly portions of each project area. There is a high probability of ASS occurring less than 1-metre below ground level in a small portion of the western section of Area 1.
- All areas intersect a Coastal Erosion Hazard Area. Area 1 intersects Erosion Precinct 1 (immediate coastal hazard precinct), Erosion Precinct 2 (50-year precinct), and Erosion Precinct 3 (100-year precinct), Area 2 intersects Erosion Precinct 2 and 3, and Area 3 intersects Erosion Precinct 1 and 3.
- All project areas intersect Heritage Areas (Figure 2). These include both General Conservation Areas and General Items.
- Trees included on the Council Significant Tree Register are present in Area 1 along Shirley Street, and in the eastern section of Area 2 along Jonson Street. Trees on this register are protected through tree removal laws stated in the Council's Local Environmental Plan (LEP) and protected under Tree Preservation Orders (TPOs). If these trees are to be impacted during the project works, arborist assessment and Council approval will be required.

## SUMMARY AND FURTHER WORK

A summary table outlining the key environmental features and constraints is provided in Table 1. The following recommendations are made from the initial review:

- A variety of environmental features within the project areas may benefit from ground-truthing where there is a risk of triggering approvals or constraining the drainage upgrade works. Key examples include:
  - Project areas intercepting mapped high ecological value waterway and water dependent ecosystem areas should be ground-truthed to ensure that these environmental values are truly present.
  - Although no koala habitat protection zones are mapped within the project footprint, koala habitat and koala suitable trees have been identified within all project areas. As such, it is recommended that a field assessment be undertaken to establish the presence or absence of koalas within project areas.
  - Exotic vegetative species within project areas should be identified to allow compliance with the Biosecurity Act (2015) where required.
  - SoS Management Sites and the BioNet Atlas cover large areas of land, encompassing the entirety of all project areas. It is recommended the findings from these assessments be ground-truthed.
  - Undertake an ecology survey to ground-truth MNES within project areas that have not yet had an ecological assessment completed. Following this survey, complete a self-assessment of any areas requiring clearing against the MNES significant impact criteria.
- Review of the environmental risks/features/constraints provided in Table 1 should be undertaken (by the approvals consultant) to determine the relevant required approvals.





Table 1: Key Environmental Features and Constraints to Inform Assessment of Necessary Approvals

	Commonwealth	State	Local
All Areas	<ul style="list-style-type: none"> <li>Potential MNES under the EPBC Act</li> <li>Cultural Heritage including ILUA, Native Title Determination, and NRSORP</li> </ul>	<ul style="list-style-type: none"> <li>Essential Energy Power Corridors</li> <li>Land uses including urban and industrial areas, agricultural areas, and high value ecological areas (Cumbegin Swamp Nature Reserve).</li> <li>Cultural Heritage, including a State ILUA Agreement</li> <li>Koala Preferred Habitat and Koala sightings</li> <li>Coastal Proximity Areas under the SEPP (Coastal Management) Act 2018</li> <li>Saving our Species Management Sites</li> <li>Exotic vegetative species potentially under the Biosecurity Act 2015</li> </ul>	<ul style="list-style-type: none"> <li>Koala Habitat, West Byron Koala Management Precinct and Planning Area</li> <li>High Environmental Value Vegetation mapped using the criteria developed by the NSW Office of Environment and Heritage (now Department of Planning and Environment)</li> <li>Coastal Erosion Hazard under the Byron Shire LEP 2014</li> <li>Heritage Areas (General Conservation Areas and General Items) under the Byron Shire LEP 2014</li> </ul>
Area 1 (Shirley Street)	<ul style="list-style-type: none"> <li>Cultural Heritage including RNTBC</li> </ul>	<ul style="list-style-type: none"> <li>Crown Land including environmental protection areas (Butler Reserve) and public recreation areas (Byron Bay Beach and an unnamed reserve)</li> <li>Rail Corridor for the Casino to Murwillumbah Railway Line (Transport for NSW)</li> <li>Land zones including 'national parks and land reserves' (Cumbegin Swamp Nature Reserve) environmental conservation, low density residential, medium density residential, rural landscape, deferred matters, infrastructure (rail infrastructure), and public recreation zones.</li> <li>NPWS Estate under the NP&amp;W Act 1974 (Cumbegin Swamp Nature Reserve)</li> <li>Coastal Wetland Areas under the SEPP (Coastal Management) Act 2018</li> <li>Biodiversity Areas (wetlands and land containing threatened species or communities with potential for serious and irreversible impacts) under the SEPP (Coastal Management) Act 2018</li> <li>Potential for high ecological value waterway and water dependent ecosystem area.</li> <li>Sensitive Regulated Land under the LLS Act 2013</li> <li>Landfill Contamination under the POEO Act 1997</li> </ul>	<ul style="list-style-type: none"> <li>Flying Fox Habitat</li> <li>Potential Acid Sulfate Soils under the Byron Shire LEP 2014</li> <li>Significant Trees under the Byron Shire LEP 2014</li> </ul>
Area 2 (Town Centre)	<ul style="list-style-type: none"> <li>Byron Bay Post Office registered on the Commonwealth Heritage List</li> </ul>	<ul style="list-style-type: none"> <li>Rail Corridor for the Casino to Murwillumbah Railway Line (Transport for NSW)</li> <li>Land zones including infrastructure (rail infrastructure and carpark), public recreation, and local centre zones.</li> <li>Byron Bay Railway Station and Yard Group is listed on the State Heritage Register.</li> </ul>	<ul style="list-style-type: none"> <li>Significant Trees under the Byron Shire LEP 2014</li> </ul>
Area 3 (Cowper Street)		<ul style="list-style-type: none"> <li>Crown Land for public recreation</li> <li>Coastal Wetlands Area</li> <li>Land zones including low density residential, deferred matter, mixed use, and local centre zones.</li> <li>Coastal Wetlands Area under the SEPP (Coastal Management) Act 2018</li> <li>Potential for high ecological value waterway and water dependent ecosystem area.</li> <li>Biodiversity Areas (land containing wetlands) under the SEPP (Coastal Management) Act 2018</li> <li>Sensitive Regulated Land under the LLS Act 2013</li> <li>Threatened flora and fauna species under the Biodiversity Conservation Act 2016</li> </ul>	<ul style="list-style-type: none"> <li>Flying Fox Habitat</li> </ul>





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Planit Consulting. (2021). *Preliminary Ecological Assessment - Sandhills Precinct, Byron Bay*.

Planit Consulting. (2022). *Biodiversity Development Assessment Report (BDAR) - Sandhills Precinct, Byron Bay*.





## DISCLAIMER

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FIGURES





**Figure 2**

Heritage Sites  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment



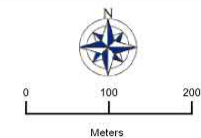
### Legend

#### Project Footprint

- Area 1 Boundary
- Area 2 Boundary
- Area 3 Boundary

#### Heritage Sites

- Local Heritage Site
- State Heritage Site
- National Heritage Site
- Commonwealth Heritage Site



Scale @ A4 1:5,500  
Date: 2/3/2023  
Drawn By: MB  
Project Number: QC2003\_002





**Figure 3**

Cultural Heritage Areas  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment



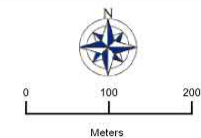
### Legend

#### Project Footprint

- Area 1 Boundary
- Area 2 Boundary
- Area 3 Boundary

#### Cultural Heritage

- Registered Native Title Bodies Corporate (RNTBCs)
- Indigenous Land Use Agreement (ILUA)
- Native Title



Scale @ A4 1:5,500  
Date: 2/3/2023  
Drawn By: MB  
Project Number: QC2003\_002





**Figure 4**

Crown Land Reserves  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment



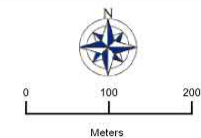
### Legend

#### Project Footprint

- Area 1 Boundary
- Area 2 Boundary
- Area 3 Boundary

#### Crown Land Reserves

- Environmental Protection
- Kindergarten
- Parking
- Public Recreation
- Senior Citizen's Centre



Scale @ A4 1:5,500  
Date: 2/3/2023  
Drawn By: MB  
Project Number: QC2003\_002





**Figure 5**

Land Zoning  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment



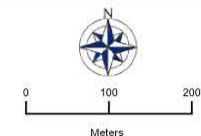
### Legend

**Project Footprint**  
Area 1 Boundary  
Area 2 Boundary  
Area 3 Boundary  
Railway Corridor

**Land Zoning**  
Deferred Matter  
Environmental Conservation  
Environmental Management  
Infrastructure

Local Centre  
Low Density Residential  
Medium Density Residential  
Mixed Use  
National Parks and Nature Reserves  
Natural Waterways

Private Recreation  
Public Recreation  
Rural Landscape  
Tourist



Scale @ A4 1:5,500  
Date: 2/3/2023  
Drawn By: MB  
Project Number: QC2003\_002



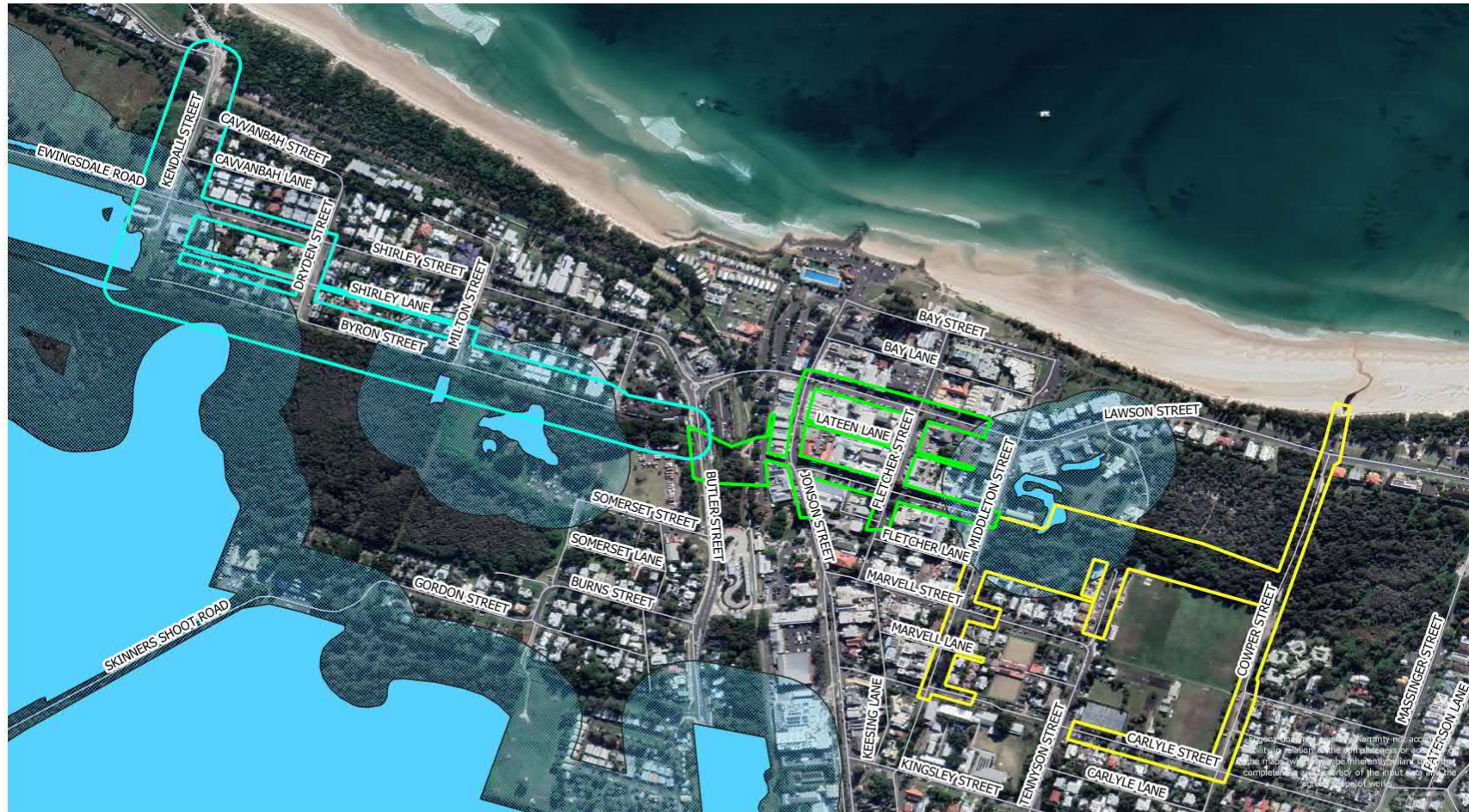


Figure 6

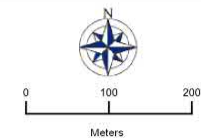
Coastal Wetlands and Proximity Areas  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment



Legend

Project Footprint  
Area 1 Boundary  
Area 2 Boundary  
Area 3 Boundary

Coastal Wetlands  
Coastal Wetlands  
Coastal Wetlands Proximity Area



Scale @ A4 1:5,500  
Date: 2/3/2023  
Drawn By: MB  
Project Number: QC2003\_002



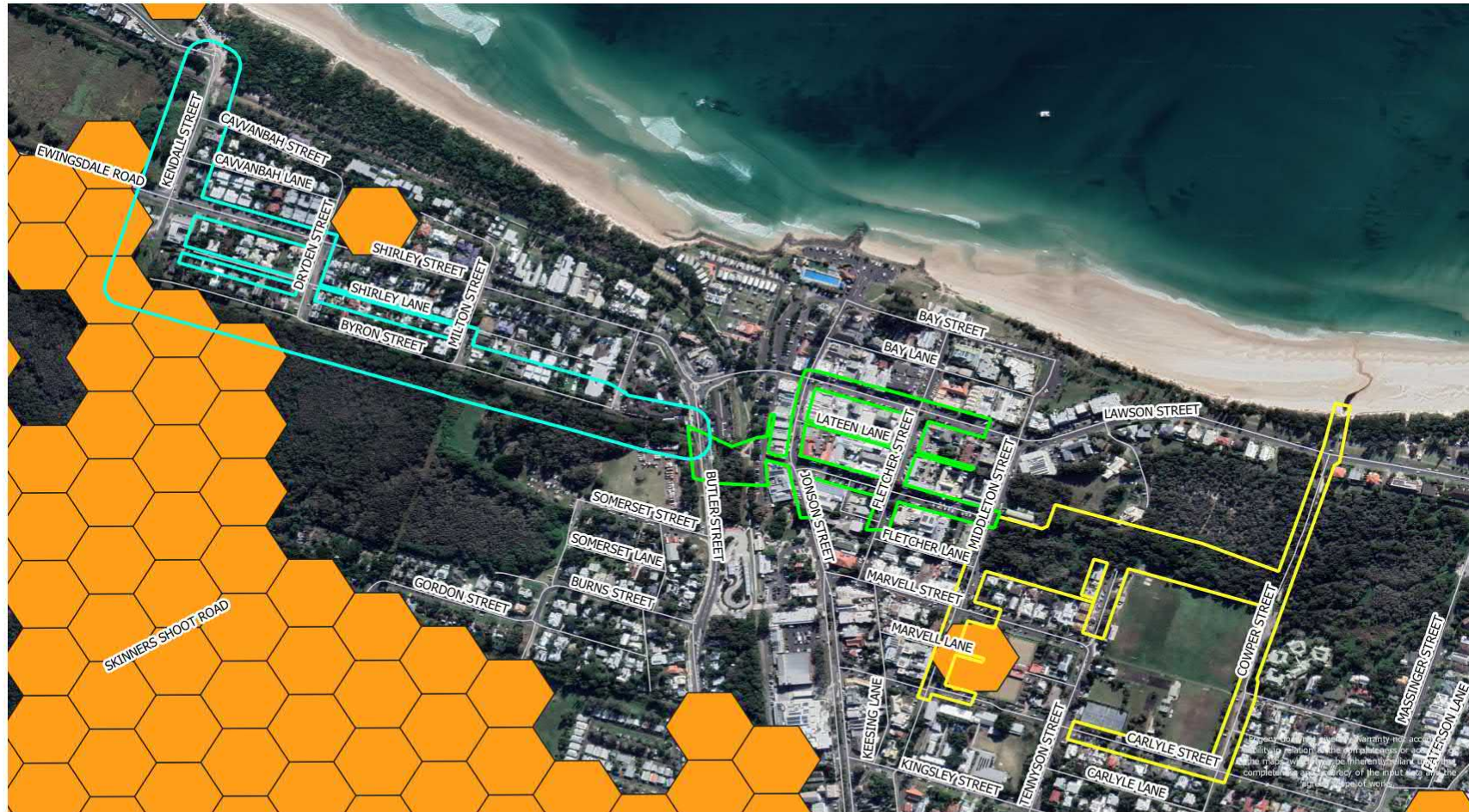


Figure 7

High Ecological Value Waterways and Water Dependent Ecosystems  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment

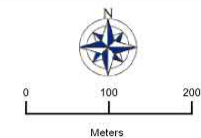


Legend

Project Footprint

- Area 1 Boundary
- Area 2 Boundary
- Area 3 Boundary

- High Ecological Value Waterways and Water Dependent Ecosystems



Scale @ A4 1:5,500  
Date: 2/3/2023  
Drawn By: MB  
Project Number: QC2003\_002





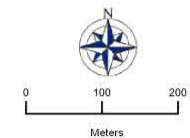
**Figure 8**  
Mapped Wetlands and Watercourses  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment



**Legend**

**Project Footprint**

- Area 1 Boundary
- Area 2 Boundary
- Area 3 Boundary
- Named Watercourse
- Wetlands



Scale @ A4 1:6,000  
Date: 2/3/2023  
Drawn By: MB  
Project Number: QC2003\_002





**Figure 9**

Flora Mapping  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment



### Legend

#### Project Footprint

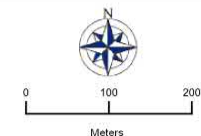
- Area 1 Boundary
- Area 2 Boundary
- Area 3 Boundary

#### Littoral Rainforest

- Littoral Rainforest
- Littoral Rainforest Proximity Area
- NPWS Managed Land

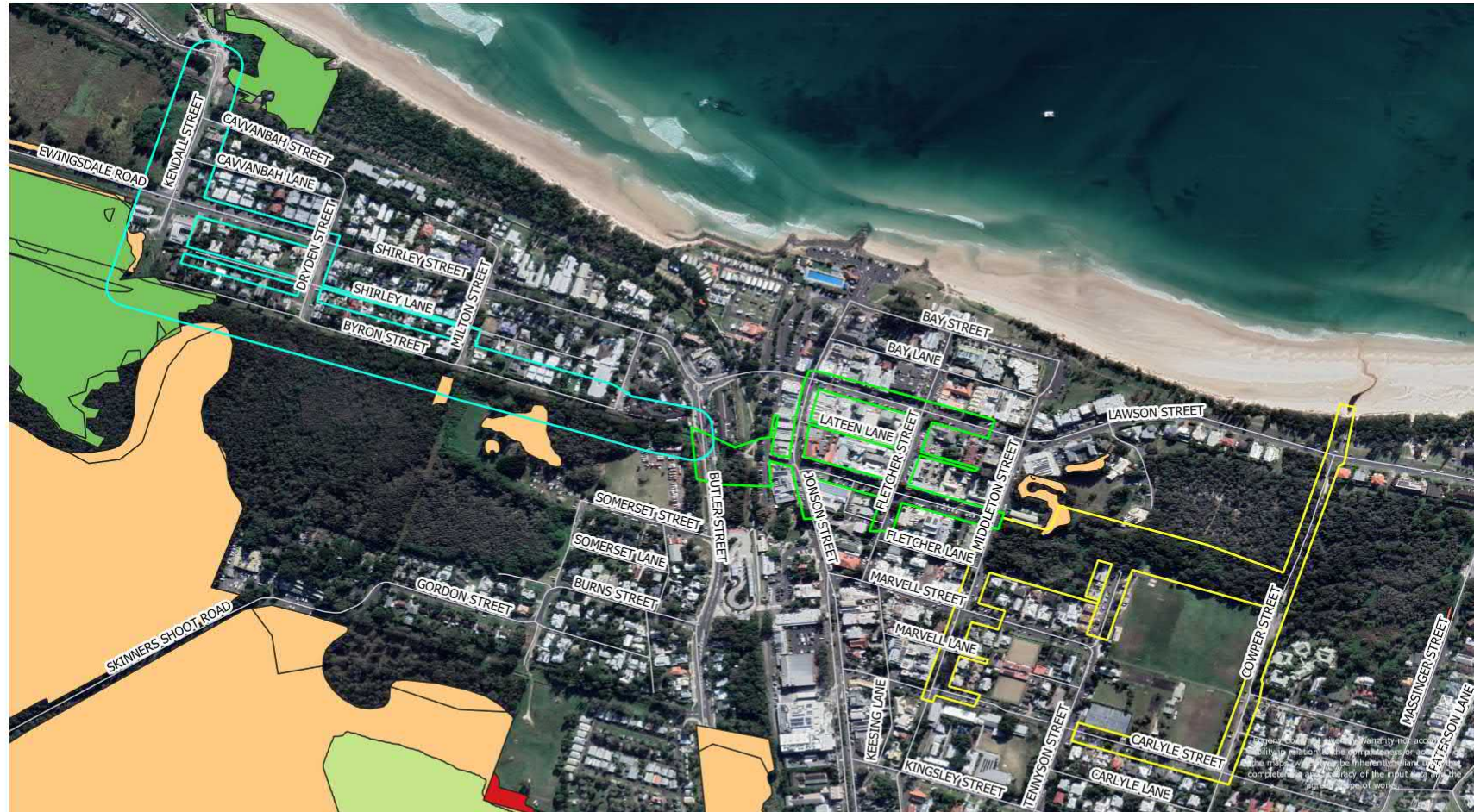
#### Transitional Native Vegetation Regulatory (NVR)

- Vulnerable Regulated Land
- Sensitive Regulated Land
- Sensitive and Vulnerable Regulated Lands Areas of Overlap



Scale @ A4 1:5,500  
Date: 2/3/2023  
Drawn By: MB  
Project Number: QC2003\_002





**Figure 10**

Biodiversity Areas  
Byron Bay Drainage Upgrade  
Environmental and Cultural Heritage Risk Assessment



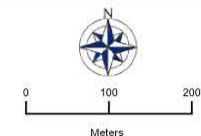
### Legend

#### Project Footprint

- ▬ Area 1 Boundary
- ▬ Area 2 Boundary
- ▬ Area 3 Boundary

#### Biodiversity Values

- Biodiverse riparian land
- Coastal Management Act - Littoral Rainforest
- Coastal Management Act - Wetlands
- Identified Rainforest
- Land identified by Environment Agency Head
- Threatened species or communities with potential for serious and irreversible impacts



Scale @ A4 1:5,500  
Date: 2/3/2023  
Drawn By: MB  
Project Number: QC2003\_002



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APPENDIX A: PROTECTED MATTERS SEARCH TOOL  
(PMST) RESULTS





Australian Government

Department of Climate Change, Energy,  
the Environment and Water

# EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 22-Feb-2023

[Summary](#)

[Details](#)

[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

[Acknowledgements](#)



## Summary

### Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

<a href="#">World Heritage Properties:</a>	None
<a href="#">National Heritage Places:</a>	None
<a href="#">Wetlands of International Importance (Ramsar)</a>	None
<a href="#">Great Barrier Reef Marine Park:</a>	None
<a href="#">Commonwealth Marine Area:</a>	None
<a href="#">Listed Threatened Ecological Communities:</a>	7
<a href="#">Listed Threatened Species:</a>	100
<a href="#">Listed Migratory Species:</a>	62

### Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at <https://www.dcceew.gov.au/parks-heritage/heritage>

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

<a href="#">Commonwealth Lands:</a>	3
<a href="#">Commonwealth Heritage Places:</a>	2
<a href="#">Listed Marine Species:</a>	89
<a href="#">Whales and Other Cetaceans:</a>	14
<a href="#">Critical Habitats:</a>	None
<a href="#">Commonwealth Reserves Terrestrial:</a>	None
<a href="#">Australian Marine Parks:</a>	None
<a href="#">Habitat Critical to the Survival of Marine Turtles:</a>	None

### Extra Information

This part of the report provides information that may also be relevant to the area you have

<a href="#">State and Territory Reserves:</a>	7
<a href="#">Regional Forest Agreements:</a>	1
<a href="#">Nationally Important Wetlands:</a>	None
<a href="#">EPBC Act Referrals:</a>	8
<a href="#">Key Ecological Features (Marine):</a>	None
<a href="#">Biologically Important Areas:</a>	5
<a href="#">Bioregional Assessments:</a>	1
<a href="#">Geological and Bioregional Assessments:</a>	None



## Details

### Matters of National Environmental Significance

#### Listed Threatened Ecological Communities

[\[ Resource Information \]](#)

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community</a>	Endangered	Community likely to occur within area	In feature area
<a href="#">Coastal Swamp Sclerophyll Forest of New South Wales and South East Queensland</a>	Endangered	Community may occur within area	In feature area
<a href="#">Grey box-grey gum wet forest of subtropical eastern Australia</a>	Endangered	Community may occur within area	In buffer area only
<a href="#">Littoral Rainforest and Coastal Vine Thickets of Eastern Australia</a>	Critically Endangered	Community likely to occur within area	In feature area
<a href="#">Lowland Rainforest of Subtropical Australia</a>	Critically Endangered	Community likely to occur within area	In buffer area only
<a href="#">Subtropical and Temperate Coastal Saltmarsh</a>	Vulnerable	Community likely to occur within area	In buffer area only
<a href="#">Subtropical eucalypt floodplain forest and woodland of the New South Wales North Coast and South East Queensland bioregions</a>	Endangered	Community likely to occur within area	In feature area

#### Listed Threatened Species

[\[ Resource Information \]](#)

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.

Number is the current name ID.

Scientific Name	Threatened Category	Presence Text	Buffer Status
<b>BIRD</b>			
<a href="#">Anthochaera phrygia</a> Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Botaurus poiciloptilus</a> Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Calidris canutus</a> Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Calidris ferruginea</a> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Calyptorhynchus lathami lathami</a> South-eastern Glossy Black-Cockatoo [67036]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Charadrius leschenaultii</a> Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Cyclopsitta diophthalma coxeni</a> Coxen's Fig-Parrot [59714]	Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#">Diomedea antipodensis</a> Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Diomedea antipodensis gibsoni</a> Gibson's Albatross [82270]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Diomedea epomophora</a> Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Diomedea exulans</a> Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Erythrorchis radiatus</a> Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Falco hypoleucos</a> Grey Falcon [929]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Fregetta grallaria grallaria</a> White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Hirundapus caudacutus</a> White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Lathamus discolor</a> Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#">Limosa lapponica baueri</a> Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Macronectes giganteus</a> Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Macronectes halli</a> Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Numenius madagascariensis</a> Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Pachyptila turtur subantarctica</a> Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Phoebastria fusca</a> Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Pterodroma leucoptera leucoptera</a> Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Pterodroma neglecta neglecta</a> Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area	In feature area
<a href="#">Rostratula australis</a> Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Sternula nereis nereis</a> Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche carteri</a> Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche cauta</a> Shy Albatross [89224]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche impavida</a> Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche melanophris</a> Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche salvini</a> Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche steadi</a> White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area	In feature area
<b>FISH</b>			
<a href="#">Epinephelus daemeli</a> Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Hippocampus whitei</a> White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]	Endangered	Species or species habitat likely to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Seriolella brama</a> Blue Warehou [69374]	Conservation Dependent	Species or species habitat known to occur within area	In feature area
<a href="#">Thunnus maccoyii</a> Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area	In feature area
<b>FROG</b>			
<a href="#">Litoria olongburensis</a> Wallum Sedge Frog [1821]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Mixophyes fleayi</a> Fleay's Frog [25960]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Mixophyes iteratus</a> Giant Barred Frog, Southern Barred Frog [1944]	Vulnerable	Species or species habitat likely to occur within area	In buffer area only
<b>INSECT</b>			
<a href="#">Argynnis hyperbius inconstans</a> Australian Fritillary [88056]	Critically Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Phyllodes imperialis smithersi</a> Pink Underwing Moth [86084]	Endangered	Breeding may occur within area	In feature area
<b>MAMMAL</b>			
<a href="#">Balaenoptera borealis</a> Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area	In buffer area only
<a href="#">Balaenoptera musculus</a> Blue Whale [36]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Balaenoptera physalus</a> Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area	In buffer area only



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#"><u>Chalinolobus dwyeri</u></a>			
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#"><u>Dasyurus maculatus maculatus (SE mainland population)</u></a>			
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#"><u>Eubalaena australis</u></a>			
Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#"><u>Petaurus australis australis</u></a>			
Yellow-bellied Glider (south-eastern) [87600]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#"><u>Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)</u></a>			
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#"><u>Potorous tridactylus tridactylus</u></a>			
Long-nosed Potoroo (northern) [66645]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#"><u>Pseudomys novaehollandiae</u></a>			
New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#"><u>Pteropus poliocephalus</u></a>			
Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area	In feature area
<a href="#"><u>Xeromys myoides</u></a>			
Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area	In feature area
<b>PLANT</b>			
<a href="#"><u>Acronychia littoralis</u></a>			
Scented Acronychia [8582]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#"><u>Allocasuarina thalassoscopica</u></a>			
[21927]	Endangered	Species or species habitat known to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Arthraxon hispidus</a> Hairy-joint Grass [9338]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Baloghia marmorata</a> Marbled Balogia, Jointed Baloghia [8463]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Bosistoa transversa</a> Three-leaved Bosistoa, Yellow Satinheart [16091]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Bulbophyllum globuliforme</a> Miniature Moss-orchid, Hoop Pine Orchid [6649]	Vulnerable	Species or species habitat may occur within area	In buffer area only
<a href="#">Cryptocarya foetida</a> Stinking Cryptocarya, Stinking Laurel [11976]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Cryptostylis hunteriana</a> Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Cynanchum elegans</a> White-flowered Wax Plant [12533]	Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#">Davidsonia jerseyana</a> Davidson's Plum [67219]	Endangered	Species or species habitat likely to occur within area	In buffer area only
<a href="#">Davidsonia johnsonii</a> Smooth Davidsonia, Smooth Davidson's Plum, Small-leaved Davidson's Plum [67178]	Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#">Diploglottis campbellii</a> Small-leaved Tamarind [21484]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Elaeocarpus williamsianus</a> Hairy Quandong [8956]	Endangered	Species or species habitat known to occur within area	In buffer area only



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Endiandra floydii</a> Floyd's Walnut, Crystal Creek Walnut [52955]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Endiandra hayesii</a> Rusty Rose Walnut, Velvet Laurel [13866]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Floydia praealta</a> Ball Nut, Possum Nut, Big Nut, Beefwood [15762]	Vulnerable	Species or species habitat known to occur within area	In buffer area only
<a href="#">Fontainea australis</a> Southern Fontainea [24037]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Gossia fragrantissima</a> Sweet Myrtle, Small-leaved Myrtle [78867]	Endangered	Species or species habitat may occur within area	In buffer area only
<a href="#">Hicksbeachia pinnatifolia</a> Monkey Nut, Bopple Nut, Red Bopple, Red Bopple Nut, Red Nut, Beef Nut, Red Apple Nut, Red Boppel Nut, Ivory Silky Oak [21189]	Vulnerable	Species or species habitat likely to occur within area	In buffer area only
<a href="#">Leichhardtia longiloba listed as Marsdenia longiloba</a> Clear Milkvine [91911]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Macadamia integrifolia</a> Macadamia Nut, Queensland Nut Tree, Smooth-shelled Macadamia, Bush Nut, Nut Oak [7326]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Macadamia tetraphylla</a> Rough-shelled Bush Nut, Macadamia Nut, Rough-shelled Macadamia, Rough-leaved Queensland Nut [6581]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Ochrosia moorei</a> Southern Ochrosia [11350]	Endangered	Species or species habitat likely to occur within area	In buffer area only
<a href="#">Owenia cepiodora</a> Onionwood, Bog Onion, Onion Cedar [11344]	Vulnerable	Species or species habitat likely to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Phaius australis</a> Lesser Swamp-orchid [5872]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Randia moorei</a> Spiny Gardenia [10577]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Rhodamnia rubescens</a> Scrub Turpentine, Brown Malletwood [15763]	Critically Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Rhodomyrtus psidioides</a> Native Guava [19162]	Critically Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Symplocos baeuerlenii</a> Small-leaved Hazelwood, Shrubby Hazelwood [19010]	Vulnerable	Species or species habitat may occur within area	In buffer area only
<a href="#">Syzygium hodgkinsoniae</a> Smooth-bark Rose Apple, Red Lilly Pilly [3539]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Syzygium moorei</a> Rose Apple, Coolamon, Robby, Durobby, Watermelon Tree, Coolamon Rose Apple [12284]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Thesium australe</a> Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Vincetoxicum woollsii listed as Tylophora woollsii</a> [40080]	Endangered	Species or species habitat may occur within area	In feature area
<b>REPTILE</b>			
<a href="#">Caretta caretta</a> Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area	In feature area
<a href="#">Chelonia mydas</a> Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#"><u>Coeranoscincus reticulatus</u></a>			
Three-toed Snake-tooth Skink [59628]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#"><u>Delma torquata</u></a>			
Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area	In buffer area only
<a href="#"><u>Dermochelys coriacea</u></a>			
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Congregation or aggregation known to occur within area	In feature area
<a href="#"><u>Eretmochelys imbricata</u></a>			
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#"><u>Lepidochelys olivacea</u></a>			
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area	In feature area
<a href="#"><u>Natator depressus</u></a>			
Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area	In feature area
<b>SHARK</b>			
<a href="#"><u>Carcharias taurus (east coast population)</u></a>			
Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat known to occur within area	In feature area
<a href="#"><u>Carcharodon carcharias</u></a>			
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#"><u>Galeorhinus galeus</u></a>			
School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark [68453]	Conservation Dependent	Species or species habitat may occur within area	In buffer area only
<a href="#"><u>Rhincodon typus</u></a>			
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#"><u>Sphyrna lewini</u></a>			
Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat likely to occur within area	In feature area
<b>SNAIL</b>			



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Thersites mitchellae</a>			
Mitchell's Rainforest Snail [66774]	Critically Endangered	Species or species habitat known to occur within area	In feature area

Listed Migratory Species		[ Resource Information ]	
Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
<a href="#">Anous stolidus</a>			
Common Noddy [825]		Species or species habitat likely to occur within area	In feature area
<a href="#">Apus pacificus</a>			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
<a href="#">Ardenna carneipes</a>			
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area	In feature area
<a href="#">Ardenna grisea</a>			
Sooty Shearwater [82651]		Species or species habitat likely to occur within area	In feature area
<a href="#">Ardenna pacifica</a>			
Wedge-tailed Shearwater [84292]		Breeding known to occur within area	In buffer area only
<a href="#">Calonectris leucomelas</a>			
Streaked Shearwater [1077]		Species or species habitat known to occur within area	In feature area
<a href="#">Diomedea antipodensis</a>			
Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Diomedea epomophora</a>			
Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Diomedea exulans</a>			
Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Fregata ariel</a>			
Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Fregata minor</a> Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area	In feature area
<a href="#">Macronectes giganteus</a> Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Macronectes halli</a> Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Phaethon lepturus</a> White-tailed Tropicbird [1014]		Species or species habitat known to occur within area	In feature area
<a href="#">Phoebastria fusca</a> Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Sternula albifrons</a> Little Tern [82849]		Breeding likely to occur within area	In feature area
<a href="#">Thalassarche carteri</a> Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche cauta</a> Shy Albatross [89224]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche impavida</a> Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche melanophrys</a> Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche salvini</a> Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Thalassarche steadi</a> White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area	In feature area
<b>Migratory Marine Species</b>			
<a href="#">Balaenoptera borealis</a> Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area	In buffer area only
<a href="#">Balaenoptera edeni</a> Bryde's Whale [35]		Species or species habitat may occur within area	In feature area
<a href="#">Balaenoptera musculus</a> Blue Whale [36]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Balaenoptera physalus</a> Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area	In buffer area only
<a href="#">Carcharhinus longimanus</a> Oceanic Whitetip Shark [84108]		Species or species habitat may occur within area	In feature area
<a href="#">Carcharodon carcharias</a> White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Caretta caretta</a> Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area	In feature area
<a href="#">Chelonia mydas</a> Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Dermochelys coriacea</a> Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Congregation or aggregation known to occur within area	In feature area
<a href="#">Dugong dugon</a> Dugong [28]		Species or species habitat may occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Eretmochelys imbricata</a> Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Eubalaena australis as Balaena glacialis australis</a> Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#">Lamna nasus</a> Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area	In feature area
<a href="#">Lepidochelys olivacea</a> Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area	In feature area
<a href="#">Megaptera novaeangliae</a> Humpback Whale [38]		Species or species habitat known to occur within area	In feature area
<a href="#">Mobula alfredi as Manta alfredi</a> Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat known to occur within area	In feature area
<a href="#">Mobula birostris as Manta birostris</a> Giant Manta Ray [90034]		Species or species habitat may occur within area	In feature area
<a href="#">Natator depressus</a> Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Orcinus orca</a> Killer Whale, Orca [46]		Species or species habitat may occur within area	In feature area
<a href="#">Rhincodon typus</a> Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Sousa sahalensis as Sousa chinensis</a> Australian Humpback Dolphin [87942]		Species or species habitat known to occur within area	In feature area
Migratory Terrestrial Species			



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Cuculus optatus</a> Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area	In feature area
<a href="#">Hirundapus caudacutus</a> White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Monarcha melanopsis</a> Black-faced Monarch [609]		Species or species habitat known to occur within area	In feature area
<a href="#">Motacilla flava</a> Yellow Wagtail [644]		Species or species habitat known to occur within area	In feature area
<a href="#">Myiagra cyanoleuca</a> Satin Flycatcher [612]		Species or species habitat known to occur within area	In feature area
<a href="#">Rhipidura rufifrons</a> Rufous Fantail [592]		Species or species habitat known to occur within area	In feature area
<a href="#">Symposiachrus trivirgatus as Monarcha trivirgatus</a> Spectacled Monarch [83946]		Species or species habitat known to occur within area	In feature area
<b>Migratory Wetlands Species</b>			
<a href="#">Actitis hypoleucos</a> Common Sandpiper [59309]		Species or species habitat known to occur within area	In feature area
<a href="#">Calidris acuminata</a> Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area	In feature area
<a href="#">Calidris canutus</a> Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Calidris ferruginea</a> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Calidris melanotos</a> Pectoral Sandpiper [858]		Species or species habitat known to occur within area	In feature area
<a href="#">Charadrius leschenaultii</a> Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Gallinago hardwickii</a> Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area	In feature area
<a href="#">Limosa lapponica</a> Bar-tailed Godwit [844]		Species or species habitat known to occur within area	In feature area
<a href="#">Numenius madagascariensis</a> Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Pandion haliaetus</a> Osprey [952]		Breeding known to occur within area	In feature area
<a href="#">Thalasseus bergii</a> Greater Crested Tern [83000]		Breeding known to occur within area	In buffer area only
<a href="#">Tringa nebularia</a> Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area	In feature area

## Other Matters Protected by the EPBC Act

### Commonwealth Lands [ Resource Information ]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Commonwealth Land Name	State	Buffer Status
Communications, Information Technology and the Arts - Australian Postal Corporation Commonwealth Land - Australian Postal Commission [11303]	NSW	In feature area
Communications, Information Technology and the Arts - Telstra Corporation Limited Commonwealth Land - Australian Telecommunications Commission [11299]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [11302]	NSW	In feature area



Commonwealth Land Name	State	Buffer Status
<b>Commonwealth Heritage Places</b> [ Resource Information ]		
Name	State	Status
Historic		
<a href="#">Byron Bay Post Office</a>	NSW	Listed place
<a href="#">Cape Byron Lighthouse</a>	NSW	Listed place

<b>Listed Marine Species</b> [ Resource Information ]			
Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
<a href="#">Actitis hypoleucos</a>			
Common Sandpiper [59309]		Species or species habitat known to occur within area	In feature area
<a href="#">Anous stolidus</a>			
Common Noddy [825]		Species or species habitat likely to occur within area	In feature area
<a href="#">Anseranas semipalmata</a>			
Magpie Goose [978]		Species or species habitat may occur within area overfly marine area	In buffer area only
<a href="#">Apus pacificus</a>			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
<a href="#">Ardenna carneipes as Puffinus carneipes</a>			
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area	In feature area
<a href="#">Ardenna grisea as Puffinus griseus</a>			
Sooty Shearwater [82651]		Species or species habitat likely to occur within area	In feature area
<a href="#">Ardenna pacifica as Puffinus pacificus</a>			
Wedge-tailed Shearwater [84292]		Breeding known to occur within area	In buffer area only
<a href="#">Bubulcus ibis as Ardea ibis</a>			
Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Calidris acuminata</a> Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area	In feature area
<a href="#">Calidris canutus</a> Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Calidris ferruginea</a> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Calidris melanotos</a> Pectoral Sandpiper [858]		Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Calonectris leucomelas</a> Streaked Shearwater [1077]		Species or species habitat known to occur within area	In feature area
<a href="#">Charadrius leschenaultii</a> Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Diomedea antipodensis</a> Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Diomedea antipodensis gibsoni as Diomedea gibsoni</a> Gibson's Albatross [82270]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Diomedea epomophora</a> Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Diomedea exulans</a> Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Fregata ariel</a> Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Fregata minor</a> Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area	In feature area
<a href="#">Gallinago hardwickii</a> Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Haliaeetus leucogaster</a> White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area	In feature area
<a href="#">Hirundapus caudacutus</a> White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Lathamus discolor</a> Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area overfly marine area	In feature area
<a href="#">Limosa lapponica</a> Bar-tailed Godwit [844]		Species or species habitat known to occur within area	In feature area
<a href="#">Macronectes giganteus</a> Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Macronectes halli</a> Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Merops ornatus</a> Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Monarcha melanopsis</a> Black-faced Monarch [609]		Species or species habitat known to occur within area overfly marine area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Motacilla flava</a> Yellow Wagtail [644]		Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Myiagra cyanoleuca</a> Satin Flycatcher [612]		Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Numenius madagascariensis</a> Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area	In feature area
<a href="#">Pachyptila turtur</a> Fairy Prion [1066]		Species or species habitat known to occur within area	In feature area
<a href="#">Pandion haliaetus</a> Osprey [952]		Breeding known to occur within area	In feature area
<a href="#">Phaethon lepturus</a> White-tailed Tropicbird [1014]		Species or species habitat known to occur within area	In feature area
<a href="#">Phoebastria fusca</a> Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Rhipidura rufifrons</a> Rufous Fantail [592]		Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Rostratula australis as Rostratula benghalensis (sensu lato)</a> Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Stercorarius skua as Catharacta skua</a> Great Skua [823]		Species or species habitat may occur within area	In buffer area only
<a href="#">Sternula albifrons as Sterna albifrons</a> Little Tern [82849]		Breeding likely to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Symposiachrus trivirgatus as Monarcha trivirgatus</a> Spectacled Monarch [83946]		Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Thalassarche carteri</a> Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche cauta</a> Shy Albatross [89224]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche impavida</a> Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche melanophris</a> Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche salvini</a> Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalassarche steadi</a> White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Thalasseus bergii as Sterna bergii</a> Greater Crested Tern [83000]		Breeding known to occur within area	In buffer area only
<a href="#">Tringa nebularia</a> Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area overfly marine area	In feature area
<b>Fish</b>			
<a href="#">Acentronura tentaculata</a> Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area	In feature area
<a href="#">Campichthys tryoni</a> Tryon's Pipefish [66193]		Species or species habitat may occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Corythoichthys amplexus</a> Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area	In feature area
<a href="#">Corythoichthys ocellatus</a> Orange-spotted Pipefish, Ocellated Pipefish [66203]		Species or species habitat may occur within area	In feature area
<a href="#">Festucalex cinctus</a> Girdled Pipefish [66214]		Species or species habitat may occur within area	In feature area
<a href="#">Filicampus tigris</a> Tiger Pipefish [66217]		Species or species habitat may occur within area	In feature area
<a href="#">Halicampus grayi</a> Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area	In feature area
<a href="#">Hippichthys cyanospilos</a> Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area	In feature area
<a href="#">Hippichthys heptagonus</a> Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area	In feature area
<a href="#">Hippichthys penicillus</a> Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area	In feature area
<a href="#">Hippocampus kelloggi</a> Kellogg's Seahorse, Great Seahorse [66723]		Species or species habitat may occur within area	In feature area
<a href="#">Hippocampus kuda</a> Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area	In feature area
<a href="#">Hippocampus planifrons</a> Flat-face Seahorse [66238]		Species or species habitat may occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Hippocampus trimaculatus</a> Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area	In feature area
<a href="#">Hippocampus whitei</a> White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]	Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#">Lissocampus runa</a> Javelin Pipefish [66251]		Species or species habitat may occur within area	In feature area
<a href="#">Maroubra perserrata</a> Sawtooth Pipefish [66252]		Species or species habitat may occur within area	In feature area
<a href="#">Micrognathus andersonii</a> Anderson's Pipefish, Shortnose Pipefish [66253]		Species or species habitat may occur within area	In feature area
<a href="#">Micrognathus brevirostris</a> thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area	In feature area
<a href="#">Microphis manadensis</a> Manado Pipefish, Manado River Pipefish [66258]		Species or species habitat may occur within area	In feature area
<a href="#">Solegnathus dunckeri</a> Duncker's Pipehorse [66271]		Species or species habitat may occur within area	In feature area
<a href="#">Solegnathus hardwickii</a> Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area	In feature area
<a href="#">Solegnathus spinosissimus</a> Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area	In feature area
<a href="#">Solenostomus cyanopterus</a> Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Solenostomus paradoxus</a> Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area	In feature area
<a href="#">Stigmatopora nigra</a> Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area	In feature area
<a href="#">Syngnathoides biaculeatus</a> Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area	In feature area
<a href="#">Trachyrhamphus bicoarctatus</a> Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area	In feature area
<a href="#">Urocampus carinirostris</a> Hairy Pipefish [66282]		Species or species habitat may occur within area	In feature area
<a href="#">Vanacampus margaritifer</a> Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area	In feature area
<b>Mammal</b>			
<a href="#">Dugong dugon</a> Dugong [28]		Species or species habitat may occur within area	In feature area
<b>Reptile</b>			
<a href="#">Astrotia stokesii</a> Stokes' Seasnake [1122]		Species or species habitat may occur within area	In feature area
<a href="#">Caretta caretta</a> Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area	In feature area
<a href="#">Chelonia mydas</a> Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Dermochelys coriacea</a> Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Congregation or aggregation known to occur within area	In feature area



Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Eretmochelys imbricata</a> Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Hydrophis elegans</a> Elegant Seasnake [1104]		Species or species habitat may occur within area	In feature area
<a href="#">Lepidochelys olivacea</a> Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area	In feature area
<a href="#">Natator depressus</a> Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Pelamis platurus</a> Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area	In feature area

Whales and Other Cetaceans			[ Resource Information ]
Current Scientific Name	Status	Type of Presence	Buffer Status
Mammal			
<a href="#">Balaenoptera acutorostrata</a> Minke Whale [33]		Species or species habitat may occur within area	In feature area
<a href="#">Balaenoptera borealis</a> Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area	In buffer area only
<a href="#">Balaenoptera edeni</a> Bryde's Whale [35]		Species or species habitat may occur within area	In feature area
<a href="#">Balaenoptera musculus</a> Blue Whale [36]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Balaenoptera physalus</a> Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area	In buffer area only



Current Scientific Name	Status	Type of Presence	Buffer Status
<a href="#">Delphinus delphis</a> Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area	In feature area
<a href="#">Eubalaena australis</a> Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#">Grampus griseus</a> Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area	In feature area
<a href="#">Megaptera novaeangliae</a> Humpback Whale [38]		Species or species habitat known to occur within area	In feature area
<a href="#">Orcinus orca</a> Killer Whale, Orca [46]		Species or species habitat may occur within area	In feature area
<a href="#">Sousa sahulensis as Sousa chinensis</a> Australian Humpback Dolphin [87942]		Species or species habitat known to occur within area	In feature area
<a href="#">Stenella attenuata</a> Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area	In feature area
<a href="#">Tursiops aduncus</a> Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area	In feature area
<a href="#">Tursiops truncatus s. str.</a> Bottlenose Dolphin [68417]		Species or species habitat may occur within area	In feature area

## Extra Information

State and Territory Reserves			[ Resource Information ]
Protected Area Name	Reserve Type	State	Buffer Status
Arakwal	National Park	NSW	In feature area
Cape Byron	State Conservation Area	NSW	In feature area
Cape Byron	Marine Park	NSW	In feature area



Protected Area Name	Reserve Type	State	Buffer Status
Cumbebin Swamp	Nature Reserve	NSW	In feature area
Hayters Hill	Nature Reserve	NSW	In buffer area only
Julian Rocks Nguthungulli	Nature Reserve	NSW	In buffer area only
Tyagarah	Nature Reserve	NSW	In buffer area only

### Regional Forest Agreements [ Resource Information ]

Note that all areas with completed RFAs have been included.

RFA Name	State	Buffer Status
<a href="#">North East NSW RFA</a>	New South Wales	In feature area

### EPBC Act Referrals [ Resource Information ]

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Controlled action				
<a href="#">Harvest Estate, West Byron Urban Release Area, Ewingsdale Road, Byron Bay, NSW</a>	2018/8166	Controlled Action	Post-Approval	In buffer area only
<a href="#">Installation of three swing moorings in Byron Bay</a>	2002/717	Controlled Action	Completed	In buffer area only
Not controlled action				
<a href="#">Byron Shire Council Sewage Treatment Plant Upgrade</a>	2000/48	Not Controlled Action	Completed	In feature area
<a href="#">Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia</a>	2015/7522	Not Controlled Action	Completed	In feature area
<a href="#">Residential dwelling, 26 Shelley Drive</a>	2004/1362	Not Controlled Action	Completed	In feature area
Not controlled action (particular manner)				
<a href="#">Byron Bay Town Centre Bypass</a>	2019/8562	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
<a href="#">Byron Shire Bioenergy Facility</a>	2021/8969	Not Controlled Action (Particular Manner)	Post-Approval	In buffer area only
Referral decision				
<a href="#">Breeding program for Grey Nurse Sharks</a>	2007/3245	Referral Decision	Completed	In feature area

### Biologically Important Areas

Scientific Name	Behaviour	Presence	Buffer Status
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Scientific Name	Behaviour	Presence	Buffer Status
<b>Dolphins</b>			
<a href="#">Tursiops aduncus</a>			
Indo-Pacific/Spotted Bottlenose Dolphin [68418]	Breeding	Likely to occur	In buffer area only
<a href="#">Tursiops aduncus</a>			
Indo-Pacific/Spotted Bottlenose Dolphin [68418]	Breeding	Known to occur	In feature area
<b>Marine Turtles</b>			
<a href="#">Caretta caretta</a>			
Loggerhead Turtle [1763]	Nesting	Known to occur	In feature area
<b>Sharks</b>			
<a href="#">Carcharias taurus</a>			
Grey Nurse Shark [64469]	Foraging	Known to occur	In feature area
<b>Whales</b>			
<a href="#">Megaptera novaeangliae</a>			
Humpback Whale [38]	Foraging	Known to occur	In feature area
<b>Bioregional Assessments</b>			
SubRegion	BioRegion	Website	Buffer Status
Clarence-Moreton	Clarence-Moreton	<a href="#">BA website</a>	In buffer area only



# Caveat

## 1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

## 2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

## 3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

## 4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.



## Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [-Office of Environment and Heritage, New South Wales](#)
- [-Department of Environment and Primary Industries, Victoria](#)
- [-Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [-Department of Environment, Water and Natural Resources, South Australia](#)
- [-Department of Land and Resource Management, Northern Territory](#)
- [-Department of Environmental and Heritage Protection, Queensland](#)
- [-Department of Parks and Wildlife, Western Australia](#)
- [-Environment and Planning Directorate, ACT](#)
- [-Birdlife Australia](#)
- [-Australian Bird and Bat Banding Scheme](#)
- [-Australian National Wildlife Collection](#)
- [-Natural history museums of Australia](#)
- [-Museum Victoria](#)
- [-Australian Museum](#)
- [-South Australian Museum](#)
- [-Queensland Museum](#)
- [-Online Zoological Collections of Australian Museums](#)
- [-Queensland Herbarium](#)
- [-National Herbarium of NSW](#)
- [-Royal Botanic Gardens and National Herbarium of Victoria](#)
- [-Tasmanian Herbarium](#)
- [-State Herbarium of South Australia](#)
- [-Northern Territory Herbarium](#)
- [-Western Australian Herbarium](#)
- [-Australian National Herbarium, Canberra](#)
- [-University of New England](#)
- [-Ocean Biogeographic Information System](#)
- [-Australian Government, Department of Defence](#)
- [Forestry Corporation, NSW](#)
- [-Geoscience Australia](#)
- [-CSIRO](#)
- [-Australian Tropical Herbarium, Cairns](#)
- [-eBird Australia](#)
- [-Australian Government – Australian Antarctic Data Centre](#)
- [-Museum and Art Gallery of the Northern Territory](#)
- [-Australian Government National Environmental Science Program](#)
- [-Australian Institute of Marine Science](#)
- [-Reef Life Survey Australia](#)
- [-American Museum of Natural History](#)
- [-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania](#)
- [-Tasmanian Museum and Art Gallery, Hobart, Tasmania](#)
- [-Other groups and individuals](#)

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.



Please feel free to provide feedback via the [Contact us](#) page.

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Department of Climate Change, Energy, the Environment and Water

GPO Box 3090

Canberra ACT 2601 Australia

+61 2 6274 1111

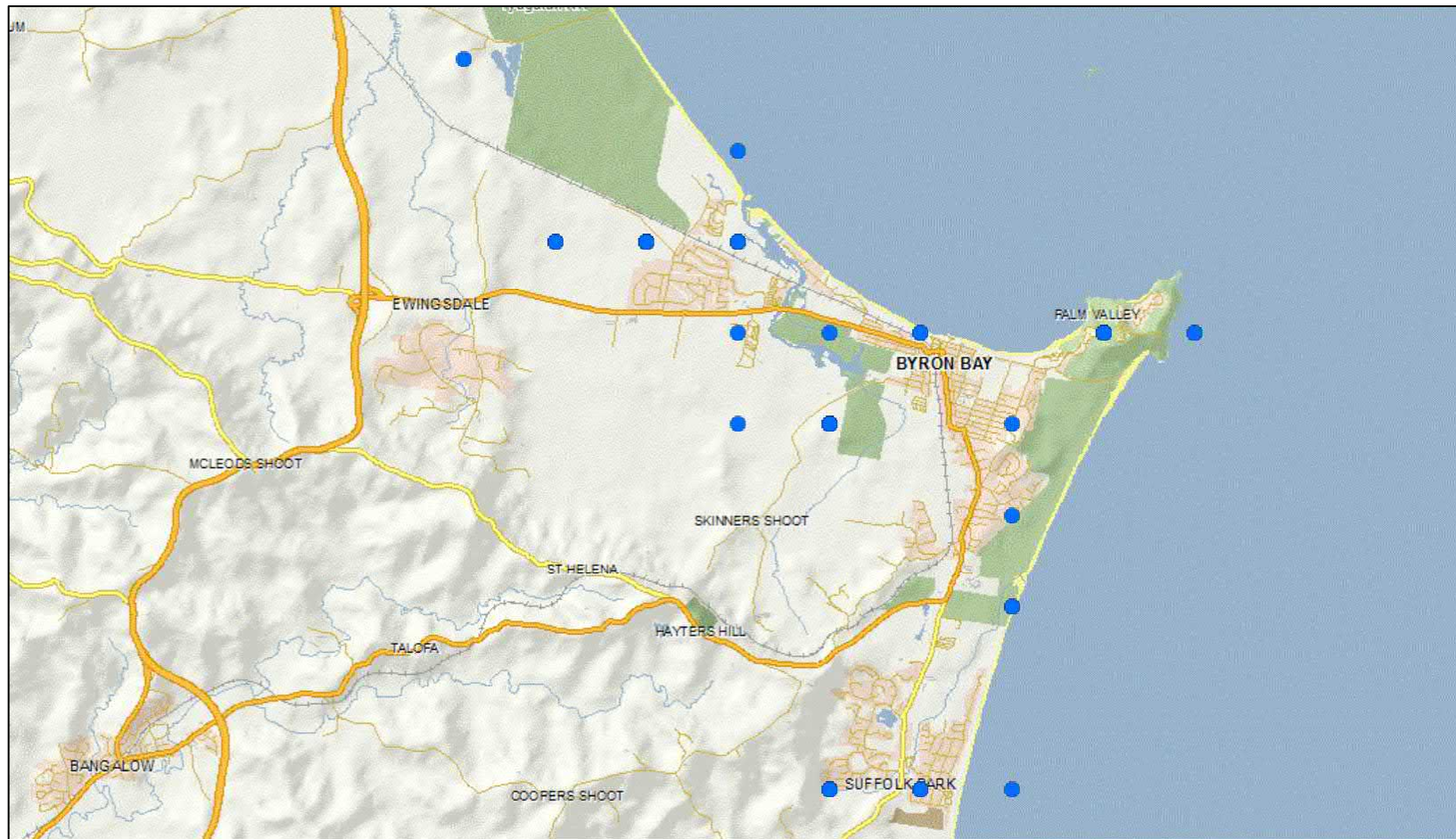


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APPENDIX B: BIONET ATLAS MAP



## Atlas Map



March 2, 2023

**drawGraphics\_poly**

— Override 1

● spc2

