ATTACHMENTS

UNDER SEPARATE COVER

Ordinary Council Meeting

24 September 2019

NARRABRI SHIRE
DISCOVER THE POTENTIAL

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Narrabri Shire Council

Bellata Recreation Precinct Plan 2019

DRAFT

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open space
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Narrabri Shire Council/ Bellata wheat harvest

Executive Summary

Facilities in Bellata developed for community, recreation and sport activities include a recreation park, sports oval, tennis courts, golf course and memorial hall. Of these facilities, Council manages the recreation park and sports oval. Community organisations manage the tennis courts, golf course and memorial hall. In recognition of a number of trends and emerging changes in the Bellata community, Council commissioned development of the Bellata Recreation Precinct Plan to guide further development of the oval and surrounding recreation and community facilities.

Bellata is a small township providing services to the surrounding agricultural district. The permanent population of the town itself has declined by over 40% in the past decade, with contributing factors including the increasing number of technological applications and mechanisation of farming, resulting in the reduced requirement for permanent and seasonal labour.

Council is intent on forming partnerships with communities to face the challenges that change brings to communities such as Bellata, and acknowledges that strong communities are those that have opportunities to connect socially. Recreation and sport is one proven way that builds strong and connected communities.

The Bellata Recreation Precinct Plan aims to analyse the current provision of recreation facilities in Bellata and the changes impacting on the community and proposes a plan to provide recreation opportunities for the community that meet its current and future recreation needs in a way that Council and the community can sustain with available resources, for the long term future.

The Precinct Plan recognises existing recreation activities occurring in the township and provides a staged plan to support community connection through recreation, sport and social activities by staged upgrading, relocating and rationalising facilities. Formalising land use is also identified where necessary.

Existing situation

Bellata oval is Council managed open space in the town and is currently used by Bellata Public School for its annual athletics carnival and cross-country. The oval has not been used for club or formal school sports for a number of years and Council is therefore reviewing how the land can best serve the recreation needs of the community in the future.

The oval is located between the school and the golf club. The tennis courts are adjacent to the school and is home to the local kindergarten/playgroup.

The services and activities of the school, tennis club and licensed golf club reach a considerable cross-section of the Bellata community.

Bellata Park currently has a number of very old pieces of play equipment that are not appealing and are used irregularly. A shelter with two table and chair settings is in fair condition and is located next to a half basketball court in good condition which was constructed in approximately 2009.

Demand for upgrades

Proposed development has been established through consultation with Council, Bellata Public School, Bellata Golf Club, targeted community members and consideration of previous community consultation undertaken during development of strategic planning processes of Council. Key directions include:

- ensuring the oval can continue to be used for recreation, informal sport and annual school sport events
- rationalising existing and developing new children's play areas
- creation of a communal area including picnic facilities and fire or yarning circle
- formalising a primitive camping ground for visitors and seasonal workers
- colocating community facilities in close proximity to amenities to create a local destination that provides for a broad cross-section of the community
- development of a new lit multi-sport court.

Design directions

The proposed precinct plan is located within Section 5 of this plan. The vision for the precinct is:

> *"...to provide a local recreation precinct for community activities and school sports, a primitive camping ground and an attractive recreation and social setting for locals and visitors."*

Proposed ultimate embellishments for the precinct includes:

- communal area including picnic shelter and camp fire circle
- primitive camping ground
- well-maintained clubhouse with upgraded amenities including a new barbeque and play area
- one lit multi-sport court (netball, basketball, tennis)
- 9 hole golf course
- defined truck turnaround and car parking area serving the oval and golf club and recognising seasonal activities in the town.

1 Background

1.1 Introduction and purpose

In early 2019, Narrabri Shire Council engaged ROSS Planning to develop a Precinct Plan to guide future development of the Bellata oval taking into account the changing recreation needs of the community and emerging drive-tourism demands. Bellata is a small township servicing the surrounding agricultural district and is located in the northern part of the Narrabri Shire local government area.

Recreation and sport facilities in Bellata consist of Council managed facilities and private facilities. Council owned and managed facilities include Bellata Park on the corner of North and Belar Streets and Bellata oval on Berrigal Road. The tennis courts adjacent to Bellata Public School, Bellata Memorial Hall in Wilga Street and the Bellata Golf Club are on either Crown or freehold land and are managed by community organisations.

Development of a shire-wide Sport, Recreation and Open Space Plan in 2017 recommended activation of recreation opportunities at the school, out-of-school hours, rationalisation of part of the Bellata Park as well as rationalisation of the former caravan park site which had been vacant for a number of years.

Bellata oval is located near the eastern edge of the township between the Bellata Public School and Bellata Golf Club. Its use is limited and is predominantly used by school children for informal school sport and the annual school athletics carnival and cross-country event. The oval and golf course are used for the school cross-country each year.

The aim of the Bellata Recreation Precinct Plan is to identify opportunities to centralise and expand recreation opportunities for residents, design an appropriate primitive camping ground to provide short-term accommodation for seasonal workers and travelling visitors and provide opportunities for community members to connect socially. Identified projects are proposed for staged development due to limited community and Council resources. Ultimately, the report will guide community, Council and user group decision-making and resource allocation.

Through site analysis, background research and consultation, the project aims to provide optimal use of the available Council and community resources for community recreation, sport and social connection.

1.2 What is a precinct plan?

A Precinct Plan provides a vision for a site, identifying what it should look like and how it should function into the future. It establishes a strong and consistent direction, providing a framework for ongoing improvement.

The precinct plan does not suggest that all elements of the plan should proceed immediately, or that Council nor the main user groups should be responsible for all capital costs in respect of those items that are progressed. It is important to note that the intent of the Precinct Plan is to provide a framework for future development of the area over an extended time period so that ad hoc improvements are avoided and community use and long-term viability are maximised. The Precinct Plan should be regularly monitored to ensure the outcomes continue to meet community needs in the best possible way.

Bellata oval looking from school toward golf club

1.3 Project methodology

The methodology used to develop the precinct plan comprised the following stages:

Stage 1 - Preliminaries

- inception meeting
- review of relevant reports, plans, policies and other documents
- review of the demographic profile of the community including consideration of seasonal fluctuations

Stage 2 - Site assessment

- detailed site assessments
- discussions with Council officers

Stage 3 - Community engagement

- discussions with key stakeholders stipulated by Council
- analysis of identified issues, ideas, needs and opportunities
- preparation of concept options for Council review

Stage 4 - Draft concept master plan

- preparation of draft precinct plan report and layout
- review of draft precinct plan by Council
- key stakeholders and public review

Stage 5 - Review and finalisation

- review of feedback on draft precinct plan report
- agreed amendments to the precinct plan report
- Council endorsement.

LITERATURE REVIEW

When considered together, the literature review highlights a number of key considerations:

- Council acknowledges the importance of sport and recreation facilities for the community
- Council highlights the benefits of colocating community facilities to increase use
- Council understands that a partnership approach with the community is essential.

1.4 Literature review

In order to present a clear picture of the background issues impacting on the potential development of the precinct, a literature review has been undertaken. A detailed summary of each document reviewed is included below, while key impacts for the development of the precinct plan are highlighted in the summary breakout box.

Narrabri Shire Community Strategic Plan 2017-2027

The Community Strategic Plan is the key document leading Council delivery over a four-year period. It is underpinned by the vision:

> *A strong and vibrant regional growth centre providing a quality living environment for the entire Shire community.*

Key strategic objectives and actions are presented under four key themes. Those with the most direct relevance to the Precinct Plan are found within the 'Our Society' and 'Our Environment' themes and include:

- Safe, inclusive and connected community
  - Our vibrant country lifestyle will be enhanced through embracing our recreational and cultural diversity
  - Our communities will be provided with facilities and services to increase social connectivity and accessibility
- Environmentally sustainable and productive shire
  - We will maintain our open spaces, natural environment and heritage for future generations

These key themes have been considered throughout the development of the precinct plan.

Sport, Recreation and Open Space Plan 2017-2032

The Sport, Recreation and Open Space Plan was developed to provide a clear statement of Council's commitment to the management, provision and development of recreation and open space in the Shire. The Plan provides strategic guidance on key identified issues and includes actions to encourage opportunities for increased participation in sport and recreation by a broad cross-section of the community.

The Plan recommends priority actions for the Bellata township including:

- rationalise the former caravan park site
- rationalise the northern section of Bellata Park
- retain and upgrade the play node in Bellata
- liaise with the Department of Education regional officers and the local principal to 'activate' (outside of school hours) the opportunities available at the school for local residents.

These recommendations have been used to guide development of the precinct plan while considering information gained through targeted community consultation.

1.5 Relevant legislation

The Local Government Act 1993

The Local Government Act provides the legal framework for the system of local government in NSW and sets out the responsibilities and powers of councils and councillors in a system that is accountable to the community[1].

Part 2 of the Act requires all public land to be classified as either community or operational. Bellata oval is currently classified as community land. Council is in the process of developing updated Plans of Management for community land and it is envisaged that this Precinct Plan will align with the relevant Plan of Management for the land, when finalised.

Section 68 sets out a range of activities that require Council approval. Operating a caravan park or camping ground is one of the activities listed that requires approval. This process, commonly referred to as Section 68 approvals, is in addition, or ancillary to, standard development application requirements.

Local Government (Manufactured Home Estates, Caravan Parks, Camping Grounds and Moveable Dwellings) Regulations 2005

The object of the Local Government (Manufactured Home Estates, Caravan Parks, Camping Grounds and Moveable Dwellings) Regulation 2005 is to guide provision of opportunities for affordable alternatives in short-term and long-term accommodation. Approval may be granted for primitive camping grounds where requirements of the regulation are met. An excerpt of the regulation is provided in Appendix 1.

Crown Land Management Act 2016

The objects of the Land Management Act are to provide for the ownership, use and management of Crown land within the context of environmental, social, cultural heritage and economic considerations. Use of Crown land is to be for the benefit of people in NSW, particularly Aboriginal people where relevant, because of the spiritual, social, cultural and economic importance of land to Aboriginal people.

The Bellata Golf Club currently leases the land for the golf course and club from the NSW Government.

Narrabri Local Environment Plan 2012

The Narrabri Local Environment Plan (LEP) aims to make local environmental planning provisions for land in Narrabri to encourage orderly management, development and conservation of resources by protecting, enhancing and conserving the highest values of the land, providing a choice of living opportunities, business and employment opportunities and being sensitive to the economic and social needs of a community.

1 Local Government Act 1993 (NSW) Chapter 2, Section 7 (Australia)

1.6 Demographic considerations

In order to understand and plan for the precinct, a snapshot of existing and future population and demographic characteristics has been undertaken. Given the predominantly rural characteristic of Bellata and the surrounding district, it is acknowledged that use of recreation and sport facilities in Bellata will be primarily by people living in the township and on surrounding agricultural properties. Analysis of these characteristics[2] reveals:

- a population of 350 people at the 2016 Census with limited population growth
- 107 people or a quarter of the population was 14 years old or younger in 2016
- In 2016, of the 107 children and youth identified above, 18 attended high school, 6 attended a Catholic primary school, 37 attended a government primary school and 8 attended preschool (in the Shire or district, not necessarily in Bellata)
- people aged 65 years and over made up approximately 17% of the population
- median age is 37 which is consistent with NSW however slightly younger than Narrabri's median age of 40
- only three households were without a motor vehicle
- 31% of households in Bellata did not have internet connection, compared with 26% for Narrabri and approximately 14% across NSW and Australia.

Bellata's official population in 2011 was 407 and in 2006 was 529 people[3]. This indicates a declining population trend that requires thinking differently to identify innovative ways to continue providing community services and activities to residents and visitors.

2 ABS (2016) Bellata
3 ABS (2011) Bellata. ABS (2006) Bellata

1.7 Trend considerations

Formal sport trends

Volunteer sport organisations

The rate of volunteering in sport and recreation clubs has been declining for many years. Often, the responsibility for running clubs falls to one or two key personnel. To address this issue, there is a move toward amalgamations, with multi-sport clubs becoming more common. In other cases, organisations may become aligned to larger licensed clubs that take over some or all of the volunteers' roles as well as asset management responsibilities.

There is an opportunity for the Bellata Golf Club to consider becoming an 'umbrella' organisation for various sport and recreation activities in the community by making relatively minor adjustments to its management model.

Social competition

Australia-wide people are opting for social sport games that are less formal and that fit around busy work and family schedules. Recent examples included Twenty-20 cricket and pickleball, a modified form of tennis and badminton currently emerging in Australia.

Female participation

Participation in formal sport by girls and women is increasing with women's cricket and women's AFL the most prominent examples of this trend.

Playing surface quality

Water is a precious resource and irrigation of the oval is not proposed during periods of severe drought. However, installing infrastructure that allows for irrigation of the field and discrete recreation areas is worth serious consideration in the future.

Passive recreation trends

Park design

Parks play multiple roles in establishing and maintaining a community's quality of life; ensuring the health of residents and visitors and contributing to the economic and environmental well-being of a community and region. The design of a park is critical in ensuring that it is successfully utilised by the community.

Creating the 'right' park setting is essential to the community's use of it for both active and passive recreation. Numerous studies highlight the need for trails linking residential areas with parks and other types of open spaces. Walking continues to be the preferred physical activity for both men and women. Consideration should be given to installation of bollards with signs indicating direction and distance along key walking networks (between points of interest) within Bellata to encourage walking (and running) for residents and visitors.

Bellata Public School website/Bellata Public School students participating in the Zone Athletics Carnival

2 Existing situation

2.1 Site description

Bellata oval is located near the eastern edge of the township and is situated between the Bellata Public School and the Bellata Golf Club. Residential areas, churches and various services are located between the highway and the oval.

Bellata oval is a 3.5ha sport park and is Council-owned and managed. It is one land parcel:

- Lot 29 on DP753908.

Immediately adjacent the sport park and on the eastern edge of the township is the Bellata Golf Club which is 17.5ha of Crown land managed under lease by the golf club. It is made up of two land parcels:

- Lot 45 on DP753908
- Lot 48 on DP753908.

2.2 Planning considerations

Narrabri Local Environment Plan 2012

Primary production zone

Bellata oval and Bellata Golf Club is zoned Primary Production (RU1). The objectives of the RU1 are to:

- encourage sustainable primary production by maintaining and enhancing the natural resource base
- encourage diversity in primary industry enterprises and systems appropriate for the area
- minimise the fragmentation and alienation of resource lands
- minimise conflict between land uses within this zone and land uses within adjoining zones
- allow for non-agricultural land uses that will not restrict the use of other land for agricultural purposes.

The developments proposed in the precinct plan are permissible with consent from Council and include camping grounds, dwelling houses, farm stay accommodation, recreation areas, recreation facilities (major), recreation facilities (outdoor), rural workers' dwellings, signage and water recreation structures.

NSW Local Government Act Section 68

The precinct plan includes provision for establishment of a primitive camping ground on the Bellata oval and part of the Bellata Golf Club, subject to application and Council approval.

Under the Local Government Act 1993 Section 68, approval is required to engage in trade or business on community land managed by Council. Council is responsible for managing land in accordance with the core objectives detailed in the legislation. The core objectives for a park are to:

- encourage, promote and facilitate recreational, cultural, social and educational pastimes and activities
- provide for passive recreation activities or pastimes and for the casual playing of games
- improve the land in such a way as to promote and facilitate its use to achieve the other core objectives for its management.

Local Government (Manufactured Home Estates, Caravan Parks, Camping Grounds and Moveable Dwellings) Regulation 2005

Primitive camping grounds (PCGs) are one type of camping ground that are modest and understated.

Further to the NSW Local Government Act, the object of the regulation is to provide opportunities for affordable alternatives in short-term and long-term accommodation by:

- continuing the standards for the design of manufactured home estates, caravan parks and camping grounds
- continuing the standards for the design and construction of manufactured homes and other moveable dwellings and for their sites
- continuing the standard to promote the health, safety and amenity of the occupiers of manufactured homes and other moveable dwellings.

Under the regulation an approval to operate a PCG can either:

- designate camp sites where tents, caravans and campervans may be located where the maximum number of camp sites is not to exceed an average of two per hectare (over the total area of the PCG)
- not designate camp sites where the above applies with the concession that two or more tents occupied by not more than 12 persons camping together as a group are to be counted as only one tent[1].

2.3 Site elements

2.3.1 Site characteristics

Bellata is situated on the black soil basalt plains of north western NSW and is located 47 kilometres north of Narrabri and approximately halfway between Narrabri and Moree.

The land where the oval, golf course and club are located is predominantly level with the land gently sloping away from the rear of the golf clubhouse.

The Nandewar Range can be seen in the distance to the east of the township.

2.3.2 Buildings and improvements

Improvements to Bellata oval are limited to fencing along property boundaries and to separate the oval from the school and the golf club car park. An additional fence line separates the active sport oval from an undeveloped area of land between the active sport oval and the golf club car park.

2.3.3 Parking

A gravel car park is located on golf club land between the oval and the golf clubhouse. While individual car parks are not marked, it is estimated that up to 50 parked cars could be accommodated at any one time.

Overflow parking is on the oval or in areas near to the golf clubhouse, on the edges of the golf course.

The verge of Berrigal Road is also suitable for overflow parking.

2.3.4 Access, linkages and connectivity

Entry and access

There are currently two gated vehicle entries to the oval. One is directly off Berrigal Road near the property boundary with the school. The other entry to the oval is via a gate from the gravel car park between the oval and the golf club. The car park is accessed directly off Berrigal Road.

Linkages and connectivity

The oval shares property boundaries with the school, tennis courts and golf club. There are no formal pedestrian paths or cycle ways linking the oval with residential areas or other community facilities.

1 *NSW Dept Planning. PS 06-001 (10 January 06)*

While school children may access the oval from the neighbouring school grounds, it is apparent that community members do not currently use the oval for unstructured recreation (walking, dog walking, running, social sport) or formal sport.

2.3.5 Shade and shelter

Temperatures in Bellata reach over 40 degrees Celsius during summer months. Winter temperatures can be sub-zero overnight and single digits during the day with strong winds contributing to the temperature feeling lower than official records. Therefore shade and shelter is essential to encourage use by the community.

Native species (mainly Eucalyptus) are located predominantly along property boundaries and fence lines, with individual small to medium trees scattered throughout areas beyond the oval.

2.3.6 Signage

There is no signage on the highway or major roads indicating the location of the oval or golf club. Signage on Berrigal Road identifies the location of the golf club.

2.4 Facility snapshot

Existing facilities

1. Bellata oval
2. Cricket pitch
3. Existing fence-line
4. Bellata Public School
5. Bellata Tennis Club clubhouse
6. Fenced concrete tennis courts
7. Kindergarten play area
8. Gravel car park
9. Bellata Golf Club clubhouse
10. Informal truck turnaround

Bellata oval

Bellata oval has been used as a sports oval in the past however the community is changing and use of the oval for formal sport has declined. Currently the oval includes the following:

- ☐ level surface able to accommodate a junior cricket field
- ☐ concrete cricket pitch
- ☐ concrete slab (previously shed or shelter)
- ☐ sparse eucalyptus trees around the perimeter
- ☐ limited shade
- ☐ no irrigation system (water connected to site)
- ☐ overflow parking
- ☐ truck turnaround
- ☐ stock grazing.

Bellata Public School

Bellata Public School has a good quality children's playground with shade from established trees and a large fixed roof structure. A large open kick-about area is located at the rear of the school immediately adjacent to the oval, although separated by a fence.

NSW Government has a policy encouraging community use of school facilities for appropriate purposes and typically out-of-school hours.

The playground is located within the school grounds on the corner of Gurley Street and Berrigal Road and is highly visible from surrounding residential areas and passing vehicles. Children living in Bellata use the playground regularly.

Bellata Tennis Courts

The tennis courts are located on the southern side of the public school and include two concrete courts with nets and perimeter fencing. A small timber clubhouse is situated on the northern side of the courts and includes a social room, newly refurbished kitchen and toilets.

The local community kindergarten/playgroup operates from the tennis clubhouse and the group has developed an infants playground including a ground level children's playhouse (cubby) and timber play structure with sand softfall and shade cover. The play structure is currently not in use and the community group intend replacing it.












Bellata Golf Club

The Bellata Golf Club includes the following facilities:

- 9 hole course with sand greens
- clubhouse with kitchen, dining hall, bar, toilets and showers
- paved social area at rear
- barbeque shed
- storage sheds.

Primitive camping ground

There is potential to develop a primitive camping ground to cater for seasonal agricultural workers and travelling visitors to Bellata. The clubhouse toilets and showers can be accessed from the exterior of the building while the remainder of the building is secured when not operating.

Bellata Park

Bellata Park currently includes the following embellishments:

- half basketball court
- shelter and two table and chair sets
- swing set
- infants slide and youth slide
- spring toy
- climbing frame
- water fountain
- mobile garbage bin.











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3 Demand analysis

Demand for upgrade and development of the oval and golf club has been established through consultation with Council officers and elected members, user groups, the school principal and targeted community members, in addition to review of Council's adopted strategic planning documents combined with an analysis of existing opportunities.

3.1 Consultation summary

3.1.1 Council

Potential opportunities and issues for consideration were discussed with a number of Council officers:

Issues

- existing play equipment at Bellata Park has reached the end of its useful life
- existing play equipment at Bellata Park does not comply with Australian standards
- community facilities are currently dispersed between a number of Council and community managed sites in the township
- community facilities are ageing and will require removal, replacement or upgrading/major maintenance within 1-5 years
- community managed recreation and sport facilities such as the golf and tennis clubs struggle to afford the maintenance of existing facilities and to attract funding for upgrades and improvements
- requests for a new and/or upgraded infant and children's playground in Bellata have been received from a number of individuals and groups in the community
- Bellata caravan park closed a number of years ago and there is currently an unmet demand for short term accommodation in the township.

Opportunities

- colocate recreation and sport infrastructure in a precinct providing a broad range of opportunities for a cross-section of the community
- plan for future shared facilities including social rooms, toilets and kitchen to maximise community resources
- facilitate an application for development of a primitive camping ground close to services and amenities.

Councillor workshop

A workshop with Councillors was held to provide an opportunity for feedback on the proposed precinct plan. While Councillors agreed with the proposal, an alternate (option two (2)) was developed to include a play area at the existing tennis courts and upgrading of one of the existing courts for sport. The rationale for this alternate option included:

- perceived need for an immediate outcome for the community given the existing play equipment at Bellata Park has been in poor condition and unusable for some time
- perceived distance from residential areas to the golf club for families and particularly for children who are encouraged to walk or cycle from home to use playgrounds (independently without supervision of parents or carers)
- historical significance of the tennis courts to the Bellata community when there was participation in social tennis competitions relative to the population.

General Manager and Director's review

Review of the proposed precinct plan by Council's General Manager and Director's has resulted in the following additions:

- information regarding a water (splash) park has been included in the Appendix
- Option three (3) proposing redevelopment of Bellata Park with equipment aimed at pre-teens, teenagers and adults.

3.1.2 Existing user groups

Bellata Public School

Facility use

- children in the town use the school playground during and after school hours and weekends
- use of the oval currently consists of informal play including sport during breaks in the school day
- annual school athletics carnival
- annual cross-country course utilises the oval and the neighbouring golf course

Proposed development and improvements

- weed management program and regular mowing
- modest shelter from which to cater for annual events
- nominated parking area on eastern side of oval (between oval and golf course car park) for events
- fencing to restrict access to the oval by motor bikes, motor vehicles and livestock.

Bellata Golf Club

Facility use

- clubhouse and golf course adjacent to Bellata oval
- 9 hole golf course with sand greens
- clubhouse including licensed bar, dining hall and kitchen, paved outdoor seating area, barbeque shed, lawn area and toilets and showers

Opportunities

- established not-for-profit club with current and potential income streams to support current and future activities
- available land for collocation of recreation and sport facilities
- area for primitive camping with access to amenities and services.

Bellata community use

Discussion in the community also revealed additional elements for consideration.

The importance of recognising that heavy vehicles use part of the Bellata oval as a truck turnaround location during harvest was highlighted.

A desire of community members, particularly those with infants and young children, to have access to water play was suggested, in part to provide relief from the hot, dry summers experienced in the Shire.

3.1.3 Catchment considerations

Bellata Park

Bellata Park, sometimes referred to as Bellata Picnic Park, is located on the corner of Belar and North Streets in Bellata.

Issues

- play equipment is old, outdated, unappealing and does not comply with current standards
- due to severe heat during summer, anecdotally community members use the playground in winter, if at all
- teenagers ‘hang out’, sitting on the top of the slide in the park
- shade from trees in the park is almost non-existent
- shelter with concrete slab and two tables and chairs is in reasonable condition
- half court basketball court and hoop is in good condition and was constructed in approximately 2009
- no public toilet currently at Bellata Park

Opportunities

- remove old and outdated play equipment and consider options for replacement
- colocate picnic and playground opportunities with like activities and services to create a more attractive and appealing destination for residents
- investigate disposal of part of the existing Bellata Park land with proceeds contributing to proposed new facilities.

Bellata Tennis Club

The tennis club is a community managed sport facility located on the southern side of the school and includes two fenced concrete tennis courts, clubhouse and children’s play area. The local kindergarten/playgroup operates from the tennis clubhouse.

Issues

- tennis court surfaces and perimeter fencing is ageing
- maintenance and upgrades to clubhouse required
- playground equipment requires replacement
- recent upgrades to kitchen and new play cubby house
- declining membership and volunteers

Opportunities

- colocate sport facilities to create one multi-sport venue
- amalgamate with other sport not-for-profit organisations to provide opportunities to the community
- consolidate ageing facilities and infrastructure to reduce overall costs to the community.

4 Design considerations

4.1 Opportunities and constraints

Key opportunities and constraints for the precinct are summarised below and provide much of the direction for the precinct design.

Issue	Opportunities/Constraints	Desired Outcomes/Design Drivers
MOVEMENT		
Entry	☐ There is an opportunity to investigate destination signage on the Newell Highway for the precinct ☐ No signage exists currently for Bellata oval ☐ The golf club is easily accessed off Berrigal Road and signage at the entry is maintained in good condition and provides clear messaging ☐ Some signage may require review	☐ Install directional signage on the Newell Highway ☐ Create an entry statement to the precinct at the Berrigal Road entrance ☐ Install vehicle speed limit signs within the car parking area and heavy vehicle warning signs for the truck turnaround
Parking	☐ Large gravel car park off Berrigal Road ☐ Trucks use part of the land adjacent to the sports field as a turnaround area during harvest ☐ Vehicle parking in the golf car park and on land adjacent to the oval ☐ Parking on the verge is practical	☐ Define truck turnaround and overflow parking areas on part of the Council land between the sports oval and the golf club car park
Pedestrian network	☐ No existing internal or external path system ☐ Limited vehicle traffic in town generally ☐ Heavy vehicle traffic during harvest	☐ Ensure regular road verge slashing to provide pedestrian access along fence lines to increase ease of movement between key community facilities (roads, school, tennis courts, golf club) ☐ Consider use of signage bollards to provide direction and distance to destinations
Fencing	☐ Oval and golf club property boundary fencing is predominantly timber posts and/or star pickets with wire strand and welded mesh (square) ☐ Child-proof/pool fencing defines a small area at the front of the golf clubhouse ☐ Maintenance vehicle gate is located at the school end of the property boundary for the oval and Berrigal Road	☐ Replace property boundary fencing within the next 3-5 years with similar style (post, mesh and top wire) ☐ Extend child-proof/pool fencing to the rear of the golf clubhouse to contain the proposed children's play area and lawn. Use black fencing (as it recedes) ☐ Proposed new multi-sport court will require 3m high perimeter fencing with pedestrian access gates

Issue	Opportunities/Constraints	Desired Outcomes/Design Drivers
BUILDINGS AND STRUCTURES		
Golf clubhouse	☐ Ageing timber building in need of maintenance and renovations including to kitchen, hall, bar, toilets and showers ☐ Toilets and showers can be accessed from the exterior while the rest of the clubhouse is locked overnight ☐ Outdoor paved social area and barbeque shed overlooking golf course ☐ Opportunities to upgrade the kitchen to commercial catering standards ☐ Opportunities to upgrade the outdoor social area particularly the barbeque area ☐ Opportunity to provide a play area for young children	☐ Obtain design and quote for upgrade to kitchen, secure funding and complete upgrades ☐ Redevelop the barbeque area and create a play area for children preferably undercover (predominantly primary school children) ☐ Widely promote community use of the facility for community meetings and gatherings ☐ Upgrade the toilets and showers and improve access for people with a disability
Communal or picnic area	☐ Concrete slab remaining from previous shelter at edge of oval ☐ Social gathering area for residents and visitors that can also be used for annual school events	☐ Construct an area for social gatherings including a picnic shelter with lighting and tables and chairs and a 'yarning' or fire circle ☐ Create a landscaped buffer planted with native species between the oval and shelter area ☐ Interpretive and information map and sign promoting activities and sites of interest in the area (tourism) including the use of proximity technology
PRIMITIVE CAMPING GROUND		
Camping areas	☐ Travellers are currently attracted to the golf club to purchase food (when the kitchen is operating) and drinks, use the amenities and play the course ☐ Overnight visitors to Bellata will contribute to the local economy	☐ Identify indicative locations for a non-designated primitive camping ground over the golf course and oval ☐ Apply to Council for relevant approvals to operate a primitive camping ground
On-site accommodation	☐ On-site accommodation may be viable in the longer term future, pending demand from travellers and seasonal casual workers in Bellata	☐ Identify service requirements for on-site accommodation (wastewater disposal, water supply, power) ☐ Apply to Council for relevant approvals for on-site accommodation
OVAL		
Recreation and sport area	☐ Open space area for recreation and sport activities ☐ Centrally located adjacent to school and golf club ☐ Used annually by school for athletics carnival and cross-country ☐ Ground is not currently irrigated and there is no demonstrated need to start irrigating the grounds	☐ Retain the land for informal recreation and sport activities ☐ Increase tree planting through the site to provide additional shade and shelter while retaining the route for the informal athletics track (used once annually)
TENNIS COURTS		
Tennis courts	☐ Tennis courts are ageing and will require either major maintenance or replacement within 3-7 years ☐ Community kindy utilises the tennis clubhouse which has a newly refurbished kitchen ☐ New children's cubby house was recently installed and the play equipment requires replacement	☐ Build a single new multi-sport court with lights at the golf club to provide opportunities for a variety of court sports ☐ Remove the internal posts and nets of the existing tennis courts to create a level surface for play and activities (wheeled toys, learn to ride circuit)

5 Precinct plan

The following precinct plan includes a primitive camping ground layout and three options for recreation facilities for consideration by the community.

Option one has been developed by considering all consultation, appropriate strategic contexts and previous research. Overall, it provides an opportunity to consolidate community facilities managed by Council or the community in order to meet the recreation and sport needs of the community and attract visitors to Bellata. Option one formalises a number of existing site features with a range of new elements and embellishments, staged over a 10 year timeframe.

Options two and three have been developed as alternative options for the community to consider and propose development of recreation and sport facilities at the existing tennis courts and Bellata Park. As these options were developed at a later stage of the project, they have not been subject to community consultation processes.

The following vision and facility design information relates primarily to option one and proposes development of recreation facilities at the oval and golf club.

5.1 Vision

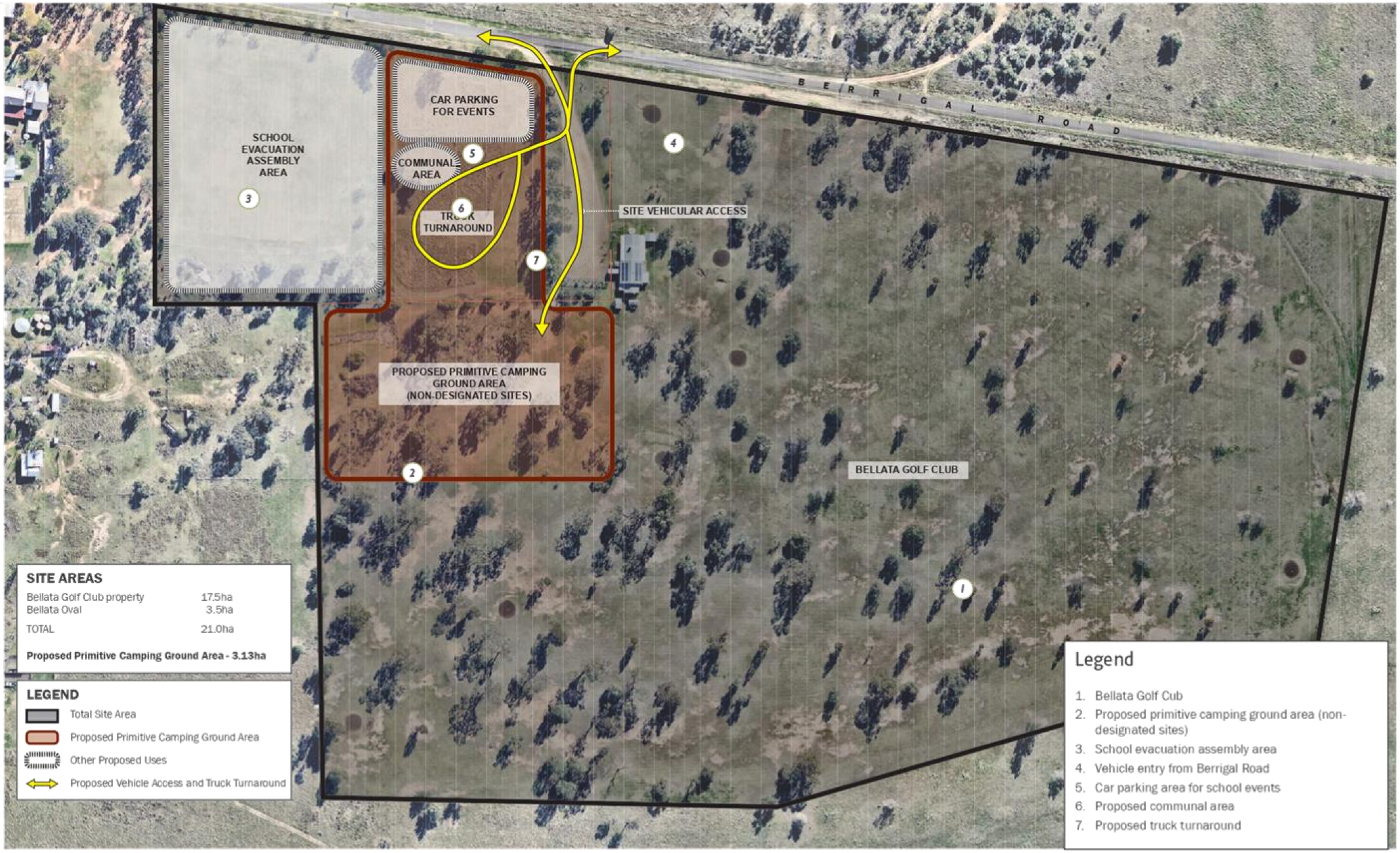
The vision for Bellata Recreation Precinct is:

> *"...to provide a local recreation precinct for community activities and school sports, a primitive camping ground and an attractive recreation and social setting for locals and visitors."*

5.2 Facility design

Element	Precinct plan reference	Description	Rationale
Recreation and sport opportunities			
Bellata oval	1	☐ Retain the oval as an open space area for recreation and social sport with additional tree planting to increase available shade over time ☐ Implement a weed management program particularly to manage burrs and other weeds that prevent use of the oval by children for recreation and sport ☐ Replace the fencing between the oval and the portion of the land between the oval and golf club car park, including a maintenance vehicle gate and at least two pedestrian access points at equal intervals along the fences length ☐ Remove the concrete slab remaining from the previous shed ☐ Remove the concrete cricket pitch when it is no longer safe or fit-for-purpose ☐ Replace the property boundary fencing and gates	☐ Retain existing open space for recreation and social sport ☐ Enhance the amenity and useability of the open space for its intended purpose ☐ Prevent vehicles and stock from accessing the oval

Golf course	-	☐ Upgrade golf tees and sand greens ☐ Plant additional trees throughout golf course	☐ Ensure golf course remains fit-for-purpose
Multi-sport court	9	☐ Design and construct a multi-sport court with lights within the golf club grounds (option 1) ☐ Resurface one of the existing tennis courts to provide a multi-sport court with lights (option 2)	☐ Provide diverse sport opportunities for residents and visitors
Bellata Park	Option 3	☐ Remove very old play equipment from the park and replace with equipment aimed at pre-teens and teenagers ☐ Retain the half basketball court, shelter and tables and chairs in the park, construct a rebound wall ☐ Construct an additional picnic shelter and plant additional shade trees ☐ Strain fence lines where required to ensure appropriate tension ☐ Install connecting pathways to link elements and provide access ☐ Dispose of lots adjoining Bellata Park and consider using proceeds to fund improvements identified in this precinct plan	☐ Remove old and unsafe play equipment ☐ Utilise Council and community resources effectively
Tennis courts	Option 2	☐ Retain and resurface one court as a multisport court ☐ Develop a children's playground where the second court is currently located	☐ Utilise existing infrastructure for alternative community purposes
Camping			
Primitive camping ground	4	☐ Define an area for non-designated primitive camping for recreation vehicles (RVs) and tents ☐ Install direction, information and vehicle speed signs to guide campers, inform them of amenities and facilities and meet legal requirements ☐ Provide access to toilets and showers in the golf clubhouse for visitors ☐ Monitor demand for a dump point for recreational vehicle use	☐ Comply with legislative and regulatory requirements ☐ Encourage travellers and visitors to Bellata to increase the time spent in the area ☐ Provide alternative accommodation options
Community facilities			
Communal area	2	☐ Construct a shelter (including provision for power in the future) and a fire or yarning circle as a communal area ☐ Establish a landscaped buffer between the oval and the communal area	☐ Create a communal area for residents and visitors
Barbeque and play area	7	☐ Refurbish and upgrade existing barbeque area ☐ Extend child-proof/pool fencing to include barbeque and children's play area (option 1) ☐ Design and construct a children's play area at the rear of the existing tennis courts (option 2)	☐ Create an outdoor social area particularly for families with children
Golf Club - operations and sustainability			
Clubhouse	-	☐ Upgrade kitchen to commercial standard ☐ Refurbish bar and cold room storage ☐ Upgrade toilets and showers including disabled access	☐ Ensure the club remains a viable not-for-profit community organisation
Equipment	-	☐ Purchase a new zero turn mower and tractor and slasher ☐ Establish sinking fund for major maintenance and upgrades to ageing clubhouse and equipment	☐ Ensure access to maintenance equipment for golf course and clubhouse surrounds



ross planning recreation open space sport

Narrabri Shire Heart of the North West

PROPOSED SITE LAYOUT (BY ACTIVITY / USE)

LOCATION: BELLATA OVAL PRECINCT

CLIENT: NARRABRI SHIRE COUNCIL

MAY 2019
REV. B

NORTH

1:2000 at A3

0 20 40 100 200m

26 / 43

Narrabri Shire Council

PROPOSED PRIMITIVE CAMPGROUND (UNDESIGNATED)

LOCATION: BELLATA OVAL PRECINCT
CLIENT: NARRABRI SHIRE COUNCIL

ross planning recreation open space sport | NARRABRI SHIRE DISCOVER THE POTENTIAL

May 2019
Rev. B

NORTH

1:1250 at A3

0 12.5 25 50 100m

ross planning recreation open space sport

NARRABRI SHIRE DISCOVER THE POTENTIAL

PROPOSED PRECINCT PLAN: OPTION 1

LOCATION: BELLATA OVAL PRECINCT

CLIENT: NARRABRI SHIRE COUNCIL

May 2019
Rev. B

NORTH

1:1250 at A3

0 12.5 25 50 100m

ross planning recreation open space sport

NARRABRI SHIRE DISCOVER THE POTENTIAL

PROPOSED PRECINCT PLAN: OPTION 2

LOCATION: BELLATA OVAL PRECINCT
CLIENT: NARRABRI SHIRE COUNCIL

June 2019
Rev. C

NORTH

1:1250 at A3

0 12.5 25 50 100m

ross planning recreation open space sport

NARRABRI SHIRE DISCOVER THE POTENTIAL

PROPOSED PRECINCT PLAN: OPTION 3

LOCATION: BELLATA PARK, NORTH STREET
CLIENT: NARRABRI SHIRE COUNCIL

Aug 2019
Version: A

NORTH

1:400 at A3

0 4 8 16 32m

30 / 43

Narrabri Shire Council

Play area

The following images are provided as examples to further explain the concepts identified in the precinct plan. A play area is proposed to support the golf club to develop into a destination where a broader cross-section of the community can socialise, particularly families with children. The images provided here are examples of the following recommended play elements:

- imaginative and self-directed play using a mixture of play equipment and readily available materials
- water play that is sensitive to the need to conserve water and that can be maintained locally
- 'street library' for exchange of community donated books and board games - one could be aimed at primary school children, another for teenagers and another for adults
- some play elements aimed at older youth and teenagers including swings and hammock
- fixed all-weather shelter
- extension of child-proof/pool fencing to define the play area.

Communal area

The following images are provided as examples to assist to explain the concept for the communal area.

The purpose of the shelter and fire or yarning circle is to provide a location for various groups in the Bellata community to meet, connect and socialise together. These groups include:

- families and community members
- school parents and carers attending annual school sports
- travellers visiting Bellata and the surrounding area.

Every community requires places to gather and connect socially. Sharing a meal is common way to achieve this. Permanent residents of Bellata need opportunities to socialise just as much as travellers visiting the town for a few days. The area could also be used by the school for the annual athletics carnival and cross-country competition, as well as an outdoor classroom for learning opportunities.

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Multi-sport court

The purpose of the multi-sport court with court lighting is to recognise the growing trend of people seeking out and participating in social games of sport rather than competition. This social aspect often extends to sharing a meal and can include families and diverse age groups. This in turn could contribute to ongoing viability of the golf club as a community facility, as shown in option 1. An alternative is provided showing the existing tennis courts refurbished in option 2. Sport courts also provide a safe place for older youth, teenagers and active young adults to interact and socialise. The proposed location close to the golf clubhouse provides access to toilets and purchased snacks.

While travellers most likely to stop and stay in Bellata are predominantly semi-retired and retired people, this age group is often active. Access to equipment to allow use of the sport court during their stay could encourage positive reviews and entice more travellers to visit.

5.3 Staged implementation and indicative costing

The cost to develop the precinct plan is beyond the Council's and the community's ability to fund in the short-term. Thus, this section provides staged budgeting. The information provided is designed as a flexible guide - changes in priorities or earlier opportunities for funding may alter staging. Timeframes are indicative and generally mean: short-term = 1-2 years; medium-term = 3-5 years; and long-term = 6-10 years. The adjoining table summarises indicative costs and the project leader or organisation responsible for driving the project. The costs do not include legal fees or goods and services tax.

Where necessary, items below have been identified as relevant to option 1 or 2 of the Precinct Plan.

Stage 1 (short-term)

- ☐ Apply for Section 68 approval from Council to operate a primitive camping ground using the Bellata oval and golf club land
- ☐ Construct the communal area
- ☐ Develop the landscaped buffer between the communal area and the oval
- ☐ Replace fencing between the communal area and the oval to prevent vehicles and stock from accessing the oval
- ☐ Define truck turnaround and overflow parking areas
- ☐ Install directional signage on the Newell Highway providing direction to travellers and seasonal workers
- ☐ Install vehicle speed limit signs within the car parking area and heavy vehicle warning signs for the truck turnaround
- ☐ Support the Golf Club to extend the child-proof/pool fencing to the rear of the golf clubhouse and the children's play area (option 1)
- ☐ Increase tree planting through the site to provide additional shade and shelter

Stage 2 (medium-term)

- ☐ Create an entry statement to the precinct at the Berrigal Road entrance
- ☐ Replace property boundary fencing (post, mesh and wire)
- ☐ Increase tree planting through the site to provide additional shade and shelter
- ☐ Consider use of signage bollards to provide direction and distance to destinations within the precinct and town
- ☐ Design upgrade to kitchen, secure funding and complete upgrades
- ☐ Redevelop the golf clubhouse barbeque area and create a play area for children (option one)
- ☐ Create a play area for children at the rear of the existing tennis courts (option two)
- ☐ Upgrade the toilets and showers and improve access for people with a disability
- ☐ Install interpretive and information map and sign promoting activities and sites of interest in the area

Stage 3 (long-term)

- ☐ Renew one of the tennis court surfaces at the existing courts and construct a lit multi-sport court within golf club grounds (option one)
- ☐ Remove the internal posts and nets of one of the existing tennis courts to create a level surface for play and activities associated with the kindergarten (option one)
- ☐ Resurface the existing tennis courts to establish one tennis court and one multi-sport court (option two)
- ☐ Identify service requirements for on-site (cabin-style) accommodation (wastewater disposal, water supply, power)
- ☐ Increase tree planting through the site to provide additional shade and shelter
- ☐ Apply to Council for relevant approvals for on-site accommodation (cabin style) and construct.

Option one

Stage	Area	Description	Council	Community
1	Primitive camping ground	Apply for Section 68 approval from Council to operate a primitive camping ground using the Bellata oval and golf club land	-	$588*
	Oval	Construct the communal area	$25,000	-
		Develop a landscaped buffer between the communal area and the oval	$5,000	-
		Replace fencing between the communal area and the oval	$7,500	-
		Define truck turnaround and overflow parking areas	$5,000	-
		Install directional signage on the Newell Highway	$50*	-
	Golf Club	Install vehicle speed limit signs within car parking area and heavy vehicle warning signs for the truck turnaround	-	$150*
		Extend child-proof/pool fencing to the rear of the golf clubhouse to enclose the children's play area	-	$15,000
	Oval and Golf Club	Increase tree planting through the site to provide additional shade and shelter	$1,500	$1,500
	Bellata Park	Remove old equipment retaining half court, shelter and table and chair settings	$2,000	-
		Install posts, mesh and wire fence through centre of existing park at rear of shelter to define new park area	$3,500	-
	Stage 1	*Sub-total (with rounding)*	*$49,500*	*$16,500*
2	Oval	Replace property boundary fencing (post, mesh and wire)	$22,500	-
	Golf Club	Upgrade golf club kitchen	-	$30,000
		Redevelop golf club barbeque area and create play area for children including fixed roof shelter	-	$85,000
		Upgrade toilets and showers and improve access for people with a disability	-	$82,500
	Oval and Golf Club	Increase tree planting through the site to provide additional shade and shelter	$750*	$750*
		Create an entry statement to the precinct at the Berrigal Road entrance	$750*	$750*
		Consider use of signage bollards to provide direction and distance to destinations	$2,500	-
		Install interpretive and information map and sign promoting activities and sites of interest in the area	$5,000	-
	Stage 2	*Sub-total (with rounding)*	*$30,000*	*$197,500*
3	Oval and Golf Club	Increase tree planting through the site to provide additional shade and shelter	$750*	$750*
	Golf Club	Identify service requirements for on-site accommodation	-	$35,000
		Apply to Council for relevant approvals for on-site accommodation and construct	-	$80,000
	Tennis courts	Remove the internal posts and nets of the existing tennis courts to create a level surface for play and activities associated with kindergarten	-	$1,500
	Golf Club	Construct a lit multi-sport court within golf club grounds	$210,000	-
	Stage 3	*Sub-total (with rounding)*	*$210,000*	*$116,500*
Sub-total			*$289,500*	*$330,500*
		Contingency and sundry site works (10%)	*$28,950*	*$33,050*
Sub-total			*$318,450*	*$366,190*
		Escalation (2%)	*$6,369*	*$7,324*
TOTAL (excl GST)			*$324,819*	*$373,514*

*Maximum 42 sites x $14.00 per site/annually = $588.00 annually (2019). Operational cost listed but excluded from total capital costs.

Option two

Stage	Area	Description	Council	Community
1	Primitive camping ground	Apply for Section 68 approval from Council to operate a primitive camping ground using the Bellata oval and golf club land	-	$588*
	Oval	Construct the communal area	$25,000	-
		Develop a landscaped buffer between the communal area and the oval	$5,000	-
		Replace fencing between the communal area and the oval	$7,500	-
		Define truck turnaround and overflow parking areas	$5,000	-
		Install directional signage on the Newell Highway	$50*	-
	Golf Club	Install vehicle speed limit signs within car parking area and heavy vehicle warning signs for the truck turnaround	-	$150*
	Oval and Golf Club	Increase tree planting through the site to provide additional shade and shelter	$1,500	$1,500
	Tennis courts	Design and construct a new children's play area on one of the existing tennis courts including shade shelter	–	$75,000
	Bellata Park	Remove old equipment retaining half court, shelter and table and chair settings	$2,000	-
		Install posts, mesh and wire fence through centre of existing park at rear of shelter to define new park area	$3,500	-
	Stage 1	*Sub-total (with rounding)*	*$49,500*	*$56,650*
2	Oval	Replace property boundary fencing (post, mesh and wire)	$22,500	-
	Stage 2	*Sub-total (with rounding)*	*$22,500*	-
3	Tennis courts	Resurface one of the tennis courts to create a multi-sport court (eg. tennis, netball, basketball)	$160,000	-
	Stage 3	*Sub-total (with rounding)*	*$160,000*	-
Sub-total			*$232,000*	*$56,650*
		Contingency and sundry site works (10%)	*$23,200*	*$5,665*
Sub-total			*$255,200*	*$62,315*
		Escalation (2%)	*$5,100*	*$1,250*
TOTAL (excl GST)			*$260,300*	*$63,565*

*Maximum 42 sites x $14.00 per site/annually = $588.00 annually (2019). Operational cost listed but excluded from total capital costs.

Option three

Stage	Area	Description	Council	Community
1	Primitive camping ground	Apply for Section 68 approval from Council to operate a primitive camping ground using the Bellata oval and golf club land	-	$588*
	Oval	Replace fencing between the communal area and the oval	$7,500	-
		Define truck turnaround and overflow parking areas	$5,000	-
		Install directional signage on the Newell Highway	$50*	-
	Golf Club	Install vehicle speed limit signs within car parking area and heavy vehicle warning signs for the truck turnaround	-	$150*
	Oval and Golf Club	Increase tree planting through the site to provide additional shade and shelter	$1,500	$1,500
	Bellata Park	Remove old equipment retaining half court, shelter and table and chair settings	$2,000	-
		Construct internal pathways, obstacle course circuit, rebound wall and plant additional shade trees throughout site	$100,000	-
	Stage 1	*Sub-total (with rounding)*	*$116,000*	*$2,100*
2	Oval	Replace property boundary fencing (post, mesh and wire)	$22,500	-
	Bellata Park	Construct and install exercise station site including softfall and shade	$50,000	
	Stage 2	*Sub-total (with rounding)*	*$72,500*	*$0*
Sub-total			*$188,500*	*$2,100*
		Contingency and sundry site works (10%)	*$18,850*	*$210*
Sub-total			*$207,350*	*$2,310*
		Escalation (2%)	*$4,150*	*$50*
TOTAL (excl GST)			*$211,500*	*$2,360*

*Maximum 42 sites x $14.00 per site/annually = $588.00 annually (2019). Operational cost listed but excluded from total capital costs.

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6 Appendix

6.1 Local Government (Manufactured Home Estates, Caravan Parks, Camping Grounds and Moveable Dwellings) Regulation 2005

Subdivision 9 Primitive camping grounds

132 Primitive camping grounds

(1) If an approval to operate a primitive camping ground designates one or more camp sites within that ground, then the maximum number of designated camp sites is not to exceed a mean average of 2 for each hectare of the camping ground (where that figure is the average calculated over the total area of the primitive camping ground).

(2) The following conditions apply to a primitive camping ground:

(a) if the approval to operate the primitive camping ground designates one or more camp sites within that ground—camping is not permitted within the primitive camping ground other than on those designated camp sites,

(b) if the approval to operate the primitive camping ground does not designate one or more camp sites within that ground—the maximum number of caravans, campervans and tents permitted to use the camping ground at any one time is not to exceed a mean average of 2 for each hectare of the camping ground (where that figure is the average calculated over the total area of the primitive camping ground),

(c) a caravan, annexe or campervan must not be allowed to be installed closer than 6 metres to any other caravan, annexe, campervan or tent,

(d) a tent must not be allowed to be installed closer than 6 metres to any caravan, annexe or campervan or closer than 3 metres to any other tent,

(e) the camping ground must be provided with a water supply, toilet and refuse disposal facilities as specified in the approval for the camping ground,

(f) unoccupied caravans, campervans and tents are not to be allowed to remain in the camping ground for more than 24 hours,

(g) if a fee is charged for camping, a register must be kept that contains entries concerning the same matters as are specified in clause 122 and, in addition, that specifies the size of the group (if any) with whom the person listed in the register camped,

(h) such fire fighting facilities as may be specified in the approval are to be provided at the primitive camping ground.

(3) If the approval to operate a primitive camping site does not designate camp sites, a council may impose as a condition of the approval that the installation of tents, caravans, campervans and annexes is not permitted on a particular area or areas of land within the primitive camping ground, for reasons of health or safety or to ensure consistency with the principles of ecologically sustainable development or for any other purpose.

(4) The provisions of Subdivisions 1–8 do not apply to a primitive camping ground.

(5) For the purposes of subclause (2) (b), in the calculation of the number of tents using a camping ground, 2 or more tents occupied by not more than 12 persons camping together as a group are to be counted as only one tent.

6.2 Splash park indicative location

Splash park

Splash parks (also referred to as water parks) are:

- classified as an aquatic centre
- required to use treated and usually heated water that requires control and monitoring for health reasons
- usually aimed at cooling-off and active play rather than immersion
- either zero depth or include shallow pools (the latter requires a lifeguard)
- considered a destination by the public therefore require support facilities including car parking, toilets, change rooms, shaded seating, rubbish bins and picnic facilities for example
- usually targeted to infants and primary aged school children and their families
- typically accessible for people with mobility issues
- relatively expensive to manage.

Feasibility study

It is essential that Council commission an independent feasibility study prior to committing funds toward development of a splash park in Bellata. This will be a requirement for external funding applications. Typically a feasibility study will investigate the following:

- assess capital, operational and maintenance costs
- assess site options
- consider management requirements including free or fee structure
- benchmark other facilities
- provide an indicative concept
- provide an opinion of probably capital cost.

Indicative location

Inclusion of an indicative location for a splash park was requested to be included in the Precinct Plan by senior Council officers.

There are two Council owned and managed parks in Bellata that could be considered as locations for a splash park. These are Bellata Park (also known as Bellata Picnic Park) and Bellata Oval. Consideration of private sites is not recommended due to the high capital and ongoing maintenance costs involved in development of splash parks, however could be included in Council's investigations, if desired. Without undertaking a detailed site assessment, of the two Council owned and managed sites, the more suitable of the two is likely to be Bellata Park due to the available land, proximity to residents, passing travellers and essential services (electricity, water etc.).

Legislation

The NSW Public Health Act 2010 (including the Public Health Amendment (Review) Act 2017) and Public Health Regulation 2012 control the public health risks associated with public swimming pools. Splash or water parks are subject to the same water disinfection requirements as public pools, to protect users from disease transmission in these environments. Water filtration and disinfection will be a significant contributor to capital, operating and maintenance costs of any proposed water park in Bellata.

Types of splash parks

Different styles of water play parks/splash parks have been developed to serve specific population catchments in a variety of contexts and for different reasons. Some examples and categories of splash parks include:

- Local, outdoor - zero depth single elements within a destination play space
- District, outdoor - dedicated splash parks (usually in conjunction with other local play elements or outdoor seasonal pool)
- District, outdoor - splash park with pools in regional parkland or river location
- Regional, outdoor - dedicated splash park in conjunction with a Council/regional aquatic centre
- Regional, indoor - splash park/water playground with regional aquatic centre
- Regional, large-scale - commercial water-based adventure playgrounds.

Probably capital costs

An opinion of cost is provided below for various sizes of splash parks (excluding design, plant components and landscaping costs):

- $225,000 - 50 square metre pad only
- $300,000 - 100 square metre pad including grounds sprays only
- $500,000 - 200 square metre pad including 30 plus features.

Plant components include plant room shed, filters, pumps, chlorine and acid dosing system, concrete in-ground balance tank, manifold and solenoid valves for feature control, electrical switchboard and wiring and pipework.

Operations

The cost of operations can vary between $1,500 - $8,000 per month and has a number of variables to consider including:

- water
- electricity (circulation pump and features)
- staffing (backwashing, water testing, cleaning)
- staff training
- cleaning (pressure washing surface, surrounds)
- rubbish removal
- grounds maintenance
- water testing (minimum daily, best practice 2-4 hourly)
- chemicals (chlorine, acid)
- repair and maintenance (servicing pumps and dosing equipment)
- insurance
- marketing
- security.


Eureka Aquatic Centre, Ballarat


Ian Potter Children's Playground, Melbourne


Broadwater Parklands, Gold Coast


Long Gully splash park, City of Greater Bendigo


Mildura Water Play Park, Mildura


Steel Park, Inner West Council


Wynnum Whale Park, Brisbane


Deniliquin, NSW

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NARRABRI SHIRE COUNCIL

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

AUGUST 2019

VOLUME 1 – REPORT

DRAFT REPORT FOR PUBLIC EXHIBITION

Job No: EE409 File: WWL_V1_Report_Rev 1.2.doc	Date: August 2019 Rev No: 1.2	Principal: SAB Authors: SAB/TDR

FOREWORD

NSW Government's Flood Policy

The NSW Government's Flood Prone Land Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities. The Policy provides for technical and financial support by the State through the following four sequential stages:

1.	Data Collection and Flood Study	Collects flood related data and undertakes an investigation to determine the nature and extent of flooding.
2.	Floodplain Risk Management Study	Evaluates management measures for the floodplain in respect of both existing and proposed development.
3.	Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
4.	Implementation of the Plan	Construction of flood mitigation works to protect existing development. Use of Local Environmental Plans to ensure new development is compatible with the flood hazard. Improvements to flood emergency management procedures.

Presentation of Study Results

The results of the flood study investigations commissioned by Narrabri Shire Council have been presented in two separate reports:

- *Wee Waa Levee Flood Investigation* dated June 2015.
- ***Wee Waa Levee Risk Management Study & Plan (this present report)***

The studies have been prepared under the guidance of the Floodplain Risk Management Committee comprising representatives from Narrabri Shire Council, the Office of Environment and Heritage, the NSW State Emergency Service and the community.

ACKNOWLEDGEMENT

Narrabri Shire Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

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ABBREVIATIONS

AEP	Annual Exceedance Probability (%)
AHD	Australian Height Datum
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff (1987 Edition)
BoM	Bureau of Meteorology
Council	Narrabri Shire Council
DECC	Department of Environment and Climate Change
FDM	Floodplain Development Manual, 2005
FFA	Flood Frequency Analysis
FRMC	Floodplain Risk Management Committee
FPL	Flood Planning Level (1% AEP flood level + freeboard)
FPA	Flood Planning Area
ICA	Insurance Council of Australia
LRMS	Levee Risk Management Study
LRMP	Levee Risk Management Plan
LRMS&P	Levee Risk Management Study and Plan
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging (form of aerial based survey)
NSWG	New South Wales Government
NSW SES	New South Wales State Emergency Service
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation

SUMMARY

S1 Study Objectives

Narrabri Shire Council (**Council**) commissioned the *Levee Risk Management Study and Plan* for the township of Wee Waa. The overall objectives of the *Levee Risk Management Study (**LRMS**)* were to assess the impacts of flooding, review existing Council policies as they relate to development of land in flood liable areas, consider measures for the management of flood affected land and to develop a *Levee Risk Management Plan (**LRMP**)* which:

i) Proposes modifications to existing Council policies to ensure that the development of flood affected land is undertaken so as to be compatible with the flood hazard and risk.

ii) Sets out the recommended program of works and measures aimed at reducing over time, the social, environmental and economic impacts of flooding.

iii) Provides a program for implementation of the proposed works and measures.

While the *LRMS* focuses principally on the existing, continuing and future flood risk associated with the urbanised parts of Wee Waa which are bounded by an 8.6 km long earthen ring levee (**Town Levee**), recommendations for managing the flood risk in a 228 ha area which lies to the south-east of Wee Waa which is zoned *R5 Large Lot Residential* are also set out in the report.

S2 Study Activities

The activities undertaken in this *LRMS* included:

1. Undertaking a consultation program over the course of the study to ensure that the Wee Waa community was informed of the objectives, progress and outcomes over the course of the study (**Chapter 1** and **3**, as well as **Appendix A**). Consultation was also undertaken with the insurance industry to gauge the likely reduction in insurance premiums that would be achieved by upgrading the Town Levee (**Chapter 1**).
2. Undertaking of a preliminary geotechnical assessment of the condition of the Town Levee (**Appendix B**).
3. Analysis of historic stream flow data to update the flood frequency relationship that has been derived for WaterNSW's *Namoi River at Mollee* stream gauge (**Chapter 2** and **Appendix C**).
4. Updating of the hydraulic model that was developed as part of the *Wee Waa Levee Flood Investigation* (URS, 2015) (***Flood Study***), as well as the development of a new hydraulic model which was used to define local drainage patterns internal to the Town Levee (**Chapter 2** and **Appendix C**).
5. Assessment of the economic impacts of flooding, including the numbers of affected properties and estimation of flood damages (**Chapter 2** and **Appendix D**).
6. Review of current flood related planning controls for Wee Waa and their compatibility with flooding conditions (**Chapter 2**).
7. Strategic review of potential floodplain management works and measures aimed at reducing flood damages, including a freeboard analysis for the Town Levee and an economic assessment of several measures (**Chapter 3** and **Appendix E**).
8. Ranking of works and measures using a multi-objective scoring system which took into account economic, financial, environmental and planning considerations (**Chapter 4**).
9. Preparation of a draft *LRMP* for Wee Waa (**Chapter 5**).

S3 Summary of Existing Flood Risk

The present study identified that the design standard of the Town Levee is equivalent to about a 5% AEP flood. It also identified that the flood range at Wee Waa is not large and that in the absence of any wind or wave action on the surface of the floodwater, the Town Levee would not be overtopped for floods up to about 0.1% AEP in magnitude.[1]

Figure 2.1 shows the alignment of the Town Levee, while **Figure 2.2** is a longitudinal section showing the elevation of the earth embankment relative to the adjacent floodplain. Also shown on **Figures 2.2** are the design water surface levels along the river side of the Town Levee for floods with AEPs of between 5% and 0.2%, as well as the Extreme Flood. **Figures 2.3** to **2.9** show the indicative extent and depths of inundation both internal and external to the Town Levee for the full range of assessed flood events.

While the Town Levee is likely to prevent major flood damages from being experienced in Wee Waa for floods of up to 0.1% AEP in magnitude (i.e. because the earthen embankment was found to generally be in good condition and is unlikely to fail unless major overtopping occurs), it cannot be relied upon for protecting the local community for floods larger than 5% AEP. This is because the NSW State Emergency Service (**NSW SES**) would deem the Town Levee to be at significant risk of failure during floods larger than 5% AEP and would therefore require the town to be evacuated prior to the arrival of the flood wave.

Should the Town Levee fail or be overtopped during a flood event, then the total flood damages in Wee Waa would be about $117 Million. The "present worth value" of damages resulting from either of these eventualities is estimated to be about $100 Million.

In the event that a 1% AEP storm event occurs over Wee Waa in the absence of elevated water levels in the Namoi River, only one residential and one commercial property would experience above-floor inundation. The number of above-floor inundated properties would increase to four residential and three commercial properties should a 1% AEP storm event occur when the penstock gates that are fitted to the fourteen stormwater pipes which extend through the Town Levee are closed and the six stormwater evacuation pumps are operational. The total flood damages that would be experienced in Wee Waa at the 1% AEP level of flooding under the latter conditions is about $0.9 Million, while the "present worth value" of damages resulting from all localised storms up to 1% AEP in intensity at a seven per cent discount rate and 50 year economic life is $0.4 Million. This number represents the amount of capital spending that would be justified if a particular stormwater upgrade scheme prevented flooding for all properties in Wee Waa up to the 1% AEP event.

S4 Development Controls

The key issue for Wee Waa is that given the design standard of the Town Levee is only equivalent to a 5% AEP flood, Council's current planning documents, namely its *Interim Floodplain Management Policy* referred to in Council's *Exempt & Complying Development DCP* are inconsistent with the NSW Government's Section 9.1 Direction given they allow development in the town to occur below the peak 1% AEP flood level on the Namoi River floodplain plus an allowance for freeboard (which in areas subject to riverine flooding is generally set at 0.5 m).

[1] The AEP of the flood that would first overtop of the Town Levee and is based on interpolation between peak flood levels resulting from a 0.2% AEP flood event and the Extreme Flood.

As it is not practical to set floor levels in Wee Waa above the peak 1% AEP Namoi River flood level (i.e. because the floor level of most dwellings would need to be set more than 1.5 m above natural ground levels), development in the town could only proceed if the design standard of the Town Levee is upgraded to 1% AEP.

Should the Town Levee be upgraded to a 1% AEP standard, then the controls that would need to be applied to future development need only amount to a minimum floor level control which is equal to the Flood Planning Level (**FPL**).[2] Note that the FPL would be based on depths of inundation resulting from runoff that is generated internal to the Town Levee, not Namoi River flooding. **Figure 3.7**, sheet 1 shows the extent of the Flood Planning Area (**FPA**)[3] internal to the Town Levee under post-upgrade conditions, as well as the corresponding FPLs.

In regards the large parcel of land that is zoned *R5 Large Lot Residential* south-east of Wee Waa, it is recommended that the portion that is classified as either *Floodway* or *High Hazard Flood Storage* at the 1% AEP level of flooding (refer **Figure 2.23**, sheet 1) be rezoned not to permit future residential and commercial type development. As the remainder of the area either lies above the 1% AEP flood level or is classified as *Flood Fringe*, then future development located within the extent of the FPA need only be subject to a minimum floor level control set equal to the FPL. **Figure 3.7**, sheet 2 shows the extent of the FPA in this area, as well as the corresponding FPLs.

S5 The Floodplain Risk Management Plan

The *LRMP* setting out recommended flood management measures for Wee Waa is presented in **Chapter 5**, with the recommended works and measures summarised below. The recommended works and measures have been given a provisional priority ranking, confirmed by the Floodplain Risk Management Committee, according to a range of economic, social, environmental and other criteria set out in **Table 4.1** of the report.

The draft *LRMP* includes four management measures which could be implemented by Council with the assistance of New South Wales State Emergency Service (**NSW SES**), all of which would not require State Government funding. The four measures are as follows:

- **Measure 1** – Council to consider updating its flood related development controls so as to recognise that the town is subject to inundation as a result of local catchment runoff which is generated internal to the Town Levee. While application of these controls by Council would ensure that future development in flood liable areas in Wee Waa is compatible with the flood risk, in relation to residential type development they can only be applied after the design standard of the Town Levee is increased to 1% AEP.[4]
- **Measure 2** – Council to consider making minor amendments to the wording of clause 6.2 of the *Narrabri Local Environmental Plan 2012*, as well as the inclusion of a new floodplain risk management clause which would apply to land which lies between the FPA and the Extreme Flood.
- **Measures 3** - Improvements in the NSW SES's emergency response planning, including use of the flood related information contained in this study to update the *Narrabri Shire Local Flood Plan*.

[2] The FPL is defined as the peak 1% AEP flood level plus an allowance of 500 mm for freeboard.

[3] The FPA is defined as land that lies at or below the FPL.

[4] In order to comply with the NSW Government's Section 9.1 Direction, no new residential type development should occur in Wee Waa below the peak 1% AEP Namoi River flood level plus an allowance of 500 mm for freeboard until such time as the Town Levee has been upgraded.

- **Measure 4** - Council should take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplain of the flood risk. This could be achieved through the preparation of a *Flood Information Brochure* which could be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with rate notices.

Measure 5 of the *LRMP* comprises the investigation and concept design of the Town Levee upgrade, while **Measure 6** comprises the detailed design and construction of the works.

While the upgrade of the Town Levee cannot be justified on economic grounds unless the impacts of a potential levee failure condition are taken into account, its upgrade would provide significant social benefits such as:

- allowing Council to approve future residential development which is set below the peak 1% AEP flood level external to the Town Levee plus 0.5 m freeboard;
- reduce the likelihood of major overtopping and/or a possible partial failure of the earthen embankment;
- reduce annual insurance premiums, which based on preliminary advice received from the Insurance Council of Australia could be around $250 per household; and
- improve provisions for the timely and safe evacuation of people by air should they not self-evacuate prior to the closure of the road network by rising floodwater.

Measures 1 to **5** have been assigned a **Priority 1** ranking in the *LRMP*, while **Measure 6** has been assigned a **Priority 2** ranking given its medium to long term nature.

S6 Timing and Funding of LRMP Measures

The total estimated cost to implement the preferred floodplain management strategy is **$7.55 Million**, exclusive of Council and NSW SES Staff Costs. The timing of the measures will depend on Council's overall budgetary commitments and the availability of both Local and State Government funds.

Assistance for funding qualifying projects included in the *LRMP* may be available upon application under the Commonwealth and State funded floodplain management programs, currently administered by the Office of Environment and Heritage.

S7 Council Action Plan

1. Council finalises the *LRMS* report and approves the draft *LRMP* according to the procedure recommended in **Section 5.13**.
2. Council and NSW SES commence work on the "non-structural" measures in the *LRMP* (**Measures 1**, **2**, **3** and **4**).
3. Council apply for Government Funding to undertake the investigation and concept design of the Town Levee upgrade (**Measure 5** of the *LRMP*).
4. Following the completion of the investigation and concept design of the upgrade requirements for the Town Levee, Council to apply for Government Funding to undertake the detailed design and construction of the levee upgrade works (**Measure 6** of the *LRMP*).

1 INTRODUCTION

1.1 Study Background

Narrabri Shire Council (**Council**) commissioned the preparation of the *Levee Risk Management Study and Plan* (***LRMS&P***) for the township of Wee Waa in accordance with the New South Wales Government's Flood Prone Land policy. This report sets out the findings of the *LRMS&P* investigation which utilises an updated set of flood models that were originally developed as part of the *Wee Waa Levee Flood Investigation* (***Flood Study***) (URS, 2015). **Figure 1.1** shows the location of Wee Waa, which lies about 34 km to the west of Narrabri on the Namoi River floodplain.

The *Levee Risk Management Study (**LRMS**)* reviewed baseline flooding conditions, including an assessment of economic impacts and the feasibility of potential measures aimed at reducing the impact of both local catchment and riverine flooding on both existing and future development at Wee Waa. This process allowed the formulation of the *Levee Risk Management Plan* (***LRMP***) for Wee Waa.

1.2 Background Information

The following documents were used in the preparation of this report.

- *Audit of Flood Levees for New South Wales – Town of Wee Waa* (Public Works (**PW**), 1992)
- *Narrabri – Wee Waa Flood Study* (Department of Infrastructure, Planning & Natural Resources (**DIPNR**), 2003)
- *Floodplain Development Manual* (New South Wales Government, 2005)
- *Narrabri-Wee Waa Floodplain Management Plan (Department of Natural Resources, 2005)*
- *Narrabri Local Environmental Plan, 2012* (*Narrabri LEP 2012*)
- *Wee Waa Levee Flood Investigation* (URS, 2015) (***Flood Study***)
- *Narrabri Shire Local Flood Plan, 2015* (NSW State Emergency Service (**NSW SES**), 2015)
- *Narrabri Flood Study – Namoi River, Mulgate Creek and Long Gully* (WRM Water & Environment (**WRM**), 2016)

1.3 Overview of LRMS Report

The results of the *LRMS* and the *LRMP* are set out in this report. Contents of each Chapter of the report are briefly outlined below:

- **Chapter 2**, **Baseline Flooding Conditions**. This Chapter includes a description of the existing drainage system, as well as the earthen ring levee which was built following the damaging February 1971 flood to protect Wee Waa from riverine flooding (herein denoted the "**Town Levee**"). The Chapter also includes a review of existing flood behaviour at Wee Waa, summarises the economic impacts of flooding on existing urban development, reviews Council's existing flood planning controls and management measures and NSW SES's flood emergency planning.

- **Chapter 3**, **Potential Floodplain Management Measures**. This Chapter reviews the feasibility of floodplain management measures for their possible inclusion in the *LRMP*. The list of measures considered is based on input from the Community Consultation process, which sought the views of residents and business owners in Wee Waa in regards to potential flood management measures which could be included in the *LRMP*. The measures are investigated at the strategic level of detail, including an indicative cost estimate of the upgrade of the Town Levee and benefit/cost analysis.
- **Chapter 4**, **Selection of Floodplain Management Measures**. This Chapter assesses the feasibility of potential floodplain management strategies using a multi-objective scoring procedure which was developed in consultation with the Floodplain Risk Management Committee (**FRMC**) and outlines the preferred strategy.
- **Chapter 5** presents the *LRMP* which comprises a number of structural and non-structural measures which are aimed at increasing the flood awareness of the community and ensuring that future development is undertaken in accordance with the local flood risk.
- **Chapter 6** contains a glossary of terms used in the study.
- **Chapter 7** contains a list of References.

Six appendices provide further information on the study results:

Appendix A – Community Consultation summarises residents' and business owners' views on potential flood management measures which could be incorporated in the *LRMP*.

Appendix B – Preliminary Geotechnical Assessment contains a copy of a report which sets out the findings of a preliminary assessment which was undertaken by Michael Adler & Associates Pty Ltd on the condition of the Town Levee and the proposed methodology for its upgrade.

Appendix C – Updated Flood Modelling sets out the approach which was adopted for updating the flood frequency analysis and hydraulic modelling that was undertaken as part of the *Flood Study*, as well as the development of new hydrologic and hydraulic models that were used to define the nature of local catchment flooding internal to the Town Levee.

Appendix D – Flood Damages is an assessment of the economic impacts of both riverine and local catchment flooding to existing residential, commercial and industrial development, as well as public buildings in Wee Waa. The damages have been assessed using the results of the flood modelling which was undertaken as part of the present study, an estimate of floor levels and characteristics of affected development derived from a 'drive-by' survey to estimate floor heights above a natural surface level derived from Light Detecting and Ranging (**LiDAR**) survey data. A damages assessment was also carried out assuming a partial failure of the Town Levee, as well as a scenario where the pumps that are used to evacuate local catchment runoff internal to the Town Levee also fail.

Appendix E – Levee Freeboard Analysis sets out the results of a preliminary analysis which was undertaken to derive the freeboard allowance which has been incorporated in the concept design of the Town Levee.

Appendix F - Details of Town Levee Upgrade Requirements contains a set of figures showing the plan layout and cross sections of the assessed levee upgrade requirements.

1.4 Community Consultation

Following the Inception Meeting of the FRMC which included representatives from Council, NSW Office of Environment and Heritage (**OEH**), NSW SES and the community, a *Community Newsletter* was prepared by the Consultants and distributed by Council to residents and business owners in Wee Waa. The *Community Newsletter* contained a *Community Questionnaire* seeking details from the community of flood experience and attitudes to potential floodplain management measures. The views of the community on potential flood management measures to be considered in the study were also taken into account in the assessment presented in **Chapter 3** of the report, with supporting information in **Appendix A.**

The FRMC reviewed the potential flood management measures developed in **Chapter 3** and assessed the measures using the proposed scoring system of **Chapter 4**. The *LRMS* and accompanying *LRMP* were also reviewed by the FRMC and amended prior to public exhibition.

1.5 Insurance Industry Consultation

During the early phase of the present study the Insurance Council of Australia (**ICA**) was contacted and asked to contact its members to seek a comparison of insurance premiums under pre- and post-Town Levee upgrade conditions. GIS data showing the nature of flooding at Wee Waa based on the findings of the *Flood Study* were provided to ICA at the time.

Prior to contacting its members ICA undertook an unsophisticated assessment of the potential reduction in Average Annual Damages as a very rough proxy for the premium reductions that may be possible if the Town Levee was to be upgraded. ICA's initial analysis indicated that reducing the risk of the 1% AEP flood event for median sum-insureds behind the Town Levee could result in a reduction of between $150 and $250 in annual premiums.

The results of the analysis were forwarded by ICA to its members. ICA later advised Council that no responses were received from its members that would alter its initial findings.

1.6 Flood Frequency and Terminology

In this report, the frequency of floods is referred to in terms of their Annual Exceedance Probability (**AEP**). The frequency of floods may also be referred to in terms of their Average Recurrence Interval (**ARI**). The approximate correspondence between these two systems is:

Annual Exceedance Probability (AEP) – %	Average Recurrence Interval (ARI) – years
0.2	500
0.5	200
1	100
10	10
20	5

The AEP of a flood represents the percentage chance of its being equalled or exceeded in any one year. Thus a 1% AEP flood, which is equivalent to a 100 year ARI, has a 1% chance of being equalled or exceeded in any one year and would be experienced, on the average, once in 100 years; similarly, a 20 year ARI flood has a 5% chance of exceedance, and so on.

Reference is also made in the report to the Extreme Flood. This flood is much rarer than the 1% AEP flood, which is usually adopted for planning purposes. It approximates the Probable Maximum Flood (**PMF**) and defines the upper limit of flooding that could reasonably be expected to occur. The discharge hydrographs of the Extreme Flood were derived by applying a multiplication factor of three (3) to the corresponding 1% AEP discharge hydrographs.

2 BASELINE FLOODING CONDITIONS

2.1 Physical Setting

Wee Waa has a population of about 1,650 and is located on the Namoi River about 34 km west (downstream) of Narrabri. Since the construction of the Town Levee the main impacts of flooding have been the inundation of agricultural land on the floodplain and the closure of local access roads.

The following local roads traverse the study area:

- Kamilaroi Highway which runs in an east-west direction linking Wee Waa with Narrabri to the east and the village of Burren Junction to the west. The Kamilaroi Highway is generally located on the northern side of the Namoi River where it runs between Wee Waa and Narrabri. A new bridge has recently been constructed by NSW Roads and Maritime Services on the Kamilaroi Highway where it crosses the Namoi River immediately to the west of Wee Waa.
- Culgoora Road also links Wee Waa with Narrabri, but is located on the southern side of the Namoi River. A new bridge has recently been constructed on Culgoora Road where it crosses Wee Waa Lagoon.
- Vera Leap Road which runs south from Wee Waa where it crosses Wee Waa Lagoon via a low level concrete causeway. Vera Leap Road becomes Pilliga Road south of its intersection with old Pilliga Road.

While development within Wee Waa is generally located internal to the Town Levee, there are a number of rural homesteads that are located in close proximity to the town which are impacted by riverine flooding.

Wee Waa Airport is located to the south of the town on Pilliga Road on the Namoi River floodplain. An earthen levee has been built around the perimeter of the airport to protect it from Namoi River Flooding. The present study has identified that in the absence of any wind or wave action the ring levee would be overtopped during floods larger than 1% AEP in magnitude. The airport is principally used by private charter companies and local land holders and businesses as part of their agricultural activities.

2.2 Drainage System

2.2.1 Namoi River Floodplain

Figures 1.1 and **2.1** (2 sheets) show the layout of the drainage system in the vicinity of Wee Waa.

Flooding patterns at Wee Waa are largely dependent on the source of the flow. For example, floodwater originating from the upper Namoi River catchment commences to spread out across the wider Namoi River floodplain near the Myall Vale homestead which is located about 10 km upstream of the township. At this location major outflows occur from the river, with the largest breakout occurring toward the north.

The floodwater that moves north from Myall Vale inundates large tracts of land on the north-western floodplain, through Spring Plains to the Doreen area and eventually into Pian Creek, while the floodwater which breaks to the south develops a flood runner along the side of the Kamilaroi Highway. The flow which breaks out to the south initially runs alongside the road before entering O'Briens Channel and then Wee Waa Lagoon. Wee Waa is effectively isolated by road once this flow breakout develops.

Immediately upstream and downstream of Wee Waa flood flows leave the Namoi River via a number of effluent streams, the most significant of which are Gunidgera and Pian Creeks. With the exception of 'high' ridges which are located adjacent to and to the north of Pian Creek, virtually all of the land to the west of Wee Waa is inundated during a major flood.

An alternative flood pattern is caused by local catchment runoff from the streams draining the south-western slopes of the Nandewar Ranges. Spring, Bobbiwaa and Galathera Creeks form the main drainage patterns of this region. All have quite small channels and when in flood, spread over wide areas of agricultural land. The majority of the flood flow generated by the local catchment does not join the Namoi River, but rather turns to the north-west where it ultimately joins flow in the Thalaba Creek system.

While the Pilliga Road can be cut by backwater flooding from the Namoi River, runoff from the Pilliga Scrub area (Bundock, Middle or Nuble Creeks) can be sufficient to inundate the low level causeway crossing of Wee Waa Lagoon.

A summary of the WaterNSW operated stream gauges in the vicinity of Wee Waa is presented in **Table 2.1**. Water levels recorded by the Namoi River at Glencoe stream gauge (GS 419900) (**Glencoe stream gauge**) which is located about 4.3 km to the north-east of the township near the Kamilaroi Highway crossing of the Namoi River are used by NSW SES to assess the consequences of flooding at Wee Waa (refer **Section 2.4** for further details). The annual series of flood peaks that have been recorded by the Namoi River at Mollee stream gauge (GS 419039) (**Mollee stream gauge**) since September 1965 was used as part of the present study to derive design peak flow estimates for the Namoi River for later input to the hydraulic model (refer **Section 2.5** for further details).

TABLE 2.1
STREAM GAUGE DATA AT WEE WAA[1]

Station Number	Gauge Name	Period of Record
419002	Namoi River at Narrabri	January 1982 to date
419003	Narrabri Creek at Narrabri	August 1891 to date
419039	Namoi River at Mollee	September 1965 to date
419900	Namoi River at Glencoe	May 1995 to date
419060	Namoi River at Gunidgera Weir – Storage Gauge	November 1975 to date
419059	Namoi River at Downstream Gunidgera Weir	April 1976 to date
419061	Gunudgera Creek at Downstream Regulator	July 1975 to date

1. Refer **Figure 1.1** for location of stream gauges that are currently in operation at Wee Waa.

2.2.2 Rural Floodways

Since the completion of Keepit Dam in 1960, significant irrigation development has occurred within the Narrabri-Wee Waa floodplain system. During the flood events of 1964, 1971 and 1974, the area suffered several major setbacks during its period of growth with large crop and stock losses. This triggered the development of several guideline documents ('original guidelines') around 1975 to coordinate the construction of flood control works. The 'original guidelines' served as the main reference document when reviewing development applications up until 2005, when the *Narrabri-Wee Waa Floodplain Management Plan* (DNR, 2005) replaced them.

DNR, 2005 aims to provide a floodway network that will improve the current drainage of the floodplain system and allow the orderly passage of flood flows, while balancing the expressed requirements of landholders with the requirement to minimise the impact of floodplain development on natural flood flow patterns and ecological functions. **Figure 2.1**, sheet 1 shows the location of the rural levees which presently form part of the floodway network near Wee Waa.

A study undertaken by the NSW Department of Natural Resources (now OEH) in 2003 found that while the rural levees would be overtopped by a 1% AEP flood on the Namoi River, they would protect the agricultural land from a 1971 type flood. While levee works on the floodplain are subject to a licencing agreement under the Water Act 1912, OEH advised that in many cases, but not all, this licence agreement does not restrict the height to which the levees can be built. This is contrary to the requirements of the DNR, 2005 which states that all existing levees must be maintained at their current height.

2.3 Town Levee

As mentioned, the Town Levee was built in response to the damaging flooding that was experienced in February 1971. Construction of the Town Levee, which is approximately 8.6 km in length, was completed in 1978. The Town Levee is an earth embankment which generally varies in height between about 2 m and 4 m. The river side of the earth embankment generally has a slope of 3:1 (Horizontal:Vertical), while the town side has a slope of 2:1 (Horizontal:Vertical). The crest of the Town Levee, which was originally set 1 m above the peak of the 1971 flood, is typically 3 m in width. The side slopes of the earth embankment are grassed, while its crest typically comprises a gravel surface. **Figure 2.1**, sheet 2 shows the alignment of the Town Levee, while **Figure 2.2** is a long section showing its elevation relative to the adjacent floodplain.[5]

There are fourteen penstock gated stormwater drainage pipes and six stormwater evacuation pumps located around the perimeter of the Town Levee, the locations of which are shown on **Figure 2.1**, sheet 2. **Figure 2.2** shows the diameters of the fourteen penstock gated stormwater drainage pipes, as well as their approximate invert levels, while **Table 2.2** sets out the details of the six stormwater evacuation pumps.

In addition to the six stormwater evacuation pumps located along the Town Levee, Council also maintains a number of small trailer mounted pumps which are mobilised on an as-needs basis following heavy rainfall events. The trailer mounted pumps are used to reduce the depth of ponding in several areas where the rate at which stormwater runoff drains toward the penstock gated pipes is considered by affected residents and business owners to be too slow.

[5] The chainages shown on **Figures 2.1**, sheet 2 and **Figure 2.2** are identical to those adopted in the *Flood Study* and are based on a survey which was undertaken by Council in 2010.

TABLE 2.2
EXISTING STORMWATER EVACUATION PUMP DETAILS

Pump Identifier	Maximum Pump Rate (m^3/s)	Pump Ownership	Pump Type
P_01	1.0	Council	2001 Deutz Lift Pump
P_02	1.0	Council	2001 Deutz Lift Pump
P_03	0.1	Council	2006 Ford Water Cooled Lift Pump
P_04	1.0	Council	2001 Deutz Lift Pump
P_05	0.15	Namoi Cotton Alliance	40 Isuzu Turbo
P_06	0.1	Namoi Cotton Alliance	22 Isuzu

Design drawings prepared by Water Resources Consulting Services in 1993 entitled "*Wee Waa Levee Rehabilitation*" set out requirements for the upgrade of the Town Levee. While the *Investigation Stage Report* referred to on the design drawings was not available at the time of writing, it is assumed that the planned upgrade was required to reinstate the 1 m freeboard to peak 1971 flood levels. Council were also unable to confirm that the works as set out in the design drawings have been implemented.[6]

DNR, 2005 states that a comparison between the design crest profile and a crest survey which was conducted in 2002 identified that while no major slumping of the Town Levee had occurred, its crest height was not consistent with the original design parameters. A recommendation was included in DNR, 2005 for Council to review the available freeboard to peak 1971 flood levels and to carry out any remedial work. It also included a recommendation for Council to determine whether the adoption of the 1971 flood as the design event in combination with 1 m freeboard was still appropriate.

By comparison of the original design and current crest heights shown on **Figure 2.2**, there is a 1 km long section between about Chainage 3500 and Chainage 4500 which lies below the original design height of the Town Levee.[7]

A geotechnical investigation was undertaken by Michael Adler & Associates as part of the present study, the findings of which are set out in a letter style report, a copy of which is contained in **Appendix B** of this report. The geotechnical investigation, which comprised a review of the available documentation and a visual inspection of the Town Levee found that the embankment was in good condition, with the following minor defects/aspects requiring rectification:

- There are a number of uncontrolled crossings which should be either closed off or upgraded to a formed/engineered surface such as a gravel of bitumen sealed roadway. These crossings should also be checked on a regular basis for damage and repair as required.

[6] There is a reference on NSW SES's *Wee Waa (Glencoe) Flood Intelligence Card* against the 1984 peak flood height that the Town Levee was audited and upgraded in 1992. It is noted that while this matches the date of an audit undertaken by the then Public Works, it pre-dates the design of the levee upgrade.

[7] Original design heights taken from the report entitled "*Audit of Flood Levees for New South Wales – Town of Wee Waa*" (PW, 1992).

- Tension cracks are present in the embankment at a number of locations. The cracks should be scarified to a depth of at least 300 mm and re-compacted to the specification set out in the report.
- Areas of dense vegetation should be removed before the roots start to form potential drainage pipes.
- The local drainage system should be cleared to prevent water ponding along the toe of the embankment on the town side at Chainages 2900, 3400 and 7500.

Recommendations are also contained in the geotechnical report regarding the approach which is to be adopted should the decision be made to raise the crest height of the Town Levee. These are discussed in more detail in **Section 3.4.1**.

The Imminent Failure Flood (**IFF**) of a levee is typically set equal to the flood for which it was designed to protect. As mentioned, the original intent of the design of the Town Levee was to protect Wee Waa from a flood approximating the February 1971 event, which based on the information contained in **Table 2.3** over had an AEP of about 4 per cent. However. based on the flood modelling undertaken as part of the present study (refer **Section 2.5** for details), the IFF for the Town Levee is actually equal to a flood which is slightly smaller than the February 1971 flood and has an AEP slightly greater than 5 per cent. The prediction of a flood higher than the IFF would trigger the evacuation of Wee Waa, as NSW SES would have deemed the Town Levee to be at significant risk of failure.

2.4 Flood History

The following discussion is based on information contained in Annex A of NSW SES, 2015 and has been reproduced verbatim in some instances. **Table 2.3** sets out the historic discharge data that are available for the Namoi River at Narrabri and Mollee, while **Table 2.4** gives the peak heights that are set out on NSW SES's Flood Intelligence Card for the Glencoe stream gauge (***Wee Waa (Glencoe) Flood Intelligence Card***).[8]

As shown in **Table 2.3**, the February 1955 flood was the largest event to have been recorded in the Namoi Valley near Wee Waa in over 100 years and was equivalent to about a 1.2% AEP flood event. Flow in the Namoi River during this flood was increased by contributions from the Manilla and Mooki Rivers, as well as significant inflows from the Peel River. NSW SES, 2015 states that the water level at the Glencoe stream gauge peaked at 9.12 m, which is 0.86 m higher than the peak height noted on NSW SES's *Wee Waa (Glencoe) Flood Intelligence Card*.[9,10]

Water level data recorded by the Mollee stream gauge indicates that prior to the February 1955 flood, major flooding was experienced in the Namoi Valley near Wee Waa in March 1908, January 1910 and July 1920. There is also reference in a newspaper article of major flooding that was experienced in Wee Waa in February 1874.

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[8] Note that the gauge zero given on the *Wee Waa (Glencoe) Flood Intelligence Card of RL 204.38 m* AHD is incorrect. WaterNSW gives the gauge zero as RL 188.5 m AHD.

[9] The reference to 8.26 m on the *Wee Waa (Glencoe) Flood Intelligence Card* for the February 1955 flood includes a note to check and confirm this level.

[10] By reference to the design flood levels set out in **Table 2.4**, the gauge height of 8.26 m given on the *Wee Waa (Glencoe) Flood Intelligence Card* is the more likely level reached by the 1955 flood.

TABLE 2.3
HISTORIC DISCHARGE DATA
NAMOI RIVER AT NARRABRI AND MOLLEE[1,2]

Rank	Date of Flood	Narrabri[3]	Namoi River at Mollee (GS 419039)			
		Peak Discharge (m^3/s)	Peak Height (m)	Peak Discharge[4,5] (m^3/s)		Approximate AEP[6] (%)
				WaterNSW Rating Table Current at Time of Flood	Present study	
1	February 1955	5,336	8.94	3,704	[4,183]	1.2
2	January 1910	5,315	-	-	(4,103)	1.3
3	July 1920	3,840	-	-	(2,984)	3.6
4	February 1971	3,637	8.43	2,431	[2,898]	3.8
5	March 1908	2,901	-	-	(2,272)	6.5
6	January 1974	2,758	8.16	2,394	[2,154]	7.1
7	1956[7]	2,700	-	-	(2,119)	7.2
8	February 1984	2,479	8.04	2,217	[1,884]	8.9
9	January 1976	2,858	8.02	2,176	[1,828]	9.6
10	July 1998	2,574	8.01	2,280	[1,807]	9.8

1. Only the ten largest flood events to have been recorded by the gauge are listed. Refer **Tables A1** and **A2** in **Annexure A** of **Appendix C** for the full record of annual maximums.
2. "-" indicates stream gauge was not in operation during flood event.
3. Taken from WRM, 2016. Derived by summing the peak annual discharges recorded by the Namoi River at Narrabri (GS 419002) and Narrabri Creek at Narrabri (GS 419003) stream gauges.
4. Numbers in () represent peak discharge derived based on correlation between annual peak flows at Narrabri and Mollee (refer **Figure C1.1** in **Appendix C**).
5. Numbers in [] represent peak discharge derived using *Pre-* or *Post-1971 OEH Rating Curves* shown on **Figure C1.2** in **Appendix C**.
6. Approximate frequency based on the findings of the flood frequency analysis which incorporated the annual peak discharges for the period 1908-2016, but omitted low flows (refer **Section C1.3.2** of **Appendix C** for discussion).
7. Exact date of flood unknown.

TABLE 2.4
COMPARISON OF HISTORIC AND DESIGN FLOOD LEVELS
GLENCOE STREAM GAUGE[1,2]

Historic/Design Flood Event	Peak Height on Gauge (m)
MINOR	5.30
12 July 1978	6.01
15 April 1978	6.31
MODERATE	6.40
MAJOR	6.70
February 1997	6.77
9 August 1990	6.79
12 August 1998	6.82
14 February 1992	6.86
29 July 1998	6.93
22 January 1977	7.02
9 September 1998	7.15
1 August 1998	7.16
17 May 1977	7.17
27 January 1976	7.26
25 July 1998	7.36
February 1984	7.51
5% AEP	7.61
2% AEP	7.87
1% AEP	8.04
0.5% AEP	8.11
0.2% AEP	8.26
February 1955	8.26 [9.12][3]
Extreme Flood	9.29

1. Source of historic flood data: *NSW SES's Wee Waa (Glencoe) Flood Intelligence Card*
2. Gauge zero = RL 188.50 m AHD
3. Peak height of 9.12 m stated as being the peak of the February 1955 in Annex A of NSW SES, 2015

The February 1971 flood was not only a major flood, but it also caused significant damage due to its long duration. Downstream of Narrabri flooding was exacerbated by concurrent flooding in the Pilliga streams. The height to which the February 1971 flood reached on the Glencoe stream gauge is not given on NSW SES's *Wee Waa (Glencoe) Flood Intelligence Card*.

The January 1974 flood differed in that there was limited contributions from the upper Namoi River and only moderate flows on the Manilla River, with significant contributions originating from the Peel and Mooki Rivers, with the latter being the major source of flood flows. At Mollee there were two flood peaks. While the Pilliga Scrub contributed significant runoff, mainly in Cox's Creek, the resulting floodwater had largely drained by the time the main flood peak from up-river arrived. The height to which the January 1974 flood reached on the Glencoe stream gauge is not given on NSW SES's *Wee Waa (Glencoe) Flood Intelligence Card*.

The January 1976 flood was similar in peak flood level to that of the January 1974 flood at Narrabri and Mollee and reached 7.26 m on the Glencoe stream gauge. While floodwaters originated mainly from the Peel and upper Namoi systems, a major flood was experienced in the Mooki River and contributions from the Manilla and Cockburn Rivers were also significant.

While not mentioned in Annex A of NSW SES, 2015, NSW SES's *Wee Waa (Glencoe) Flood Intelligence Card* states that a flood with a peak height of 7.17 m occurred in May 1977.

Major flooding was experienced in late January and early February 1984 after above-average rainfalls which had saturated the catchment lead to rapid rates of runoff when the flood producing rain occurred. The catchment in the vicinity of and downstream of Narrabri had experienced wet conditions right through the latter half of 1983 and into 1984. Flooding was made worse by the arrival of significant inflows from Bohena Creek which filled the main channel of the Namoi River prior to the arrival of the main flood peak. Dense vegetation on the floodplain, the poor condition of many floodways and obstructions in the entrances to floodways all contributed to the unique behaviour of this flood. Breakouts were hampered, floodways did not begin to operate until levels above those for which they were designed and some areas of the floodplain stored more floodwater than was expected. These factors meant that in some areas higher than expected flood levels were experienced and an unusual redistribution of flows occurred. For example, a peak discharge almost 35 per cent greater than expected for a flood of this magnitude was experienced in Wee Waa Lagoon and to the south-west of Wee Waa. Although the flood was estimated to be only one third of the total volume of the February 1971 flood, it produced similar flood heights in some locations such as immediately upstream of Collins Bridge.

NSW SES's *Wee Waa (Glencoe) Flood Intelligence Card* states that the water level reached 7.51 m during the 1984 flood. While it also states that the water level was only 300 mm below the levee crest due to contributions from the Pilliga Scrub and high wave action, it also includes a note to say that the levee was subsequently upgraded to an equivalent height of 8.5 m on the gauge in 1992.[11]

Major flooding occurred in the valley in 1998 which lasted several months. The largest flood peak was recorded at the Glencoe stream gauge on 25 July 1998, when water levels peaked at 7.36 m. This flood peak was caused by a rain band which crossed the central eastern parts of NSW on the 18 July and included some unusual thunderstorm activity for mid-winter. As in the 1976 flood, floodwaters originated mainly from the Peel and upper Namoi systems which combined with a major flood in the Mooki River, as well as with contributions from the Manilla and Cockburn Rivers. Wee Waa was isolated on four occasions from late July to early September.

[11] Note that the nominated date of construction pre-dates the design drawings that were prepared by Water Resources Consulting Services in 1993.

2.5 Design Flood Behaviour

2.5.1 Background

The *Flood Study* defined the nature of flooding on the Namoi River floodplain in the vicinity of Wee Waa for the 1% AEP and Extreme floods based on a design 1% AEP discharge hydrograph that was extracted from a quasi-two-dimensional cross sectional based MIKE 11 hydraulic model that is presently being maintained by OEH. The design discharge hydrographs were used as input to a two-dimensional (in plan) hydraulic model that was developed based on the TUFLOW software (**Flood Study TUFLOW Model**). The Flood Study TUFLOW Model was calibrated to the floods that occurred in 1971, 1984 and 1998.

Table 2.5 provides a comparison of the design peak 1% AEP flow estimate that was adopted by the *Flood Study* compared to those derived as part of WRM, 2016 and the present study at the Mollee stream gauge and Wee Waa.

TABLE 2.5
COMPARISON OF PEAK 1% AEP FLOWS
(m^3/s)

Location	*Flood Study*	WRM, 2016	Present Study
Narrabri	-	4,860	-
Mollee stream gauge	6,672	-	4,400
Wee Waa	4,302	-	2,935

By inspection of the values set out in **Table 2.5**, the *Flood Study* adopted a peak flow for the 1% AEP flood event which is about 40% higher than the flow that was derived as part of WRM, 2016 at Narrabri, noting that previous studies have shown that significant attenuation occurs to the flood wave as it travels from Narrabri to Wee Waa.

As discussed in **Section C1.2.4** of **Appendix C**, WRM, 2016 undertook a flood frequency analysis based on an annual series of total peak flows for a 116 year period between 1890 and 2015 at Narrabri. A set of design discharge hydrographs were then generated by factoring the ordinates of the discharge hydrograph that was recorded during the January 1974 flood.

Based on the findings of WRM, 2016, OEH requested that a flood frequency analysis be undertaken as part of the present study for the Mollee stream gauge (refer **Section C1.3** of **Appendix C** for details). The findings of the flood frequency analysis were used to factor the ordinates of the 1% AEP discharge hydrograph that is presented in DIPNR, 2003 at the Mollee stream gauge to the peak 1% AEP flow estimate of 4,400 m^3/s. OEH then routed the design 1% AEP discharge hydrograph from Mollee to the Glencoe stream gauge using its MIKE 11 model.

The structure of the Flood Study TUFLOW Model was updated as part of the present study in order to more accurately define flooding behaviour in the vicinity of Wee Waa (**Namoi River TUFLOW Model**). **Chapter C3** in **Appendix C** provides details of the changes that were made to the structure of the Flood Study TUFLOW Model as part of the present study.

In addition to updating the Flood Study TUFLOW Model, a second TUFLOW model was developed as part of the present study to define drainage patterns internal to the Town Levee (**Wee Waa TUFLOW Model**). The direct-rainfall-on-grid approach was adopted for defining drainage patterns in the town due to the very flat nature of the area and the ill-defined nature of the drainage paths. Background to the development of the Wee Waa TUFLOW Model is provided in **Chapter C3** of **Appendix C**.

Both the Namoi River and Wee Waa TUFLOW Models were used to define flooding and drainage patterns on either side of the Town Levee for design events with AEPs of 5, 2, 1, 0.5 and 0.2 per cent, as well as the Extreme Flood.

2.5.2 Design Flooding and Drainage Patterns

Figures 2.3 to **2.8** show the nature of both Namoi River and local catchment flooding at Wee Waa for the 5, 2, 1, 0.5 and 0.2% AEP flood events, as well as the Extreme Flood for present day rural floodplain conditions.

The extents and depths of inundation shown on the figures are a combination of Namoi River flooding on the river side, and local catchment flooding on the protected side of the Town Levee. For presentation purposes it has been assumed that the penstock gates are in their closed positon and floodwater cannot backwater into town in the case of Namoi River flooding. Conversely, in the case of local catchment flooding, it has been assumed that river levels are not elevated and the penstock gates are in their open position. Refer **Section 2.10** for discussion on the impact coincident Namoi River and local catchment flooding would have on the depth and extent of ponding behind the Town Levee.

In order to demonstrate the impact the occurrence of extreme rainfall directly over Wee Waa would have on flooding behaviour internal to the Town Levee, depths of inundation resulting from Probable Maximum Precipitation are shown on **Figure 2.9**.

Figure 2.2 shows design water surface profiles and the available freeboard along the length of the Town Levee for the full range of assessed design flood events, while **Figure 2.10** (3 sheets) shows stage hydrographs at low points along the roads that traverse the floodplain. **Table 2.4** includes the design flood levels at the Glencoe stream gauge and provides a comparison with historic flood levels, while **Table 2.6** sets out the minimum freeboard which is available to the crest of the Town Levee for the design flood events that were assessed as part of the present study.

TABLE 2.6
MINIMUM AVAILABLE FREEBOARD TO CREST OF TOWN LEVEE

AEP (%)	Present Day Floodplain Conditions	Raised Rural Levee Floodplain Conditions	
	Available Freeboard (m)	Available Freeboard (m)	Reduction in Available Freeboard (m)
5	0.87	0.81	0.06
2	0.67	0.47	0.20
1	0.52	0.26	0.26
0.5	0.45	-	-
0.2	0.34	-	-
Extreme	-0.51 (1)	-	-

1. Represents the maximum height to which the crest of the Town Levee would in the absence of any wind or wave action be overtopped.

Namoi River Flooding

The key features of Namoi River flooding at Wee Waa are as follows:

- While floodwater would generally not exceed 1.2 m depth along the northern side of the Town Levee during a 5% AEP flood, it would exceed 2 m depth along its southern side.
- Flood levels would exceed the IFF level of the Town Levee at its eastern end by up to 130 mm in a 5% AEP flood.
- Floodwater would pond up against the flood protection barriers on the Narrabri-West Walgett railway crossings at Chainage 4700 by about 0.3 m in a 5% AEP flood event and at Chainage 7000 by about 0.2 m in a 2% AEP flood event.
- The minimum available freeboard to the crest of the Town Levee reduces from about 0.9 m at the 5% AEP level of flooding to about 0.5 m at the 1% AEP level of flooding. **Table 2.7** gives the height on the Glencoe stream gauge which corresponds with the existing low points along the Town Levee, noting that these corresponded with the existing road and rail crossings.
- The Town Levee would in the absence of any wind or wave action not be overtopped for floods up to a 0.2% AEP in magnitude.
- Peak flood levels are about 0.5-1.0 m higher in the Extreme Flood when compared to those at the 1% AEP level of flooding. As a result, floodwater would overtop the Town Levee at five locations, where it would inundate the town to depths of between 0.7 m and 3.5 m.

TABLE 2.7
PEAK HEIGHTS ON GLENCOE STREAM GAUGE CORRESPONDING WITH LOW POINTS ALONG TOWN LEVEE

Location	Chainage	Peak Height on Glencoe Stream Gauge when Low Point First Overtopped (m)
Narrabri West Walgett Railway	4700	7.40[1]
Narrabri West Walgett Railway	7000	7.89[1]
Kamilaroi Highway	2200	8.70
Vera Leap Road	5600	8.78
Myalla Lane	8600	8.98

1. Gauge level corresponds to the level of the rail line. Concrete flood barriers which are about 1.5 m in height are installed at the location of the rail crossings during a flood event.

Local Catchment Flooding

The key features of local catchment flooding at Wee Waa are as follows:

- Runoff generated by the catchment which is bounded by Boolcarrol Road, Warrior Street and the Narrabri-West Walgett Railway ponds on the northern side of the railway before being conveyed in a westerly direction via a table drain to the 1800 mm diameter pipe that extends through the Town Levee at about Chainage 7200 (refer FG_01).

- Water ponds to a maximum depth of about 600 mm in the rear of existing residential and industrial allotments that are located adjacent to the northern side of the Town Levee during a 1% AEP storm event (i.e. between Chainages 0 and 500, and Chainages 7100 and 8600).
- An overland flow path develops along Mitchell Street which extends into residential development and Department of Education owned land that is located along its northern side. Flow conveyed along this overland flow path drains to the Namoi River via the 750 mm diameter pipe that extends through the Town Levee at about Chainage 8210 (refer FG_02).
- Water ponds to a maximum depth of about 400 mm in the rear of existing residential allotments that are located on the southern side of Alma Street between Maitland and River streets during a 1% AEP storm event (i.e. between Chainages 3400 and 3600 m). Water also ponds in parts of the Wee Waa District Health Service to depths exceeding 0.8 m, albeit that the deeper ponding water is located at the toe of the Town Levee where a drainage swale is located.
- The pipes extending through the Town Levee south of the Narrabri-West Walgett railway have sufficient capacity to prevent major flooding from occurring in the Namoi Cotton Co-op during storms with AEPs up to 1 per cent in intensity.

2.6 Impact of Flooding on Vulnerable Development and Critical Infrastructure

Figure 2.11 (2 sheets) shows the location of vulnerable development and critical infrastructure relative to the extent of flooding for events with AEPs of 5 and 1 per cent , as well as the Extreme Flood, while **Table 2.8** over the page summarises the impact that flooding has on this type of development/infrastructure.[12]

While the Town Levee would in the absence of any wind or wave action not be overtopped for Namoi River Floods of up to 0.2% AEP in magnitude, the telephone exchange, RFS Brigade and Mainway Caravan Park would be impacted by local catchment runoff during a 5% AEP storm. The Wee Waa District health Service and Wee Waa Community Child Centre and Pre School, as well as the Fire and Rescue NSW station will also be affected by local catchment runoff during slightly more intense storm events.

The Wee Waa Sewerage Treatment Plant which is located to the south of the township is impacted by riverine flooding during a 5% AEP event.

2.7 Hydrologic Standard of Existing Road Network

As set out in **Table 2.8**, all but Yarrie Lake Road near its crossing of the Narrabri-West Walgett Railway would be inundated by floodwater during a 5% AEP Namoi River Flood. **Figure 2.5** shows the time or rise of floodwater, as well as the maximum depth and duration of inundation at the location of the road markers that are shown on sheet 1 of **Figures 2.3** to **2.9**. **Table 2.9** gives the maximum depth of inundation for each road marker, as well as the peak height on the Glencoe stream gauge when the road would first be overtopped by floodwater.

[12] Critical infrastructure has been split into two categories; community assets and emergency services.

TABLE 2.8
IMPACT OF FLOODING ON CRITICAL INFRASTRUCTURE AND VULNERABLE DEVELOPMENT[(1)]

Type	Development/Structure	Location Identifier	Design Flood Event					
			5% AEP	2% AEP	1% AEP	0.50%	0.20%	Extreme
Vulnerable Development	Hospital (Wee Waa District Health Service)	-	0	LCF-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	Educational Facility (Namoi Valley Christian School)	EF1	0	0	0	0	0	NRF
	Educational Facility (St Joseph's Primary School)	EF2	0	0	0	0	0	NRF
	Educational Facility (Wee Waa High School)	EF3	0	LCF-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	Educational Facility (Wee Waa Public School)	EF4	0	0	0	0	0	NRF
	Educational Facility (Wee Waa & Disctrict Pre-School)	CC1	0	LCF-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	Child Care Facility (Wee Waa Community Child Centre & Pre School)	CC2	0	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	Caravan Park / Camping Ground (Mainway Caravan Park)	CP1	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	Caravan Park / Camping Ground (Waioma Caravan Park)	CP2	0	0	0	LCF-GCP	LCF-GO-GCP	NRF
	Aged Care Facilities (The Whiddon Group Wee Waa)	-	0	LCF-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
Emergency Services	NSW SES Headquarters	-	0	LCF-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	RFS Brigade	-	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	Police Station	-	0	0	0	0	0	NRF
	Fire & Rescue NSW Station	-	0	LCF-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	Ambulance	-	0	0	0	0	0	NRF
	Evacuation Centre (Wee Waa Public School)	EC1	0	0	0	0	0	NRF
	Evacuation Centre (Wee Waa High School)	EC2	0	LCF-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	Evacuation Centre (Sports Complex)	EC3	0	0	0	0	0	NRF
	Evacuation Centre (Church Hall)	EC4	0	0	0	0	0	NRF
	Evacuation Centre (CWA Rooms)	EC5	0	0	0	0	0	NRF
	Evacuation Centre (Cotton Growers Services)	EC6	0	0	0	0	0	NRF

Refer over for footnotes

Cont'd Over

TABLE 2.8 (Cont'd)
IMPACT OF FLOODING ON CRITICAL INFRASTRUCTURE AND VULNERABLE DEVELOPMENT

Type	Development/Structure	Location Identifier	Design Flood Event					
			5% AEP	2% AEP	1% AEP	0.50%	0.20%	Extreme
Community Assets	Electricity Substation	-	0	0	0	0	0	NRF
	Telephone Exchange	-	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	LCF-GO-GCP	NRF
	Sewage Treatment Plant	-	NRF	NRF	NRF	NRF	NRF	NRF
	Culgoora Road	RC01	NRF	NRF	NRF	NRF	NRF	NRF
	Yarrie Lake Road	RC02	0	NRF	NRF	NRF	NRF	NRF
	Culgoora Road	RC03	NRF	NRF	NRF	NRF	NRF	NRF
	Culgoora Road	RC04	NRF	NRF	NRF	NRF	NRF	NRF
	Kamilaroi Highway	RC05	NRF	NRF	NRF	NRF	NRF	NRF
	Tulladunna Lane	RC06	NRF	NRF	NRF	NRF	NRF	NRF
	Cotton Lane	RC07	NRF	NRF	NRF	NRF	NRF	NRF
	Vera Leap Road	RC08	NRF	NRF	NRF	NRF	NRF	NRF
	Old Pilliga Road	RC09	NRF	NRF	NRF	NRF	NRF	NRF
	Sandy Hook Lane	RC10	NRF	NRF	NRF	NRF	NRF	NRF
	Kamilaroi Highway	RC11	NRF	NRF	NRF	NRF	NRF	NRF
	Kamilaroi Highway	RC12	NRF	NRF	NRF	NRF	NRF	NRF
	Kamilaroi Highway	RC13	NRF	NRF	NRF	NRF	NRF	NRF
	Kamilaroi Highway	RC14	NRF	NRF	NRF	NRF	NRF	NRF
	Cudgewa Lane	RC15	NRF	NRF	NRF	NRF	NRF	NRF

Refer **Figure 2.11** for location of vulnerable development and critical infrastructure

"O" = Vulnerable development and critical infrastructure not impacted by flooding.

"NFR" = Vulnerable development and critical infrastructure impacted by Namoi River Flooding

"LCF-GCP" = Vulnerable development and critical infrastructure impacted by local catchment flooding in the situation when the flood gates are closed and the stormwater evacuation pumps are operational.

"LCF-GO-GCP" = Vulnerable development and critical infrastructure impacted by local catchment flooding in the situation when the flood gates are open or when the flood gates are closed and the stormwater evacuation pumps are operational.

TABLE 2.9
DETAILS OF NAMOI RIVER FLOODING OF ROADS AT WEE WAA

Identifier[(1)]	Road Name	Maximum Depth of Inundation (m)				Peak Height on Glencoe Stream Gauge when Road First Overtopped (m)
		5% AEP	2% AEP	1% AEP	Extreme	
RC01	Culgoora Road	0.13	0.39	0.53	1.49	7.44
RC02	Yarrie Lake Road	0.07	0.16	0.24	1.22	7.56
RC03	Culgoora Road	0.25	0.47	0.62	1.59	7.39
RC04	Culgoora Road	1.70	1.97	2.15	3.15	6.78
RC05	Kamilaroi Highway	1.08	1.28	1.41	2.39	6.20
RC06	Tulladunna Lane	1.12	1.29	1.39	2.13	6.63
RC07	Cotton Lane	0.96	1.12	1.24	1.96	6.57
RC08	Vera Leap Road	2.54	2.77	2.92	3.95	6.69
RC09	Old Pilliga Road	0.97	1.15	1.27	2.13	6.99
RC10	Sandy Hook Lane	0.59	0.91	1.09	2.08	7.09
RC11	Kamilaroi Highway	0.82	1.07	1.23	1.97	7.06
RC12	Kamilaroi Highway	0.54	0.78	0.93	1.65	7.37
RC13	Kamilaroi Highway	0.52	0.71	0.87	1.77	7.14
RC14	Kamilaroi Highway	0.65	0.79	0.90	1.67	7.08
RC15	Cudgewa Lane	5.05	5.13	5.18	5.56	6.73

1. Refer sheet 1 of **Figures 2.3** to **2.8** for identifiers.

2.8 Potential Impact of a Partial Levee Failure

While the present study found that in the absence of any wind or wave action the Town Levee would only be overtopped during very rare and extreme flood events, its design freeboard of 1 m is compromised by floods that are larger than about a 5% AEP event. While investigations have shown that the embankment is in good condition, there is still the potential for it to fail prior to it being overtopped.

The Namoi River TUFLOW Model was used to assess the impact a partial failure of the Town Levee would have on depths of inundation in the town for a 1% AEP Namoi River flood event. **Figure 2.12** (2 sheets) shows the three locations where short sections of the Town Levee were assumed to fail, as well as the resulting depths of inundation within the town.

Peak flood levels in Wee Waa should the Town Levee partially fail are controlled by the height of the earth embankment at the western end of town, as floodwater would pond to this height before discharging back onto the Namoi River floodplain. This results in depths of inundation occurring at the western end of town of over 2 m, reducing to less than 0.2 m at the toe of the Town Levee at the eastern end of town.

2.9 Potential Impact of Raising Rural Levees

As mentioned, the majority of the licences held by the landowners on the rural floodplain do not place height restrictions on the elevation of the rural levees. It is therefore possible that these levees could be raised in the future, thereby impacting flooding behaviour in the vicinity of the Town Levee.

Figure 2.13 (2 sheets) shows the nature of Namoi River Flooding at Wee Waa should the unrestricted levees be raised to prevent overtopping during a 1% AEP flood event, while **Figure 2.14** (2 sheets) shows the impact that their raising would have on flooding behaviour for a 1% AEP flood event.

The investigation found that raising the levees upstream of Wee Waa diverts floodwater to the south into Wee Waa Lagoon, thereby reducing the volume of floodwater that enters Quinns Billabong. The raised levees also reduce the volume of floodwater that can enter Pian Creek and also Gundigera Creek near the Cudgewa Road crossing, with the result that floodwater discharges in a southerly direction between the raised rural levee which lies to the west of Cottons Lane and the Town Levee.

As shown in **Table 2.6**, the available freeboard to the crest of the Town Levee would be reduced from 0.52 m under current floodplain conditions to 0.26 m should all the unrestricted levees be raised to prevent overtopping in a 1% AEP flood event.

2.10 Potential Impact of Coincident Namoi River and Local Catchment Flooding

During periods when water levels in the Namoi River are elevated, Council closes the fourteen penstock gates which are fitted to the stormwater drainage pipes which are located around the perimeter of the Town Levee. If a rainfall event coincides with the closure of the penstock gates, then stormwater runoff is forced to pond behind the Town Levee until water levels in the river recede, or alternatively the six stormwater evacuation pumps are used to pump water to the river side of the Town Levee.

Figure 2.15 shows the depth of inundation that would occur behind the Town Levee should a 1% AEP storm occur over Wee Waa while the penstock gates are in their closed position and the stormwater evacuation pumps are operating at full capacity. **Figure 2.16** shows that the depth and extent of inundation would generally be less for the case where the six stormwater evacuation pumps are operating at full capacity when compared to the 'penstock gates open' case. This is because the rate at which the pumps evacuate water ponding behind the Town Levee is faster than it can drain to the river side of the Town Levee under gravity. The exception is the area near the Wee Waa District Health Service, where the pump rate of stormwater evacuation pump P_04 is less than the rate at which stormwater can discharge to Wee Waa Lagoon under gravity. In this case, peak 1% AEP flood levels are between 20-50 mm higher than for the 'penstock gates open' case.

An assessment was also made of the impact not starting the stormwater evacuation pumps during a 1% AEP storm event in the case when the penstock gates are in their closed position would have on flooding behaviour. **Figure 2.17** shows the resulting depth and extent of inundation that would occur under these conditions. **Figure 2.18** shows that depths of ponding would be increased by up to about 0.3 m in the vicinity of the Wee Waa District Health Service and on the northern side of the Narrabri-West Walgett railway, while they would be increased by up to about 0.5 m south of the railway line within the Namoi Cotton Co-op. The extent of ponding would also increase significantly in these three areas.

2.11 Potential Impact of a Change in Hydraulic Roughness

The sensitivity of flooding behaviour to variations in hydraulic roughness was assessed. The main purpose of the assessment was to give some guidance on the freeboard to be adopted when setting the crest height of the Town Levee.

Figure 2.19 shows the difference in peak flood levels for the 1% AEP flood event resulting from an assumed 20% increase in hydraulic roughness on the Namoi River floodplain when compared to the values set out in **Table C3.2** of **Appendix C**. The typical increase in peak flood level along the Namoi River in the vicinity of the Town Levee was found to be in the range 90 to 180 mm.

2.12 Potential Impact of a Partial Blockage of Major Hydraulic Structures

The mechanism and geometrical characteristics of blockages in hydraulic structures and piped drainage systems are difficult to quantify due to a lack of recorded data and would no doubt be different for each system and also vary with flood events. Realistic scenarios would be limited to waterway openings becoming partially blocked during a flood event (no quantitative data are available on instances of blockage of the drainage systems which may have occurred during historic flood events).

EA, 2013 includes guidance on modes of blockage which are likely to be experienced for different hydraulic structures. In regards bridge structures, those with clear opening heights less than 3 m are said to be susceptible to blockage in streams where large floating debris is conveyed by floodwater, presumably due to large woody debris becoming lodged in the clear opening of the bridge. For bridges of all heights, EA, 2013 considers that debris is likely to also wrap around the bridge piers.

The impact an accumulation of floating debris on the Kamilaroi Highway and Narrabri-West Walgett railway crossings of the Namoi River immediately west of Wee Waa, as well as the Culgoora Road crossing of Wee Waa Lagoon would have on flood behaviour was assessed as part of the present study assuming the following three modes of blockage:

- **Blockage Mode 1**: Assumes a 1 m thick raft of debris lodges beneath the underside of the bridge deck.
- **Blockage Mode 2**: Assumes a 4 m wide raft of debris lodges on the upstream side of each bridge pier over the full height of the clear opening.
- **Blockage Mode 3**: Combination of Blockage Modes 1 and 2.

A 50% blockage was also applied to the box-culverts which are located under the Kamilaroi Highway on the eastern side of the Namoi River crossing.

Figure 2.20 shows that a partial blockage of the three bridges and two box culvert structures would result in less than a 50 mm increase in peak 1% AEP flood levels. In regards the potential blockage of the local stormwater drainage system would have on internal drainage patterns, reference is made to **Section 2.10** which sets out the increase that would occur in the depth of inundation in the area protected by the Town Levee for the case where the penstock gates are closed and the stormwater evacuation pumps are inoperable.

2.13 Potential Impacts of Future Urbanisation

Future urbanisation has the potential to increase the rate and volume of runoff conveyed along the various overland flow paths which drain toward the low points which are located behind the Town Levee. This in turn would require the installation of larger stormwater evacuation pumps if depths of ponding internal to the Town Levee are not to be increased.

While there is presently limited pressure for new largescale development to occur in Wee Waa, it will be necessary for Council to consider the implications the introduction of new hard stand and roof areas would have on internal drainage patterns and possible pump rate requirements when assessing future development applications.

2.14 Potential Impacts of Climate Change

Consideration was given to the impacts on design flood levels of future climate change when estimating the freeboard requirements for the Town Levee and minimum floor levels in future development at Wee Waa.

OEH recommends that its guideline *Practical Consideration of Climate Change, 2007* be used as the basis for examining climate change in projects undertaken under the State Floodplain Management program and the *FDM, 2005*. The guideline recommends that until more work is completed in relation to the climate change impacts on rainfall intensities, sensitivity analyses should be undertaken based on increases in rainfall intensities ranging between 10 and 30 per cent.

On current projections the increase in rainfalls within the service life of developments or flood management measures is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit which may apply near the end of the century. Under present day climatic conditions, increasing the 1% AEP design rainfall intensities by 10 per cent would produce about a 0.5% AEP flood; and increasing those rainfalls by 30 per cent would produce about a 0.2% AEP event.

For the purpose of the present study, the impact 10% and 30% increases in design 1% AEP rainfall intensities would have on flooding behaviour was assessed by comparing the peak flood levels which were derived from the flood modelling for design events with AEPs of 1, 0.5 and 0.2 per cent.

Figure 2.21 shows the afflux data (i.e. increase in peak flood levels compared with present day conditions) derived from the hydraulic modelling that was undertaken as part of the present study for the 1 and 0.5% AEP events. The potential impact of a 10% increase in rainfall intensity on flooding and drainage patterns at Wee Waa may be summarised as follows:

- Peak 1% AEP flood levels resulting from Namoi River flooding would be increased in the range 50-100 mm around the full perimeter of the Town Levee, with the exception of a short section of the earth embankment in the vicinity of Quinns Billabong where the increases would be slightly less than 50 mm.
- By reference to **Table 2.6**, the available freeboard to the crest of the Town Levee would be a minimum of 0.45 m.

- Depths of inundation due to direct rainfall over Wee Waa would result in an increase in the depth of local catchment flooding east of Warrior Street of between 10 and 50 mm, with greater increases of between 50 and 200 mm shown to occur in a number of properties that are located along the southern side of Alma Street, including the Wee Waa District Health Service. Similar increases in the depth of inundation would occur to the west of Warrior Street in land currently zoned *B4 Mixed Use* and *IN1 General Industrial*.

Figure 2.22 shows the afflux data derived from the hydraulic modelling that was undertaken as part of the present study for the 1 and 0.2% AEP events. The potential impact of a 30% increase in rainfall intensity on flooding and drainage patterns at Wee Waa may be summarised as follows:

- Peak 1% AEP flood levels resulting from Namoi River Flooding would be increased in the range 100-200 mm along the northern and western sides of the Town Levee between Chainage 0 and 1700, as well as between Chainage 5200 and 8600, while they would be increased in the range 200-300 mm along its eastern and southern sides between Chainage 1700 and 5200.
- By reference to **Table 2.6**, the available freeboard to the crest of the Town Levee would be a minimum of 0.34 m.
- Depths of inundation due to direct rainfall over Wee Waa would generally result in an increase in the depth of local catchment flooding east of Warrior Street of between 10 and 100 mm, with greater increases of between 100 and 300 mm shown to occur in a number of properties that are located along the southern side of Alma Street, including the Wee Waa District Health Service. Similar increases in the depth of inundation would occur to the west of Warrior Street in the *B4 Mixed Use* and *IN1 General Industrial* zoned land.

Note that the assessment of the impact future climate change could have on the extent and depth of flooding internal to the Town Levee is based on the case where the Namoi River is not in flood and the flood gates are in their open position.

2.15 Economic Impacts of Flooding

The economic consequences of floods are discussed in **Appendix D**, which assesses flood damages to residential, commercial and industrial property, as well as public buildings that are located in Wee Waa. There was only limited quantitative data available on historic flood damages in Wee Waa since major flooding in the town has not occurred since construction of the Town Levee was completed in 1978. Accordingly it was necessary to use data on damages experienced as a result of historic flooding in other urban centres. The residential flood damages were based on the publication *Floodplain Risk Management Guideline No. 4, 2007* (**Guideline No. 4**) published by the Department of Environment and Climate Change (**DECCW**) (now OEH). Damages to industrial and commercial development, as well as public buildings were evaluated using data from previous floodplain management investigations in NSW.

It is to be noted that the principle objectives of the damages assessment were to gauge the severity of urban flooding likely to be experienced at Wee Waa and also to provide data to allow the comparative economic benefits of upgrading the Town Levee and the local stormwater drainage system. As explained in **Appendix D**, it is not the intention to determine the depths of inundation or the damages accruing to *individual properties*, but rather to obtain a reasonable estimate of damages experienced over the extent of the urban area in the town for the various design flood events. The estimation of damages using *Guideline No. 4* (in lieu of site specific data determined by a loss adjustor) also allows a uniform approach to be adopted by Government when assessing the relative merits of measures competing for financial assistance in flood prone centres in NSW.

Damages were estimated for the design flood levels determined from the hydraulic modelling that was undertaken as part of the present study, while the elevations of the floors of affected properties were estimated by a "drive-by" survey which assessed the height of the floor above local natural surface elevations. These natural surface elevations were derived from the LiDAR survey used to construct the Namoi River and Wee Waa TUFLOW Models. Flood damages in Wee Waa resulting from the following five scenarios were assessed as part of the present study:

Damage due to local stormwater runoff

- No river flooding and gravity drainage of the protected area via the fourteen penstock gated stormwater drainage pipes that control ponding levels behind the Town Levee (**Damage Scenario 1**).
- Pumping of stormwater runoff to the Namoi River floodplain via the six permeant stormwater evacuation pumps and assuming the fourteen penstock gates are in their closed position and the Town Levee is not overtopped (**Damage Scenario 2**).
- Failure of the six permanent stormwater evacuation pumps to operate during a storm event and assuming the fourteen penstock gates are in their closed position and the Town Levee is not overtopped (**Damage Scenario 3**).

Damage due to riverine flooding

- No coincident rainfall over Wee Waa during a Namoi River Flood (**Damage Scenario 4**).
- No coincident rainfall over Wee Waa during a Namoi River Flood that causes a partial failure of the Town Levee (**Damage Scenario 5**).

The number of flood affected properties and the estimated damages which would occur for the five damage scenarios are summarised in **Tables 2.10** and **2.11** over the page.

It is estimated that only one dwelling and one commercial/industrial property would experience above-floor inundation should a 1% AEP storm event occur over Wee Waa during a period when the flood gates are open. The fact that there are only two properties that would experience above-floor flooding due to local catchment runoff for storms up to 1% AEP in intensity probably dates back to the pre-Town Levee era, when buildings would have been built off the ground to reduce the likelihood that they would be inundated by riverine flooding. While a large number of respondents to the questionnaire were in favour of upgrading the local stormwater drainage system (refer **Section 3.2** and **Appendix A** for further details), this finding indicates that the issue is likely related more to nuisance flooding, rather than damaging above-floor flooding.

While the number of properties that would experience above-floor flooding should a 1% AEP storm occur over Wee Waa when the penstock gates are closed would increase slightly, should the six stormwater evacuation pumps fail or not be started up during a storm of this intensity the total number of properties that would experience above-floor inundation would increase to only 30 properties (15 dwellings and 15 commercial/industrial buildings).

The "present worth value" of damages in Wee Waa resulting from rain falling directly over Wee Waa up to the 1% AEP event assuming the stormwater evacuation pumps are operational is $0.4 Million. This value represents the amount of capital spending which would be justified if a particular stormwater drainage upgrade scheme prevented flooding for all properties up to this event.

TABLE 2.10
FLOOD DAMAGES AT WEE WAS RESULTING FROM LOCAL STORMWATER RUNOFF[(1)]

Design Flood Event (% AEP)	Number of Properties																		Total Damage ($ Million)		
	Residential						Commercial/Industrial						Public								
	Flood Affected			Flood Damaged			Flood Affected			Flood Damaged			Flood Affected			Flood Damaged					
	DS1	DS2	DS3	DS1	DS2	DS3	DS1	DS2	DS3	DS1	DS2	DS3	DS1	DS2	DS3	DS1	DS2	DS3	DS1	DS2	DS3
5	17	18	31	1	1	2	3	3	14	0	0	3	2	2	2	0	0	0	0.39	0.40	0.9
2	20	24	45	1	1	6	4	5	18	0	2	9	2	2	2	0	0	0	0.45	0.56	1.53
1	26	33	55	1	4	15	6	10	23	1	3	15	5	4	5	0	0	0	0.58	0.90	2.43
0.5	31	40	61	2	6	19	8	20	28	2	7	17	5	5	5	0	0	0	0.76	1.36	3.94
0.2	50	60	73	6	14	25	20	25	34	7	14	21	5	5	5	0	0	0	1.51	2.50	6.54
PMF	215	221	221	119	137	137	54	54	54	46	48	48	19	20	19	10	13	13	22.29	26.14	26.14

1. DS1 – Damage Scenario 1 DS2 – Damage Scenario 2 DS3 – Damage Scenario 3

TABLE 2.11
FLOOD DAMAGES AT WEE WAS RESULTING FROM RIVERINE FLOODING[(1)]

Design Flood Event (% AEP)	Number of Properties												Total Damage ($ Million)	
	Residential				Commercial/Industrial				Public					
	Flood Affected		Flood Damaged		Flood Affected		Flood Damaged		Flood Affected		Flood Damaged			
	DS4	DS5	DS4	DS5	DS4	DS5	DS4	DS5	DS4	DS5	DS4	DS5	DS4	DS5
5	0	674	0	560	0	133	0	123	0	36	0	29	0	109.9
2	0	678	0	585	0	135	0	126	0	37	0	30	0	114.6
1	0	681	0	595	0	135	0	126	0	37	0	32	0	116.5
0.5	0	681	0	596	0	135	0	126	0	37	0	32	0	116.8
0.2	0	682	0	601	0	135	0	129	0	38	0	33	0	118.1
0.1[(2)]	681	-	594	-	129	-	126	-	42	-	33	-	117.8	-
Extreme Flood	703	703	696	696	135	135	135	135	42	42	42	42	163.3	163.3

1. DS4 – Damage Scenario 4 DS5 – Damage Scenario 5
2. Approximate AEP when overtopping of the Town Levee first occurs.

While damages due to overtopping of the Town Levee are limited to floods with AEPs less than about 0.1 per cent, once overtopping does occur, all but a small number of buildings would experience above-floor inundation. A similar situation would arise were the Town Levee to partially fail during a flood. The total damages in Wee Waa were the Town Levee to either be overtopped or fail during a major flood event is estimated to be about $117 Million. The present worth value of damages under a Town Levee failure scenario (i.e. Damage Scenario 5) is about $100 Million. This is the amount that could be spent upgrading the Town Levee to ensure that it is geotechnically stable, free of defects and arguably incorporates the required 1 m freeboard to the 1% AEP flood.

2.16 Flood Hazard and Hydraulic Categorisation of the Floodplain

2.16.1 General

According to Appendix L of *NSWG, 2005*, in order to achieve effective and responsible floodplain risk management, it is necessary to divide the floodplain into areas that reflect:

1. The impact of flooding on existing and future development and people. To examine this impact it is necessary to divide the floodplain into *"flood hazard"* categories, which are provisionally assessed on the basis of the velocity and depth of flow. This task was undertaken in the *Flood Study* where the floodplain was divided into *Low Hazard* and *High Hazard* zones. In this present report, a *final determination* of hazard was undertaken which involved consideration of a number of additional factors which are site specific to Wee Waa. **Section 2.16.2** below provides details of the procedure adopted.
2. The impact of future development activity on flood behaviour. Development in active flow paths (i.e. *"floodways"*) has the potential to adversely re-direct flows towards adjacent properties. Examination of this impact requires the division of flood prone land into various *"hydraulic categories"* to assess those parts which are effective for the conveyance of flow, where development may affect local flooding patterns. Hydraulic categorisation of the floodplain was also undertaken in the *Flood Study* and was reviewed in this present study. **Section 2.16.3** below summarises the procedure adopted.

2.16.2 Flood Hazard Categorisation

As mentioned above, flood prone areas may be *provisionally* categorised into *Low Hazard* and *High Hazard* areas depending on the depth of inundation and flow velocity. A flood depth of 1 m in the absence of significant flow velocity represents the boundary between *Low Hazard* and *High Hazard* conditions. Similarly, a flow velocity of 2.0 m/s but with a small flood depth around 200 mm also represents the boundary between these two conditions. Interpolation may be used to assess the hazard for intermediate values of depth and velocity. Flood hazards categorised on the basis of depth and velocity only are *provisional*. They do not reflect the effects of other factors that influence hazard.

These other factors include:

1. Size of flood – major floods though rare can cause extensive damage and disruption.
2. Effective warning time – flood hazard and flood damage can be reduced by sandbagging entrances, raising contents above floor level and also by evacuation if adequate warning time is available.

3. Flood awareness of the population – flood awareness greatly influences the time taken by flood affected residents to respond effectively to flood warnings. The preparation and promotion by Council of Flood Studies and Floodplain Risk Management Studies and Plans increases flood awareness, as does the formulation and implementation of response plans by NSW SES (Local Flood Plans) for the evacuation of people and possessions.
4. Rate of rise of floodwaters – situations where floodwaters rise rapidly are potentially more dangerous and cause more damage than situations in which flood levels increase slowly.
5. Duration of flooding – the duration of flooding (or length of time a community is cut off) can have a significant impact on costs associated with flooding. This duration is shorter in smaller, steeper catchments.
6. Evacuation problems and access routes – the availability of effective access routes from flood prone areas directly influences flood hazard and potential damage reduction measures.

Provisional hazard categories may be reduced or increased after consideration of the above factors in arriving at a final determination. A qualitative assessment of the influence of the above factors on the *provisional flood hazard* (i.e. the hazard based on velocity and depth considerations only) is presented in **Table 2.12** over the page.

Figure 2.23 (2 sheets) shows the division of the floodplain into high and low hazard areas following consideration of the factors set out in **Table 2.12**. While the *provisional flood hazard* classification has been adopted for the majority of the floodplain, pockets of low hazard floodway areas have been identified as *high hazard* areas.

2.16.3 Hydraulic Categorisation of the Floodplain

According to the *NSWG, 2005*, the floodplain may be subdivided into the following zones:

- ***Floodways*** are those areas where a significant volume of water flows during floods and are often aligned with obvious natural channels. They are areas that, even if partially blocked, would cause a significant increase in flood level and/or a significant re-distribution of flow, which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flow or areas where higher velocities occur.
- ***Flood Storage*** areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.
- ***Flood Fringe*** is the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

TABLE 2.12
INFLUENCE OF FLOOD RELATED PARAMETERS ON PROVISIONAL FLOOD HAZARD

Parameter	Flood Characteristics	Influence on Provisional Hazard	
		Namoi River Floodplain	Internal to Town Levee
Size of flood	Flooding is generally confined to the Namoi River floodplain and the risk to existing development is minor given the Town Levee is not overtopped for all but an extreme flood events. There is only one residential and one commercial/industrial property that experience above-floor inundation due to local catchment flooding a 1% AEP storm, and only then to relatively shallow depths.	-1	-1
Effective warning time	The flood wave takes between about 12-24 hours to travel from Narrabri to Wee Waa. While BoM and NSW SES maintain an effective and proven Flood Warning System for the Namoi River, high flows from the Pilliga Scrub area can cause unexpected flooding in the rural area south of Wee Waa. While there is presently no formal weather warning service in place for Wee Waa, there is only one residential and one commercial/industrial property that would experience above-floor inundation as a result of local catchment flooding in a 1% AEP storm and only then to relatively shallow depths.	0	-1
Flood awareness	Flood awareness would generally be quite high on the unprotected side of the Town Levee due to the relatively frequent nature of flooding in the rural areas. An awareness that the Town Levee could be overtopped during an extreme flood event is likely to be low in the community. An awareness for the need to evacuate during a flood that exceeds the IFF level would also likely be low in the community Landowners are aware of the deficiencies in the local stormwater drainage system, as evidenced by the strong response to the *Community Questionnaire*.	+1	0
Rate of rise and velocity of floodwaters	Flooding rises to a peak over a number of days, which in conjunction with the Flood Warning System, would provide sufficient warning for Council to close the penstock gates and check the stormwater evacuation pumps to make sure that they are fully functional. Overtopping or a partial failure of the Town Levee would result in a rapid increase in water levels.	0	0
Duration of flooding	Flooding of medium to major events may be maintained for up to one week. While local catchment flooding would be of a relatively short duration nature, it does cause disruption to movements around parts of Wee Waa and also the operation of some businesses.	0	+1
Evacuation problems	While the Town Levee is only overtopped during extreme flood events, the evacuation of people during a flood that exceeds the IFF level for the Town Levee would be costly should they not self-evacuate by vehicle prior to the local roads being inundated by floodwater. This is because the evacuation of people who did not self-evacuate would likely need to be carried out by air.	0	-1
	OVERALL SCORE	**0**	**-2**

Legend 0 = neutral impact on provisional hazard
+ 1 = tendency to increase provisional hazard
– 1 = tendency to reduce provisional hazard

Floodplain Risk Management Guideline No. 2 Floodway Definition, offers guidance in relation to two alternative procedures for identifying floodways. They are:

- **Approach A**. Using a *qualitative approach* which is based on the judgement of an experienced hydraulic engineer. In assessing whether or not the area under consideration was a floodway, the qualitative approach would need to consider; whether obstruction would divert water to other existing flow paths; or would have a significant impact on upstream flood levels during major flood events; or would adversely re-direct flows towards existing development.

- **Approach B**. Using the hydraulic model, in this case TUFLOW, to define the floodway based on *quantitative experiments* where flows are restricted or the conveyance capacity of the flow path reduced, until there was a significant effect on upstream flood levels and/or a diversion of flows to existing or new flow paths.

One quantitative experimental procedure commonly used is to progressively encroach across either floodplain towards the channel until the designated flood level has increased by a significant amount (for example 0.1 m) above the existing (un-encroached) flood levels. This indicates the limits of the hydraulic floodway since any further encroachment will intrude into that part of the floodplain necessary for the free flow of flood waters – that is, into the floodway.

The *quantitative assessment* associated with **Approach B** is technically difficult to implement. Restricting the flow to achieve the 0.1 m increase in flood levels can result in contradictory results, especially in unsteady flow modelling, with the restriction actually causing reductions in computed levels in some areas due to changes in the distribution of flows along the main drainage line.

Accordingly the *qualitative approach* associated with **Approach A** was adopted, together with consideration of the portion of the floodplain which conveys approximately 80% of the total flow. The findings of *Howells et al, 2004* who defined the floodway based on velocity of flow and depth were also taken into consideration. For example, Howells et al suggested the following criteria for defining those areas which operate as a "floodway" in a 1% AEP flood event:

- Velocity x Depth greater than 0.25 m^2/s **and** Velocity greater than 0.25 m/s; or
- Velocity greater than 1 m/s.

Flood storage areas on the Namoi River floodplain were identified as those areas which do not operate as floodways in a 1% AEP flood event but where the depth of inundation exceeds 1 m. The remainder of the flood affected area outside the Town Levee was classified as flood fringe.

No floodway areas are present internal to the Town Levee. Rather flood storage areas were defined as areas where the depth of inundation exceeds 0.3 m, while the remainder was classified as flood fringe.

Figure 2.23 (2 sheets) shows the division of the Namoi River floodplain and the area internal to the Town Levee into floodway, flood storage and flood fringe areas at the 1% AEP level of flooding.

2.17 Council's Existing Planning Instruments and Policies

2.17.1 General

The *Narrabri Local Environmental Plan 2012* (***Narrabri LEP 2012***) is the principal statutory planning document used by Council for controlling development by defining zoning provisions, establishing permissibility of land use and regulating the extent of development in Wee Waa.

Council does not maintain a consolidated development control plan, but rather maintains fourteen individual development control plans which deal with specific types of development.

2.17.2 Land Use Zoning – Narrabri Local Environmental Plan 2012

Figure 2.24 shows the zonings incorporated in *Narrabri LEP 2012* at Wee Waa. The area that is bounded by the Town Levee and lies to the east of Warrior Street is zoned *B2 Local Centre*, *B4 Mixed Use*, *IN2 Light Industrial*, *R1 General Residential*, *RE1 Public Recreation* and *SP2 Infrastructure*, while the area to the west of Warrior Street is zoned *B4 Mixed Use* and *IN1 General Industrial*.

The area surrounding the township is zoned *RU1 Primary Production*, with the exception of a 228 ha area which lies to the south-east which is zoned *R5 Large Lot Residential*.

2.17.3 Flood Provisions – Narrabri LEP 2012

Clause 6.2 of *Narrabri LEP 2012* entitled “Flood planning” outlines its objectives in regard to development of land that is at or below the Flood Planning Level (**FPL**). It is similar to the standard Flood Planning Clause used in recently adopted LEPs in other NSW country centres and applies to land at or below the FPL.

The FPL referred to is the 1:100 ARI (or 1% AEP) flood plus an allowance for freeboard of 500 mm. The area encompassed by the FPL (i.e. the FPA) denotes the area subject to flood related development controls, such as locating development outside high hazard areas and setting minimum floor levels for future residential development. It is now standard practice for the residential FPL to be based on the 1% AEP flood plus an appropriate freeboard unless exceptional circumstances apply.

While Clause 6.2 also applies to land identified as the FPA on the “*Flood Planning Map*”, the flood related mapping attached to *Narrabri LEP 2012* does not cover the township of Wee Waa. For the *Flood Planning Map* to be modified, a formal amendment would need to be made to *Narrabri LEP 2012*, which would take considerable time. It is therefore recommended that the *Flood Planning Map* not be attached to *Narrabri LEP 2012*, as this way it can be updated without the need to update the LEP. Recommended amendments to the wording of clause 6.2 are set out in **Section 3.5.1.4** of the report.

2.17.4 Flooding and Stormwater Controls

Schedule 2 of Council’s *Exempt & Complying Development Development Control Plan* (***DCP***) under Section 4 titled “Dwelling house (single storey)” and the heading “Bulk and scale” contains the following flood related controls:

> *“(1) The ground floor level of the structure is located at least 150 mm. for raft construction or 650 mm. for timber frame flooring but not more than 700 millimetres above the natural ground level (except where the dwelling complies with the Narrabri Shire Interim Floodplain Management Policy.)*
>
> *(2) The Finished Floor Level of all habitable areas of the dwelling are constructed 500mm higher than the 1:100 year flood event, for the subject land, in accordance with Narrabri Shire Council’s Interim Floodplain Management Policy. Note: Written verification of the finished floor level is to be provided to Council after the establishment of the flooding system.*
>
> *(3) The height of any landfill placed on the land is no more than 225mm.”*

Under Section 5 of Schedule 2 titled "Extensions" and the heading "Bulk and scale", the following flood related controls are also set out:

> *"(1) The ground floor level of the structure at any point is not more than 700 millimetres above the natural ground level (except where the dwelling complies with the Narrabri Shire Interim Floodplain Management Policy.)*
>
> *(2) The Finished Floor Level of all habitable areas of the dwelling extension are constructed 500mm higher than the 1:100 year flood event, for the subject land, in accordance with Narrabri Shire Council's Interim Floodplain Management Policy. Note: Written verification of the finished floor level is to be provided to Council after the establishment of the flooding system."*

Council's *Landfill Development DCP* states that the aims and objectives of the document are to set reasonable environmental standards in respect to flood liable land, privacy, on-site drainage, streetscape and other impacts on adjoining land uses. The *Landfill Development DCP* requires that a Statement of Environmental Effects be prepared which demonstrates that consideration has been given to the environmental impact of the development, including the probable effect on natural and stormwater drainage, flood water flows, privacy, soil erosion and management, and any other identifiable impacts on adjoining lands. It also requires that all batters of the landfill edges are to be stabilised in a manner to prevent surface erosion from storm or flood water events.

Council's *Subdivision Code DCP* under Section 4.6.1 titled "Flooding" states the following:

> *"Where a subdivision is undertaken within urban areas which are subject to flooding, the applicant is required to provide Council with the level of water on the property in a 1:100 year flood.*
>
> *With rural subdivisions, the applicant is required to supply Council with evidence that an area suitable for the construction of a dwelling is available which is in a low flood risk area. Where the subdivision is not for a residential purpose, evidence should be submitted to Council showing that the proposed used* [sic] *will not be adversely effected* [sic] *by a foreseeable flood event."*

The *Interim Floodplain Management Policy* referred to in Council's *Exempt & Complying Development DCP* was first adopted in October 1987 and later updated in March 1988 and October 1998. The interim policy states the following (**bold** and <u>underlined</u> text has been added for emphasis):

1. *All habitable rooms as described under clause A1.1 of the Building Code of Australia, for new houses and residential flat buildings are to be constructed at least 0.5 of a metre above the 1:100 ARI flood level.* ***This <u>does not</u> apply in the Town of Wee Waa, which is protected by the flood levee.***
2. *Alterations and additions to dwelling houses constructed prior to the enactment date for Council's current flood policy adopted in 1987 and requiring the floor levels of houses and residential flat buildings to be 0.5 of a metre above the 1:100 ARI flood level will be considered on an individual merit basis up to an area equal to 50% of the existing floor area of habitable rooms.* ***This provision <u>does not</u> apply to the Town of Wee Waa, which is protected by the flood levee.***

3 All Commercial and Industrial buildings whether new or additions, are considered on merit generally.

4 All building materials, for all types of development, that are to be utilised below the 1:100 ARI flood level, must be floodwater tolerant or resistant. Further, Council recommends that all electrical fittings and equipment be installed above the 1:100 ARI flood height for that land.

5 In the areas which may be affected by the 1:100 ARI flood landholders land filling in excess of 225mm.of material will be required to provide a permanent drain to the street from backyard run off and the backyard be graded to a sump which is to be drained by permanent piping to the street or by concrete dish drains or other approved drainage systems of permanent material, Such provisions must not restrict natural drainage from adjoining lands. Where the installation of land filling adversely affects the drainage of the adjoining site or sites a provision for drainage of the adjoining site or sites shall be incorporated in the drainage system provided by the person carrying out land filling. ***This provision <u>also applies</u> to the Town of Wee Waa.***

6 Where, in the opinion of the Director of Environmental Services or Council Planner, Council holds insufficient information to provide reasonably accurate flood information to enable compliance with Item 1 of this Policy, any applicant for the erection of new dwellings or residential flat buildings must provide to Council accurate information as to the level of the land, where the development is to occur and the 1955 flood level for that particular area.

7 With respect to new dwellings and residential buildings, where, in the opinion of Council, a proposed development could sustain structural damage by flooding, no work on the development will be allowed to commence until the applicant obtains and submits a Certificate of Structural Adequacy of the proposed dwelling or residential building from a qualified Structural/Civil Engineer.

8 With respect to commercial and industrial development, new and existing, in flood liable areas, applications for development are to be accompanied by a Certificate from a qualified practising Structural or Civil Engineer stating that the building will not sustain structural damage from the forces and impact of debris associated with flood waters equal to the 1:100 ARI flood, except - with respect to extensions and alterations to commercial buildings, shops, offices, motels, hotels, and the like having a floor area of 50 m^2 or less or industrial buildings including workshops, stores associated with such workshops, warehouses and bulk stores having an area of 100 m^2 or less.

NOTE: Major residential and rural areas of this Shire were affected by the 1955 flood peak. The Council has details of the depth of flooding in Narrabri Township (Narrabri Shire Council 1:100 ARI Flood Contour Map, Town of Narrabri) and the extent of flooding with respect to the 1955 flood at the Town of Boggabri. Council's records relating to Narrabri and Boggabri may be inspected by any interested person. ***With respect to the residue of the Shire, the Town of Wee Waa is protected by a levee bank which at the time of construction was***

designed in accordance with the requirements of the then Water Resources Commission of New South Wales, The integrity of the Wee Waa levee bank depends on the future nature of flooding In the area.

With respect to rural areas, Council holds very little information regarding the depth of flooding in portions of the Shire affected by the 1955 flood event and reference should be made to the Department of Land and Water Conservation who may hold useful Information in this regard.

THE FILLING OF LAND AT NARRABRI WITH FILL OF A GREATER DEPTH THAN 225mm IN AREAS AFFECTED BY THE 1:100 ARI YEAR FLOOD EVENT REQUIRES COUNCIL'S DEVELOPMENT CONSENT PRIOR TO WORK BEING COMMENCED.

DEFINITION AS PER BCA

Habitable room means a room used for normal domestic activities, and–

(a) includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room and sunroom; but

(b) excludes a bathroom, laundry, water closet, pantry, walk–in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes–drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.

Based on the controls set out in Council's *Exempt & Complying Development DCP* and the *Interim Floodplain Management Policy*, there is no requirement to set the floor level of any new development or extension in Wee Waa above the peak 1% AEP flood level. This requirement does not take into account the depth to which stormwater will pond behind the Town Levee during a 1% AEP storm event and assumes that it has the required freeboard to protect new development from inundation by a 1% AEP Namoi River flood (which it presently doesn't provide given insufficient freeboard).

In the knowledge that the Town Levee does not have the required 1 m freeboard and therefore does not protect development for a 1% AEP flood, the provisions set out in *Interim Floodplain Management Policy* allow development to occur in Wee Waa below the level of the FPL. The policy is therefore inconsistent with the NSW Government's Section 9.1 Direction which states that unless there are exception circumstances[13] the residential FPL is the 1% AEP plus an appropriate freeboard (which in areas subject to riverine flooding is generally set at 0.5 m). Further discussion on this issue is contained in **Chapter 3**.

Development Design Specification D5 titled "*Stormwater Drainage*" sets out Council's requirements for the design of new stormwater drainage systems. It adopts the "major/minor" system concept set out in the 1987 version of Australian Rainfall & Runoff (IEAust, 1987).

[13] In this context, exception circumstances relate to the adoption of a higher flood standard, not a lower flood standard which is presently the case at Wee Waa where development is allowed to occur based on a maximum height above ground.

2.18 Flood Warning and Flood Preparedness

The NSW SES is nominated as the principal combat and response agency for flood emergencies in NSW. NSW SES is responsible for the issuing of relevant warnings (in collaboration with BoM), as well as ensuring that the community is aware of the flood threat and how to mitigate its impact.

The *Narrabri Local Flood Plan*, 2015 (herein referred to as the ***Local Flood Plan***) published by NSW SES covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for all levels of flooding within the Narrabri Shire area. The *Local Flood Plan* is administered by the NSW SES Narrabri Local Controller who controls flood operations within the Narrabri Shire area and is based in Narrabri. A NSW SES unit is also based in Wee Waa and assists the Narrabri Local Controller administer the *Local Flood Plan* in relation to the township. The NSW SES Wee Waa unit is located at No. 52 Rose Street, Wee Waa.

The main body of the *Local Flood Plan* follows the standard NSW SES template and is divided into the following sections:

- ***Introduction***; this section of the *Local Flood Plan* identifies the responsibilities of the NSW SES Local Controller, Unit Controllers and NSW SES members, as well as supporting services such as the Police, BoM, Ambulance, Country Energy, Fire Brigades, Department of Community Services, Council, etc. The *Local Flood Plan* identifies the importance for NSW SES and Council to coordinate the development and implementation of a public education program to advise the population of the flood risk.
- ***Preparedness***; this section deals with activities required to ensure the *Local Flood Plan* functions during the occurrence of the flood emergency. The Plan will devote considerable attention to flood warning and emergency response.
- ***Response***. The NSW SES maintains an operation centre at the NSW SES Local Headquarters in Reid Street, Narrabri. Response operations will commence: on receipt of a Preliminary Flood Warning, Flood Warning, Flood Watch, Severe Thunderstorm Warning or a Severe Weather Warning for flash flooding from BoM, on receipt of a dam failure or when other evidence leads to an expectation of flooding within the Narrabri Shire area. Sources of Flood Intelligence identified will include BoM, NSW Office of Water, the Keepit Dam Storage Monitoring System, NSW SES Namoi Regional Headquarters and Council.

  The *Local Flood Plan* states that the Wee Waa Public School on Cowper Street, Wee Waa High School on Purcell Street, the Church Hall on Cowper Street, the Sports Complex on the Kamilaroi Highway, the Country Women's Association Rooms in Rose Street, and the Namoi Cotton Co-Op and Cotton Grower Services on Boolcarrol Road are suitable flood evacuation centres. The location of the nominated flood evacuation centres are shown on **Figure 2.11**, sheet 2.
- ***Recovery***, involving measures to ensure the long term welfare for people who have been evacuated, recovery operations to restore services and clean up and de-briefing of emergency management personnel to review the effectiveness of the *Local Flood Plan*.

Annexes A and B of the *Local Flood Plan* describe the flood threat and impact that flooding has on the community in the Narrabri Shire area, respectively. **Sections 2.4** and **2.5** of this report contain a description of flooding behaviour at Wee Waa, as well as the impact that flooding has on the local community which is based partially on the information contained in Annexes A and B of the *Local Flood Plan*.

Annex F of the *Local Flood Plan* which deals with evacuation arrangements in the Narrabri Shire area states that up to eighteen residences that are located outside the Town Levee may require evacuation into Wee Waa during a flood. The *Local Flood Plan* also states that the most likely event to trigger the decision to undertake a large-scale evacuation of Wee Waa would be evidence of a possible failure or overtopping of the Town Levee.

In the event of actual levee failure or overtopping, the *Local Flood Plan* states that all essential services would be cut and the town would almost certainly have to be completely evacuated. As Wee Waa usually has up to three days warning of a peak flood height, as well as up to two days warning of when the town may be isolated by road, some preliminary evacuations may be possible.

In the event that predicted flood heights indicate a threat of levee overtopping, the NSW SES Narrabri Local Controller, Wee Waa Unit Controller and the Narrabri Local Emergency Operations Controller will consider preliminary road evacuation of the aged, infirm and children. It is thought that this could reduce the population by up to 40 per cent.[14]

In the case where the town is isolated by road, the *Local Flood Plan* states that evacuees will be flown to a transit area at "The Pines". If the Bohena Creek crossing on the Narrabri to Yarrie Lake Road is open, the evacuees could be moved out of "The Pines" by bus. If not, they will need to be moved by air from Nicholson's Airport, which is located adjacent to 'The Pines" and is flood free.

2.19 Environmental Considerations

The river and creek systems at Wee Waa are largely in their natural state where they run to the north and south of the township. Given the relatively wide floodplain at Wee Waa and the fact that there are a limited number of properties affected by Namoi River Flooding, modifications to the main arm of the river would not result in a significant reduction in flood damages. As a result, channel modifications and stream clearing do not form part of the recommended set of flood mitigation measures at Wee Waa.

Consideration would need to be given to the impact the upgrade of the Town Levee would have on existing vegetation and Wee Waa Lagoon as its footprint would increase as a result of an increase in the elevation of its crest. **Section 3.4.1** of this report sets out the requirements for the upgrade of the Town Levee.

[14] Note that this would still leave about 1,000 people in Wee Waa who would need to be evacuated during a flood emergency by air.

3 POTENTIAL FLOODPLAIN MANAGEMENT MEASURES

3.1 Range of Available Measures

A variety of floodplain management measures can be implemented to reduce flood damages. They may be divided into three categories, as follows:

Flood modification measures change the behaviour of floods in regard to discharges and water surface levels to reduce flood risk. This can be done by the construction of levees, detention basins, channel improvements and upgrades of piped drainage systems in urban areas. Such measures are also known as "structural" measures as they involve the construction of engineering works. Vegetation management is also classified as a flood modification measure.

Property modification measures reduce risk to properties through appropriate land use zoning, specifying minimum floor levels for new developments, voluntary purchase of residential property in high hazard areas, or raising existing residences in the less hazardous areas. Such measures are largely planning (i.e. "non-structural") measures, as they are aimed at ensuring that the use of floodplains and the design of buildings are consistent with flood risk. Property modification measures could comprise a mix of structural and non-structural methods of damage minimisation to individual properties.

Response modification measures change the response of flood affected communities to the flood risk by increasing flood awareness, implementation of flood warning and broadcast systems and the development of emergency response plans for property evacuation. These measures are entirely non-structural.

3.2 Community Views

Comments on potential flood management measures were sought from the Wee Waa community by way of the *Community Questionnaire* which was distributed at the commencement of the study. The responses are summarised in **Appendix A** of this report. Question 13 in the *Community Questionnaire* outlined a range of potential flood management measures. The responses are shown on **Table 3.1** over the page together with initial comments on the feasibility of each measure. The measures are discussed in more detail in later sections of this Chapter.

The Community favoured the following measures:

- Raising of the Town Levee
- Improvements in the stormwater system within Wee Waa.
- Advice of flood affectation via Planning Certificates for properties located within the *Flood Planning Area*.
- Flood related controls over future development in flood liable areas.
- Improved flood warning, evacuation and flood response procedures.
- Community education to promote flood awareness.

TABLE 3.1
COMMUNITY VIEWS ON POTENTIAL FLOOD MANAGEMENT MEASURES

Flood Management Measure		Classification[(1)]	Respondent's Views			Comments
			Yes	No	Don't Know	
a)	Raising of the existing earthen levee using the same construction methodology	FM	52	2	3	The community is strongly in favour of this measure, which is an essential part of the *LRMP*. Details of the upgrade requirements for the Town Levee are set out in **Section 3.4.1**.
b)	Raising of the existing earthen levee during times of flood using temporary/relocatable flood barriers	FM	12	20	5	The community is not in favour of this measure. Nonetheless, a brief discussion on this approach is contained in **Section 3.4.1**.
c)	Improvements to the internal drainage system	FM	45	1	1	This measure is strongly supported by the community and needs to be considered as part of the *LRMP*. While the present study shows that the severity of flooding internal to the Town Levee is reduced by the operation of the stormwater evacuation pumps, there is merit in increasing the temporary flood storage in several areas. This flood management measure and the technical requirements associated with the upgrade of the existing stormwater system are discussed in **Section 3.4.2**.
d)	Removal of floodplain obstructions, such as rural levees	FM	12	18	7	This measure is not supported by the community. This is likely due to the reliance of the town on the surrounding agricultural industry, namely cotton farms which rely on the rural levees to protect crops from inundation by floodwater.
e)	Voluntary purchase of the most severely affected flood-liable properties	PM	7	17	11	The community is not in favour of this measure, which is often adopted to remove residential property in high hazard areas of the floodplain. As there are no dwellings internal to the Town Levee located in the High Hazard Floodway area, this measure was not assessed.
f)	Provide funding or subsidies to raise houses above major flood level in low hazard areas	PM	19	13	6	The community is not in favour of this measure. As there are no more than four residential properties that would experience above-floor inundation during a 1% AEP storm event other than for the case where the stormwater evacuation pumps were inoperable, and only then to relatively shallow depths, this measure by inspection could not be justified economically. As a result, it was not considered further.
g)	Flood proofing of individual properties by waterproofing walls, putting shutters across doors, etc.	PM	4	21	12	The community is not in favour of this measure, which should only be adopted as a means by which to mitigate the impact of flooding on existing development. As a result, this measure was not assessed.
h)	Improve flood warning and evacuation procedures both before and during a flood	RM	34	8	1	NSW SES is responsible for the issuing of relevant warnings (in collaboration with BoM), as well as ensuring that the community is aware of the flood threat and how to mitigate its impact. BoM operates a flood warning system which provides predictions of gauge heights along the Namoi River, including at Wee Waa. Improvements to flood emergency response planning (using information contained in this study) are supported by the community and are considered in **Section 3.6.3**.
i)	Community education, participation and flood awareness programs	RM	29	4	5	Ensuring the community is aware of the flood risk in Wee Waa is favoured by the questionnaire respondents. This measure is reviewed in **Section 3.6.3**.
j)	Ensuring all residents and business owners have Flood Action Plans	RM	33	6	4	Ensuring the community knows what actions to take during a flood event is favoured by the questionnaire respondents. This measure is reviewed in **Section 3.6.3**.
k)	Specify controls on future development in flood-liable areas (e.g. controls on extent of filling, minimum floor levels, etc.)	PM	27	5	11	The community supports this measure, which is an essential part of the *LRMP*. The issue is covered in **Section 3.5.1**.
l)	Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected	PM	38	2	3	Provision of information on flood affection of properties is strongly favoured by the community. This may be achieved by notation of flood affectation of allotments on Section 10.7 Planning Certificates. This measure is discussed in **Section 3.5.1.3**.
m)	Ensuring all information about the potential risks of flooding is available to all residents and business owners	PM	47	1	0	Ensuring the community is aware of the flood risk in Wee Waa is favoured by the questionnaire respondents. This measure is reviewed in **Section 3.6.3**.

1. FM = Flood Modification Measure
   PM = Property Modification Measure
   RM = Response Modification Measure

3.3 Outline of Chapter

Several of the measures set out in **Table 3.1** were examined at the strategic level of detail in **Chapter 3** and then tested for feasibility on a range of assessment criteria in **Chapter 4**. Following consideration of the results by the FRMC, selected measures were included in the *LRMP* in **Chapter 5**.

Only two flood modification measures were assessed as part of the present study given the two principal issues are:

i) the design standard of the Town Levee is currently equivalent to about a 5% AEP flood, and

ii) parts of the town are subject to nuisance flooding that occurs during periods of heavy and/or prolonged rainfall.

In the economic analysis, the damages prevented by the upgrade of the Town Levee represent its benefits. The damages were computed for present day and post-scheme conditions for a range of flood events. By integrating the area beneath the damage–frequency curve up to the "design standard" of the scheme (in this case the 1% AEP), the long term "average annual" value of benefits were calculated (by subtraction of post-scheme from present day damages). These average annual benefits were then converted to an equivalent present worth value for each of the three discount rates nominated by NSW Treasury Guidelines for the economic analysis of public works (i.e. 4, 7 and 11 per cent), over an economic life of 50 years. These present worth values of benefits were then divided by the capital costs of the Town Levee upgrade scheme to give benefit/cost ratios for the three discount rates. An economic analysis was not undertaken of the assessed stormwater drainage upgrade scheme as by inspection, it could not be justified on economic grounds (i.e. because its benefit cost ration would be significantly less than one).

Given the limited number of properties in Wee Waa that would experience above-floor inundation during a 1% AEP storm event and the low hazard nature of the stormwater which ponds behind the Town Levee, property modification measures such as voluntary purchase of residential properties and house raising were not considered. Flood related development controls over future development in the protected part of town could be limited to a minimum fill height and floor level control based on peak 1% AEP local catchment flood levels. However, until such time as the Town Levee is upgraded, this requirement would be deemed not to protect new development from a 1% AEP Namoi River flood (i.e. because the Town Levee does not incorporate sufficient freeboard to protect against a flood of this magnitude). Response modification measures such as improvements to emergency planning and responses, and public awareness programs have been considered for Wee Waa.

3.4 Flood Modification Measures

3.4.1 Town Levee Upgrade

While the Town Levee would not be overtopped for all but extreme flood events, the analysis set out in **Appendix E** of the report confirms the 1 m freeboard requirement that was adopted as part of its original design. Based on this finding, the design standard of the Town Levee is only equivalent to about a 5% AEP flood, which is slightly less than the level of flooding that it was originally designed to protect against (As previously mentioned, the original design adopted the February 1971 flood as the design standard which had an AEP of about 4 per cent).

Upgrading the Town Levee to provide a 1% AEP level of flood protection would require its crest to be raised over about a 6.2 km length. **Figure 3.1** shows the eight sections of the Town Levee that would need to be raised by a maximum height of about 0.5 m in order to provide the required 1 m freeboard to peak 1% AEP flood levels, while **Figure 3.2** is a long section showing the upgraded crest relative to existing ground and peak 1% AEP and Extreme flood levels.

While temporary relocatable flood barriers could be used to achieve the required 1 m freeboard to peak 1% AEP flood levels, reasons for not adopting this approach include:

- the logistics associated with installing the temporary measures over such a long length of levee prior to the arrival of the flood peak;
- the large flood damages that would result should these temporary measures fail or not be installed either correctly or in time;
- the hazardous nature of the flooding that would result from an overtopping event; and
- this type of approach to protecting the town is not favoured by the community.

The preferred option for upgrading the Town Levee is to raise its crest similar to the design which was prepared by Water Resources Consulting Services as part of the previous levee upgrade in 1993. This would require the removal of topsoil from the crest and front face of the embankment and the placement of a new engineered skin and associated toe arrangement. **Figure 3.3** is a typical section showing the scope of the upgrade works, while **Figures F1.1** (7 sheets) and **F1.2** (10 sheets) in **Appendix F** provide details of the upgrade requirements along the full length of the Town Levee.

The geotechnical report contained in **Appendix B** also provides recommendations associated with the upgrade of the Town Levee which includes a requirement to undertake further more detailed subsurface investigations to ascertain the condition of its core.

Table 3.2 gives a breakdown of the estimated $7.55 Million that it would cost to upgrade the Town Levee to a 1% design flood standard, noting that this does not include the cost of purchasing any easements over the Town Levee which at this point in time has been assumed not to be required.

If it is assumed that major overtopping of the Town Levee does not occur for all floods up to the 1% AEP (which could occur for reasons such as wind and wave action in the flow), then on economic grounds its upgrade could not be justified as there are no damages to prevent.

If it costs the community say $1 Million to evacuate people by air and relocate them to Narrabri for all floods between 5 and 1% AEP, then the present worth value of costs that would be saved by its upgrade would be about $0.6 Million, resulting in a benefit cost ratio of about 0.08.

In addition to the above, if the cost of flood insurance was to reduce by $250 on average in the 707 residential and say $500 on average in the 135 commercial/industrial properties that are protected by the Town Levee should it be upgraded, then the present worth value of costs that would be saved by its upgrade would increase to about $0.9 Million, resulting in a slight increase in the benefit cost ratio to about 0.1.

If the Town Levee is deemed not to protect property in Wee Waa for floods larger than 5% AEP in magnitude (i.e. equal to or larger than the IFF), then the present worth value of flood damages saved by its upgrade increases to about $100 Million. This results in a benefit cost ratio of about 13.

TABLE 3.2
BREAKDOWN OF CAPITAL COST ESTIMATE
TOWN LEVEE UPGRADE
1% AEP PLUS 1 m FREEBOARD

Item	Description	Unit	Rate	Quantity	Amount
1	Geotechnical Testing along levee route	Item	$100,000	1	$100,000
2	Preliminaries (Site Establishment, Sediment Control, etc)	Item	$50,000	1	$50,000
3	Clear and Grub along Route of Levee, including tree removal	m^2	$2.00	87,000	$174,000
4	Strip and Store Topsoil (150 mm) for later spreading over levee batters	m^2	$1.50	87,000	$130,500
5	Excavate additional 150 mm below adjacent natural surface to form foundation of new levee	m^3	$10.00	48,000	$480,000
6	Roll and Compact Levee Foundation	m^2	$5.00	87,000	$435,000
7	Supply and compact suitable impervious fill to form levee embankment	m^3	$40.00	71,000	$2,840,000
8	Excavate from stockpile and spread topsoil over face of levee	m^2	$1.00	87,000	$87,000
9	Grass seed levee batters	m^2	$5.00	87,000	$435,000
10	Road Crossing (Bitumen)	Item	$50,000	5	$ 250,000
11	Road Crossing (Dirt)	Item	$10,000	1	$10,000
12	Railway Crossing	Item	$20,000	2	$40,000
13	Drainage Works	Item	$10,000	10	$100,000
14	Un-estimated items and contingencies (40%)				$1,892,600
	Sub-total				$7,024,100
	Survey, Investigation and design (7.5%)				$526,808
	Total Estimated Cost (Rounded to nearest $10,000)				**$7,550,000**

As mentioned in **Section 2.17.4**, as the design standard of the Town Levee is only equivalent to about a 5% AEP flood, Council's *Interim Floodplain Management Policy* is not consistent with the NSW Government's Section 9.1 Direction which states that unless there are exception circumstances the residential FPL is the 1% AEP plus an appropriate freeboard (which in areas subject to riverine flooding is generally set at 0.5 m) (i.e. because it allows development to occur based on a maximum height of 700 mm above the natural ground level, which is below the peak 1% AEP flood level in the river for which the Town Levee does not protect against).

This finding is a major issue for Council and the Wee Waa community, as unless the Town Levee is upgraded to incorporate the required 1 m freeboard, future development can only be approved if its floor level is set 0.5 m above the peak 1% AEP flood level on the Namoi River floodplain, which in most areas would place it more than 1.5 m, and in some areas more than 2.5 m above natural surface levels.

3.4.2 Upgrade of Stormwater Drainage System

Stormwater drainage systems are an effective means of preventing frequent flooding of urban areas by local catchment runoff. Stormwater drainage systems are usually designed to convey flows associated with more frequent rainfall events. Flows resulting from rarer events will usually exceed the capacity of the stormwater drainage system and travel along flow paths as local overland flow. While upgrading key elements of a stormwater drainage system may prevent nuisance flooding in low lying properties or inundation of low points in roads due to small storms that occur frequently, it is generally not a cost effective or practical way to mitigate damaging flooding that results from intense, rare storm events.

While major upgrades to the stormwater drainage system at Wee Waa could not be economically justified (i.e. because the present worth value of flood damages in Wee Waa for all localised storms up to 1% AEP is only $0.4 Million and a scheme costing more than this would have a benefit cost ratio less than 1), three options for reducing flooding resulting from the major flow path that develops through the centre of Wee Waa were assessed as part of the present study.

Figures 3.4, **3.5** and **3.6** show the impact three options for upgrading the existing stormwater drainage system on the northern side of Mitchell Street between George Street and the existing 750 mm diameter pipe which extends through the Town Levee at Chainage 8200 would have on drainage patterns for storms with AEPs of 5, 2 and 1 per cent. While all three stormwater drainage upgrade schemes would reduce the depth and extent of inundation, most of the benefits would be confined to land which is low lying and presently undeveloped. The exception is on the northern side of Boolcarrol Road, west of Warrior Street where the depth and extent of ponding in several industrial properties would be reduced.

Given the stormwater drainage upgrade schemes would be relatively expensive to construct and do not remove flooding in Wee Waa, they could not be justified on either economic or social grounds. Based on this finding, they were not considered further.

3.5 Property Modification Measures

3.5.1 Controls over Future Development

3.5.1.1 Considerations for Setting Flood Planning Level

Selection of the FPL for an area is an important and fundamental decision as the standard is the reference point for the preparation of floodplain risk management plans. It is based on adoption of the peak level reached by a particular flood plus an appropriate allowance for freeboard. It involves balancing social, economic and ecological considerations against the consequences of flooding, with a view to minimising the potential for property damage and the risk to life and limb. If the adopted FPL is too low, new development in areas outside the FPA (particularly where the difference in level is not great) may be inundated relatively frequently and damage to associated public services will be greater. Alternatively, adoption of an excessively high FPL will subject land that is rarely flooded to unwarranted controls.

Councils are responsible for determining the appropriate FPLs within their local government area. While *Narrabri LEP 2012* nominates the "*1:100 ARI (average recurrence interval) flood event plus 0.5 m freeboard*" as the FPL, the *Interim Floodplain Management Policy* allows development in Wee Waa to proceed subject to it being built no more than 700 mm above the natural ground surface, even though the design standard of the Town Levee is only equivalent to about a 5% AEP flood.

As it is not practical to apply the 1% AEP Namoi River flood level plus 0.5 m freeboard to development in Wee Waa given the height to which floor levels would need to be set above natural ground levels, the only means by which development can occur at a lower level is if the design standard of the Town Levee is increased to 1% AEP. The following discussion on flood related planning controls for Wee Waa therefore assumes that the Town Levee is upgraded to achieve a 1% AEP level of protection from Namoi River Flooding.

3.5.1.2 Current Government Policy

The circular issued by the Department of Planning on 31 January 2007 contained a package of changes clarifying flood related development controls to be applied on land in low flood risk areas (land above the 1% AEP flood). The package included an amendment to the Environmental Planning and Assessment Regulation 2000 in relation to the questions about flooding to be answered in Section 149 planning certificates (now referred to as Section 10.7 planning certificates), a revised ministerial direction (Direction 15 – now Direction 4.3 issued of 1 July 2009) regarding flood prone land (issued under Section 9.1 of the EP&A Act, 1979) and a new Guideline concerning flood-related development controls in low flood risk areas. The Circular advised that councils will need to follow NSWG, 2005, as well as the Guideline to gain the legal protection given by Section 733 of the Local Government Act.

The Department of Planning Guideline confirmed that unless exceptional circumstances applied, councils should adopt the 1% AEP flood with appropriate freeboard as the FPL for residential development. In proposing a case for exceptional circumstances, a council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood. Unless there were exceptional circumstances, Council should not impose flood-related development controls on residential development on land with a low probability of flooding, that is land above the residential FPL.

Nevertheless, the safety of people and associated emergency response management needs to be considered in low flood risk areas, which may result in:

- Restrictions on types of development which are particularly vulnerable to emergency response, for example, developments for aged care and schools.
- Restrictions on critical emergency response and recovery facilities and infrastructure. These aim to ensure that these facilities and the infrastructure can fulfil their emergency response and recovery functions during and after a flood event. Examples include evacuation centres and routes, hospitals and major utility facilities.

While typically this would lead to a recommendation to locate the abovementioned types of development off the floodplain (i.e. on land which lies above the Extreme Flood in the case of Wee Waa), this is not necessarily practical given there would be the potential for the upgraded Town Levee to be overtopped in an Extreme Event. Controls on this type of development should therefore be limited to a minimum floor level control above the peak 1% AEP local catchment flood event (in this case 0.5 m). An added requirement in the case of the Wee Waa District Health Service would be to provide rising pedestrian access to the crest of the Town Levee from the floor level of the main building.

3.5.1.3 Proposed Planning Controls

Figure 3.7 (2 sheets) is an extract from the *Flood Planning Map* covering the area which is bounded by the Town Levee, as well as the 228 ha area that lies to the south-east of Wee Waa which is zoned *R5 Large Lot Residential*. The extent of the FPA (the area subject to flood related development controls) is shown in a solid red colour in **Figure 3.7** and has been defined as land which lies at or below the 1% AEP plus 500 mm freeboard.[15,16]

It is proposed that properties intersected by the extent of the FPA would be subject to S10.7 flood affectation notification and planning controls graded according to flood. NSWG, 2005 suggests wording on S10.7 (2) Planning Certificates along the following lines:

> *"Council considers the land in question to be within the Flood Planning Area and therefore subject to flood related development controls. Information relating to this flood risk may be obtained from Council. Restrictions on development in relation to flooding apply to this land as set out in Council's Flood Policy which is available for inspection at Council offices or website."*

As the flooding internal to the Town Levee is of a low hazard ponding nature, controls applied to future development need only amount to a minimum floor level control which is equal to the height of the FPL shown on **Figure 3.7**.

In regards the 228 ha area which lies to the south-east of Wee Waa which is zoned *R5 Large Lot Residential*, it is recommended that Council consider rezoning the portion that is classified as either Floodway or High Hazard Flood Storage at the 1% AEP level of flooding (refer **Figure 2.23**, sheet 1) so as not to permit future residential and commercial type development. As the remainder of the area either lies above the 1% AEP flood level or is classified as Flood Fringe, then future development need only be subject to a minimum floor level control set equal to the FPL.

3.5.1.4 Revision of Narrabri LEP 2012 by Council

To improve Council's approach to floodplain risk management, clause 6.2 of *Narrabri LEP 2012* would require minor amendments, namely in regards the wording of sub clause (2) and (5). It is recommended that Council consider updating the wording in the existing clause 6.2 of *Narrabri LEP 2012* as follows:

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[15] When defining the extent of the FPA internal to the Town Levee, it has been assumed that the levee has been upgraded to provide a 1% AEP level of protection from Namoi River Flooding

[16] Internal to the Town Levee, the higher of the peak 1% AEP flood levels resulting from the 'penstock gates open' and the 'penstock gates closed and stormwater evacuation pumps operational' scenarios were adopted for setting the FPL's, while external to the Town Levee the higher of the 'present day' and 'raised rural levee' scenarios were adopted for setting the FPL's.

"6.2 Flood planning

(1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to land at or below the flood planning level.

(3) Development consent must not be granted for development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual, unless it is otherwise defined in this Plan."

In order to support the proposed changes to clause 6.2 of *Narrabri LEP 2012*, it would be necessary to include the following definitions in the Dictionary:

- ***Flood planning level*** means the level of a 1% AEP (annual exceedance probability) flood event plus 0.5 metre freeboard, or other freeboard as determined by any floodplain risk management plan adopted by the Council in accordance with the Floodplain Development Manual.
- ***Floodplain Development Manual*** means Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005.

While not strictly relevant to Wee Waa, it is also recommended that Council consider incorporating a new floodplain risk management clause in *Narrabri LEP 2012* as follows:

"Floodplain risk management

(1) The objectives of this clause are as follows:

(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events exceeding the flood planning level,

(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

(2) This clause applies to land which lies between the flood planning level and the level of the probable maximum flood, but does not apply to land at or below the flood planning level.

(3) Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land:

(a) child-based child care facility

(b) correctional centre

(c) educational establishment

(d) emergency services facility

(e) extractive industry

(f) group homes

(g) mining

(h) place of public worship

(i) residential care facilities

(j) respite day care centre

(k) senior housing

(l) tourist and visitor accommodation

(m) waste or resource management facility

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual, unless it is otherwise defined in this Plan."

In order to support the inclusion of the new clause in *Narrabri LEP 2012*, it would be necessary to include the following definitions in the Dictionary:

- ***probable maximum flood*** means the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation.

The steps involved in Council's amending *Narrabri LEP 2012* following the finalisation and adoption of the *LRMS&P* are:

1. Council Planning Staff consider the conclusions of the *LRMS&P* and suggested amendments to *Narrabri LEP 2012*.
2. Council resolves to amend *Narrabri LEP 2012* in accordance with the *LRMS&P*.
3. Council prepares a Planning Proposal in accordance with NSW Planning and Environment Guidelines. Planning Proposal submitted to NSW Planning and Environment in accordance with section 3.33 of the EP&A Act, 1979.
4. Planning Proposal considered by NSW Planning and Environment and determination made in accordance with section 3.34 of the EP&A Act, 1979 as follows:
   - (a) whether the matter should proceed (with or without variation),
   - (b) whether the matter should be resubmitted for any reason (including for further studies or other information, or for the revision of the planning proposal),
   - (c) community consultation required before consideration is given to the making of the proposed instrument (the community consultation requirements),
   - (d) any consultation required with State or Commonwealth public authorities that will or may be adversely affected by the proposed instrument,
   - (e) whether a public hearing is to be held into the matter by the Planning Assessment Commission or other specified person or body,
   - (f) the times within which the various stages of the procedure for the making of the proposed instrument are to be completed.
5. Planning Proposal exhibited for public comment.
6. Planning Proposal reviewed following public submissions and submissions from relevant State and Commonwealth authorities.
7. Final Local Environmental Plan with proposed amendments drafted.
8. Amending Local Environmental Plan made by the Minister and gazetted.

3.6 Response Modification Measures

3.6.1 Improvements to Flood Warning System

Improvements to the flood warning and response procedures were strongly favoured by the community during the consultation process. An effective flood warning system has three key components, i.e. a flood forecasting system, a flood warning broadcast system and a response/evacuation plan. All systems need to be underpinned by an appropriate public flood awareness program.

As mentioned in **Section 2.13**, BoM currently operates a well-established and proven flood warning system which provides predictions of gauge heights along the Namoi River, including at Wee Waa. BoM's system is based on the conversion of rainfalls recorded at telemetered gauges within the catchments to predicted peak flood levels at the gauges, which are updated and conveyed to NSW SES Local Units during a flood emergency. The flood warning system includes the Glencoe stream gauge.

To improve flood response it is recommended that the *Local Flood Plan* be updated (see **Section 3.6.2**) to provide the most up to date information on the nature of flooding at Wee Waa.

3.6.2 Improved Emergency Planning and Response

As mentioned in **Section 2.18**, the *Local Flood Plan* provides detailed information regarding preparedness measures, conduct of response operations and coordination of immediate recovery measures for all levels of flooding.

NSW SES should ensure information contained in this report on the impacts of flooding on urban development, as well as recommendations regarding flood warning and community education are used to update the *Narrabri Local Flood Plan*:

1 – The Flood Threat includes the following sub-sections:

1.1 Land Forms and River Systems – ref. **Sections 2.1** and **2.2** of the report for information on these topics.

1.4 Characteristics of Flooding – The elevation to which peak flood levels reach relative to the crest height of the Town Levee for floods ranging between 5% and 0.2% AEP, as well as the PMF is shows on **Figure 2.2**, while the indicative extent and depth of inundation both internal to the Town Levee for the assessed flood events are shown on **Figures 2.3** to **2.8**. **Figure 2.10** shows the rate of rise and duration of inundation at several locations along the roads which lead into Wee Waa. **Table 2.4** provides a comparison between historic and design peak heights on the Glencoe stream gauge, while **Table 2.8** summarises the impact Namoi River and Local Catchment Flooding has on vulnerable development and critical infrastructure at Wee Waa. The location of vulnerable development and critical infrastructure relative to the flood extents is shown on **Figure 2.11**.

1.5 Flood History – Recent flood experience at Wee Waa is discussed in **Section 2.4** of the report.

1.6 Flood Mitigation Systems – The Town Levee forms the major flood mitigation system at Wee Waa, a description of which is contained in **Section 2.3**.

1.7 Extreme Flood Events – An Extreme Flood on the Namoi River was modelled and the indicative extent and depth of inundation is presented on **Figure 2.8**. The Probable Maximum Flood was also assessed in order to define the upper limit of flooding internal to the Town Levee, the results of which are shown on **Figure 2.9**.

2 – Effects on the Community

The depth and extent of inundation in individual properties resulting from both a 1% AEP Namoi River and Local Catchment Flood are shown on **Figure 2.5**.

Table 2.7 gives the peak heights on the Glencoe stream gauge which correspond with the existing low points in the Town Levee, noting that these correspond with existing road and rail crossings.

Figure 2.10 shows stage hydrographs at several locations along the roads which lead into Wee Waa. The figure contains information such as the assessed minimum road/bridge level, times to peak flood levels, times to overtopping of the road crossing, and maximum depth of inundation. In addition to giving the maximum depth of inundation at the road locations shown on **Figure 2.10**, **Table 2.8** also gives the corresponding height on the Glencoe stream gauge when the road is first overtopped.

Figure 2.11 shows the location of vulnerable development and critical infrastructure at Wee Waa relative to the flood extents of the 5% and 1% AEP flood events, as well as the Extreme Flood/PMF. Refer **Section 2.6** and **Table 2.8** for details of affected infrastructure.

Figures 3.8 and **3.9** show the flood emergency response planning classifications for the 1% AEP and Extreme Flood/PMF events, respectively, based on the definitions set out in the *Floodplain Risk Management Guideline – Flood Emergency Response Classification of Communities* (DECC, 2007).[17]

At the 1% AEP level of flooding (refer **Figure 3.5**), areas internal to the Town Levee that are not classified as *Low Hazard Hydraulic Flooding* are classified as *Low Flood Island*. This is because in an overtopping event there would be insufficient high ground to which people could safely evacuate. This finding demonstrates that it would be necessary to evacuate Wee Waa if flood levels are predicted to exceed the crest height of the Town Levee.

3.6.3 Public Awareness Programs

Community awareness and appreciation of the existing flood hazards in the floodplain would promote proper land use and development in flood affected areas. A well informed community would be more receptive to requirements for flood proofing of buildings and general building and development controls imposed by Council. Council should also take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplains of the flood risk.

One aspect of a community's preparedness for flooding is the "flood awareness" of individuals. This includes awareness of the flood threat in their area and how to protect themselves against it. The overall level of flood awareness within the community tends to reduce with time, as memories fade and as residents move into and out of the floodplain. The improvements to flood warning arrangements described above, as well as the process of disseminating this information to the community, would represent a major opportunity for increasing flood awareness in Wee Waa.

Means by which community awareness of flood risks can be maintained or may be increased include:

- displays in Wee Waa using the information contained in the present study; and
- talks by NSW SES officers with participation by Council and longstanding residents with first-hand experience of flooding in the area.
- preparation of a *Flood Information Brochure* which could be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with rate notices.

The community should also be made aware that a flood greater than historic levels or the planning level can, and will, occur at some time in the future.

[17] Note that the flood emergency response planning classifications for the 1% AEP flood event are based on the envelope of ideal flow and partially blocked conditions, since either condition may arise during a major flood event.

As mentioned in **Section 3.6.1**, it is recommended that a community awareness programme be developed which specifically targets residents and business owners in Wee Waa. The community awareness program would be aimed at ensuring that residents and business owners are aware of the existing flood risk at Wee Waa and understand the need to respond to evacuation orders when issued by NSW SES.

4 SELECTION OF FLOODPLAIN MANAGEMENT MEASURES

4.1 Background

NSWG, 2005 requires a Council to develop a *LRMP* based on balancing the merits of social, environmental and economic considerations which are relevant to the community. This chapter sets out a range of factors which need to be taken into consideration when selecting the mix of works and measures that should be included in the *LRMP*.

The community will have different priorities and, therefore, each needs to establish its own set of considerations used to assess the merits of different measures. The considerations adopted by a community must, however, recognise the State Government's requirements for floodplain management as set out in NSWG, 2005 and other relevant policies. A further consideration is that some elements of the *LRMP* may be eligible for subsidy from State and Federal Government sources and the requirements for such funding must, therefore, be taken into account.

Typically, State and Federal Government funding is given on the basis of merit, as judged by a range of criteria:

- The magnitude of damage to property caused by flooding and the effectiveness of the measure in mitigating damage and reducing the flood risk to the community.
- Community involvement in the preparation of the *LRMP* and acceptance of the measure.
- The technical feasibility of the measure (relevant to structural works).
- Conformance of the measure with Council's planning objectives.
- Impacts of the measure on the environment.
- The economic justification, as measured by the benefit/cost ratio of the measure.
- The financial feasibility as gauged by Council's ability to meet its commitment to fund its part of the cost.
- The performance of the measure in the event of a flood greater than the design event.
- Conformance of the measure with Government Policies (e.g. NSWG, 2005 and Catchment Management objectives).

4.2 Ranking of Measures

A suggested approach to assessing the merits of various measures is to use a subjective scoring system. The chief merits of such a system are that it allows comparisons to be made between alternatives using a common "currency". In addition, it makes the assessment of alternatives "transparent" (i.e. all important factors are included in the analysis). The system does not, however, provide an absolute "right" answer as to what should be included in the *LRMP* and what should be left out. Rather, it provides a method by which Council can re-examine the measures and if necessary, debate the relative scoring given to aspects of the *LRMP*.

Each measure is given a score according to how well the measure meets the considerations discussed above. In order to keep the scoring simple, the following system is proposed:

+2	Measure rates very highly
+1	Measure rates well
0	Measure is neutral
- 1	Measure rates poorly
- 2	Measure rates very poorly

The scores are added to get a total for each measure.

Based on considerations outlined in this chapter, **Table 4.1** presents a suggested scoring matrix for the measures reviewed in **Chapter 3** at Wee Waa. This scoring has been used as the basis for prioritising the components of the *LRMP*.

4.3 Summary

Table 4.1 indicates that there are good reasons to consider including the following elements into the draft *LRMP*:

- Planning controls for future development in Wee Waa.
- An update of the *Narrabri LEP 2012* to allow better management of the floodplain
- Incorporation of the catchment specific information on flooding impacts contained in this Study in NSW SES Response Planning and Flood Awareness documentation for the study area.
- Improved public awareness of flood risk in the community.
- Upgrade of the Town Levee

TABLE 4.1
ASSESSMENT OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR INCLUSION IN THE FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Impact on Flooding/ Reduction in Flood Risk	Community Acceptance	Technical Feasibility	Planning Objectives	Environ. Impacts	Economic Justification	Financial Feasibility	Extreme Flood	Government Policies and TCM Objectives	Score
Flood Modification										
Upgrade of the Town Levee	+2	+2	+2	+2	0	-2	-1	0	+2	+7
Stormwater Upgrade Scheme 1	+1	+2	+1	0	0	-2	0	0	0	+3
Stormwater Upgrade Scheme 2	+1	+2	+1	0	0	-2	0	0	0	+3
Stormwater Upgrade Scheme 3	+1	+2	+1	0	0	-2	0	0	+2	+3
Property Modification										
Controls over Future Development	+2	+2	+2	+2	0	0	0	+1	+2	+11
Response Modification										
Improved Emergency Planning and Response	+2	+2	+2	+1	0	0	0	+2	+2	+11
Public Awareness Programs	+1	+2	+2	+1	0	0	0	+1	+2	+9

5 DRAFT LEVEE RISK MANAGEMENT PLAN

5.1 The Floodplain Risk Management Process

The *Levee Risk Management Study (**LRMS**)* and draft *Levee Risk Management Plan* (***LRMP***) have been prepared for Wee Waa as part of a Government program to mitigate the impacts of major floods and reduce the hazards in the floodplain. The *LRMP* which is set out in this Chapter has been prepared as part of the Floodplain Risk Management Process in accordance with NSW Government's Flood Prone Land Policy.

The first steps in the process of preparing the *LRMP* were the collection of flood data and the review and update of the flood modelling which was originally undertaken as part of the *Wee Waa Levee Flood Investigation* (URS, 2015) (***Flood Study***). The updated flood modelling for Wee Waa formed the formal starting process of defining management measures for flood liable land and represented a detailed technical investigation of flood behaviour for Wee Waa.

5.2 Purpose of the Plan

The overall objectives of the *LRMS* were to assess the impacts of flooding, review policies and measures for management of flood affected land and to develop a *LRMP* which:

- Sets out the recommended program of works and measures aimed at reducing over time, the social, environmental and economic impacts of flooding and establishes a program and funding mechanism for the *LRMP*.
- Proposes amendments to Narrabri Shire Council's (**Council's**) existing policies to ensure that the future development of flood affected land at Wee Waa is undertaken so as to be compatible with the flood hazard and risk.
- Ensures that the *LRMP* is consistent with NSW SES's local emergency response planning procedures.
- Ensures that the *LRMP* has the support of the community.

5.3 The Study Area

The study area for this *LRMP* comprises the town of Wee Waa and its immediate environs. The *LRMP* applies to the urbanised parts of Wee Waa that are protected by an existing earthen ring levee (Town Levee), as well as a 228 ha area which lies to the south-east of the town which is zoned *R5 Large Lot Residential*.

5.4 Community Consultation

The Community Consultation process provided valuable direction over the course of the investigations, bringing together views from key Council staff, other departments and agencies, and importantly, the views of the community gained through:

- the delivery of a *Community Newsletter* and *Community Questionnaire* to property occupiers located in the floodplain which allowed the wider community to gain an understanding of the issues being addressed as part of the study; and
- meetings of the Floodplain Risk Management Committee to discuss results as they became available.

The views of the community on potential flood management measures to be considered in the study were also taken into account in the assessment presented in **Chapter 3** of the report, with supporting information in **Appendix A**.

5.5 Town Levee

The Town Levee, the alignment of which is shown on **Figure 2.1**, was constructed in response to the damaging flooding that was experienced in Wee Waa as a result of the February 1971 flood. The Town Levee, which is about 8.6 km in length, is an earth embankment which generally varies in height between about 2 m and 4 m. **Figure 2.2** is a long section showing the elevation of the Town Levee relative to the adjacent floodplain.

There are fourteen penstock gated stormwater drainage pipes and six stormwater evacuation pumps located around the perimeter of the Town Levee, the locations of which are shown on **Figure 2.1**, sheet 2. These pipes allow stormwater runoff which is generated internal to the Town Levee to discharge to the Namoi River floodplain.

The Town Levee was originally designed to protect against a February 1971 type flood event and incorporated a 1 m freeboard to peak flood levels that were recorded at the time of the event. While a design was prepared in 1992 which was aimed at reinstating the design freeboard to February 1971 flood levels, there are no records of this work having been completed. By inspection of **Figure 2.2**, there is a 1 km long section between about Chainage 3500 and Chainage 4500 which lies below the original design height of the Town Levee.

A geotechnical investigation was undertaken as part of the present study, the findings of which are set out in a letter style report, a copy of which is contained in **Appendix B**. The geotechnical investigation, which comprised a review of the available documentation and a visual inspection of the Town Levee found that the embankment was generally in good condition, with only a few minor defects/aspects requiring rectification.

The Imminent Failure Flood (**IFF**) of the Town Levee is slightly smaller than the February 1971 flood and corresponds with a flood with an Annual Exceedance Probability (**AEP**) of about 5 per cent. The prediction of a flood higher than the IFF would trigger the evacuation of Wee Waa, as NSW SES would have deemed the Town Levee to be at significant risk of failure.

The present study found that the available freeboard between the crest of the Town Levee and a 1% AEP Namoi River flood is a minimum of about 0.5 m, reducing to less than 0.3 m if the surrounding network of rural levees were to be raised in the future. While there is some freeboard to the crest of the Town Levee, it is likely that it would be overtopped at the 1% AEP level of flooding due to wave set up and run up, albeit to an extent that would likely not inundate the whole of the town. The present study confirmed that the design freeboard for the Town Levee should be 1 m (refer **Appendix E** for details). This accounts for factors such as wave action, local water surge, inaccuracies in the design flood level estimates, levee settlement, defects in the levee and future climate change.

5.6 Indicative Flood Extents

Figures 2.3 to **2.8** show the indicative extent and depths of inundation on the Namoi River floodplain for floods with AEPs of between 5 and 0.2%, as well as the Extreme Flood. The figures also show the indicative extent and depths of inundation that would result from direct rain falling over Wee Waa with the same AEP. For presentation purposes, it has been assumed that the aforementioned penstock gates are in their closed positon and floodwater cannot backwater into town in the case of Namoi River flooding. Conversely, in the case of local catchment flooding, it has been assumed that river levels are not elevated and the penstock gates are in their open position.

The 1% AEP design flood which has been adopted as the "planning flood" for the purposes of specifying flood related controls over future development. The extent of flooding is indicative only, being based on hydrologic and hydraulic models that were developed as part of the present study.

5.7 Economic Impacts of Flooding

Flood damages in Wee Waa were assessed for the following five scenarios:

- No river flooding and gravity drainage of the protected area via the fourteen penstock gated stormwater drainage pipes that control ponding levels behind the Town Levee (**Damage Scenario 1**).
- Pumping of stormwater runoff to the Namoi River floodplain via the six permeant stormwater evacuation pumps and assuming the fourteen penstock gates are in their closed position and the Town Levee is not overtopped (**Damage Scenario 2**).
- Failure of the six permanent stormwater evacuation pumps to operate during a storm event and assuming the fourteen penstock gates are in their closed position and the Town Levee is not overtopped (**Damage Scenario 3**).

<u>Damage due to riverine flooding</u>

- No coincident rainfall over Wee Waa during a Namoi River Flood (**Damage Scenario 4**).
- No coincident rainfall over Wee Waa during a Namoi River Flood that causes a partial failure of the Town Levee (**Damage Scenario 5**).

Table 5.1 over shows the number of properties that would be flooded to above-floor level for the various classes of property in Wee Waa, as well as the total flood damages for the five damage scenarios.

It is estimated that only one dwelling and one commercial/industrial property would experience above-floor inundation should a 1% AEP storm event occur over Wee Waa during a period when the flood gates are open. The fact that there are only two properties that would experience above-floor flooding due to local catchment runoff for storms up to 1% AEP in intensity probably dates back to the pre-Town Levee era, when buildings would have been built off the ground to reduce the likelihood that they would be inundated by riverine flooding. While a large number of respondents to the questionnaire were in favour of upgrading the local stormwater drainage system, this finding indicates that the issue is likely related more to nuisance flooding, rather than damaging above-floor flooding.

While the number of properties that would experience above-floor flooding should a 1% AEP storm occur over Wee Waa when the penstock gates are closed would increase slightly, should the six stormwater evacuation pumps fail or not be started up during a storm of this intensity the total number of properties that would experience above-floor inundation would increase to about 30 properties (15 dwellings and 15 commercial/industrial buildings).

The "present worth value" of damages in Wee Waa resulting from rain falling directly over Wee Waa up to the 1% AEP event assuming the stormwater evacuation pumps are operational is $0.4 Million. This value represents the amount of capital spending which would be justified if a particular stormwater drainage upgrade scheme prevented flooding <u>for all</u> properties in Wee Waa up to this event.

TABLE 5.1
ECONOMIC IMPACTS OF FLOODING AT WEE WAA

Design Flood Event (% AEP)	No. of Flood Damaged Properties															Total Damage ($ Million)				
	Residential					Commercial/Industrial					Public									
	DS1	DS2	DS1	DS4	DS5	DS1	DS2	DS1	DS4	DS5	DS1	DS2	DS1	DS4	DS5	DS1	DS2	DS1	DS4	DS5
5	1	1	2	0	560	0	0	3	0	123	0	0	0	0	29	0.39	0.40	0.9	0	109.9
2	1	1	6	0	585	0	2	9	0	126	0	0	0	0	30	0.45	0.56	1.53	0	114.6
1	1	4	15	0	595	1	3	15	0	126	0	0	0	0	32	0.58	0.90	2.43	0	116.5
0.5	2	6	19	0	596	2	7	17	0	126	0	0	0	0	32	0.76	1.36	3.94	0	116.8
0.2	6	14	25	0	601	7	14	21	0	129	0	0	0	0	33	1.51	2.50	6.54	0	118.1
Extreme Flood/PMF	119	137	137	696	696	46	48	48	135	135	10	13	13	42	42	22.29	26.14	26.14	163.3	163.3

1. DS1 – Damage Scenario 1 DS2 – Damage Scenario 2 DS3 – Damage Scenario 3 DS4 – Damage Scenario 4 DS5 – Damage Scenario 5

Once major overtopping of the Town Levee occurs, all but a small number of buildings would experience above-floor inundation. A similar situation would arise were the Town Levee to partially fail during a flood. The total damages in Wee Waa were the Town Levee to either be overtopped or fail during a major flood event is estimated to be about $117 Million. The present worth value of damages under a Town Levee failure scenario (i.e. Damage Scenario 5) is about $100 Million. This is the amount that could be spent upgrading the Town Levee to ensure that it is geotechnically stable, free of defects and arguably incorporates the required 1 m freeboard to the 1% AEP flood.

5.8 Structure of Floodplain Risk Management Study and Plan

The *LRMS* and *LRMP* are supported by Appendices which provide additional details of the investigations. A summary of the *LRMP* proposed for the study area along with broad funding requirements for the recommended measures are shown in **Table 5.2**. These measures comprise preparation of planning documentation by Council, improvements to the flood warning system and community education on flooding by Council and NSW SES to improve flood awareness and response, and the upgrade of the Town Levee to increase its design standard to 1% AEP. The measures will over time achieve the objectives of reducing the flood risk to existing and future development for the full range of floods.

The *LRMP* is based on a mix of measures which have been given a provisional priority ranking according to a range of economic, social, environmental and other criteria set out in **Table 4.1** of the report:

TABLE5.2
MEASURES COMPRISING THE WEE WAA FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Priority
Measure 1 - Planning and development controls for future development in flood prone areas	Council staff costs	1[(1)]
Measure 2 – Update wording in *Narrabri LEP 2012*	Council's staff costs	1
Measure 3 – Improvements to emergency response planning	NSW SES costs	1
Measure 4 – Increase public awareness of the risks of flooding in the community	Council staff costs	1
Measure 5 – Investigation and concept design of Town Levee upgrade works	$350,000	1
Measure 6 – Detailed design and construction of Town Levee upgrade works	$7.2 Million	2[(2)]

1. Only controls on development other than residential type development could be implemented in the short-term, as the Town Levee would need to be upgraded before minimum floor levels for residential type development could be set below the peak 1% AEP Namoi River flood level plus an allowance of 500 mm freeboard.
2. Because of its medium to long term nature, this measure has been given a **Priority 2** ranking.

5.9 Planning and Development Controls

The results of the *LRMS* indicate that an important measure (**Measure 1**) for Council to consider adopting in the floodplain would be strong floodplain management planning applied consistently by all branches of Council.

The key issue for Wee Waa is that given the design standard of the Town Levee is less than 1% AEP, Council's current planning documents, namely the *Interim Floodplain Management Policy* referred to in Council's *Exempt & Complying Development DCP* is inconsistent with the NSW Government's Section 9.1, as it allows development to occur below the 1% AEP plus an appropriate freeboard (which in areas subject to riverine flooding is generally set at 0.5 m).

As it is not practical to set the floor levels of residential type development in Wee Waa above the peak 1% AEP Namoi River flood level (i.e. because the floor level of most dwellings would need to be set more than 1.5 m above natural ground levels), it is recommended that Council consider that this type of development should only proceed if the design standard of the Town Levee is upgraded to 1% AEP. This would require the crest of the Town Levee to be raised to a height of no less than 1 m above the peak 1% AEP Namoi River flood level.

Should the Town Levee be upgraded to a 1% AEP standard, then it is recommended that Council consider that the controls that would need to be applied to future residential type development would amount to a minimum floor level control which is equal to the Flood Planning Level (**FPL**).[18] Note that the FPL would be based on depths of inundation resulting from runoff that is generated internal to the Town Levee, not Namoi River flooding. **Figure 3.7**, sheet 1 shows the extent of the Flood Planning Area (**FPA**)[19] under post-Town Levee upgrade conditions, as well as the corresponding FPLs.

In regards the 228 ha area which lies to the south-east of Wee Waa which is zoned *R5 Large Lot Residential*, it is recommended that Council consider rezoning the portion that is classified as either *Floodway* or *High Hazard Flood Storage* at the 1% AEP level of flooding (refer **Figure 2.23**, sheet 1) so as not to permit future residential and commercial type development. As the remainder of the area either lies above the 1% AEP flood level or is classified as *Flood Fringe*, then future development located within the extent of the FPA need only be subject to a minimum floor level control set equal to the FPL. **Figure 3.7**, sheet 2 shows the extent of the FPA in this area, as well as the corresponding FPLs.

Measure 2 recommends that Council consider updating the wording in the *Narrabri LEP 2012* concerning flood planning. Clause 6.2 of *Narrabri LEP 2012* entitled "Flood planning" outlines its objectives in regard to development of flood prone land. It is similar to the standard Flood Planning Clause used in recently adopted LEPs in other NSW country centres and applies to land at or below the Flood Planning Level (**FPL**). The FPL referred to is the 1% AEP flood plus an allowance for freeboard of 500 mm. The area encompassed by the FPL is known as the FPA and denotes the area subject to flood related development controls, such as setting minimum floor levels for future residential development. Suggested amendments to Clause 6.2 of *Narrabri LEP 2012* are given in **Section 3.5.1.4**.

While not strictly relevant to Wee Waa, it is also recommended that Council consider incorporating a new floodplain risk management clause in *Narrabri LEP 2012*. The objectives of the new clause are as follows:

- in relation to development with particular evacuation or emergency response issues (e.g. group homes, residential care facilities, etc.) to enable evacuation of land subject to flooding in events exceeding the flood planning level; and

[18] The FPL is defined as the peak 1% AEP flood level plus an allowance of 500 mm for freeboard.
[19] The FPA is defined as land that lies at or below the FPL.

- to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

The new clause would apply to land which lies between the FPA and the extent of the Extreme or Probable Maximum Flood. Suggested wording in relation to this new clause is given in **Section 3.5.1.4**.

5.10 Improvements to Flood Warning, Emergency Response Planning and Community Awareness

Two measures are proposed in the *LRMP* to improve flood warning, emergency response planning and community awareness to the threat posed by flooding.

Measure 3 involves the update by NSW SES of the *Narrabri Shire Local Flood Plan* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in this report. Figures have been prepared showing indicative extents of flooding, high hazard areas, expected rates of rise of floodwaters in key areas and locations where flooding problems would be expected. **Section 3.6.2** references the locations of key data within this report.

Council should also take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplains of the flood risk (included as **Measure 4** of the *LRMP*). This information could be included in a *Flood Information Brochure* to be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with the rate notices. The community should also be made aware that a flood greater than historic levels or the planning level can, and will, occur at some time in the future. The *LRMP* should be publicised and exhibited at community gathering places to make residents aware of the measures being proposed.

5.11 Flood Modification Works

While the present study found that the design standard of the Town Levee is equivalent to about a 5% AEP flood, the earth embankment is generally in good condition and therefore is unlikely to fail unless major overtopping occurs. While wind and wave action could result in minor overtopping of the Town Levee during larger floods, it is estimated that major overtopping would only occur during floods with AEPs less than about 0.1 per cent.

While it is only under a levee failure or a major overtopping scenario that the upgrade of the Town Levee can be justified economically (the resulting benefit cost ratio is 13), there are two significant social reasons supporting its upgrade. These are:

i) As mentioned in **Section 5.9**, the minimum floor level requirements for future development in Wee Waa should, contrary to Council's current planning documents, be set equal to the peak 1% AEP Namoi River flood level plus an allowance of 500 mm for freeboard. As this in impractical given the height to which future development would need to be built above natural ground level, there is a need to upgrade the design standard of the Town Levee to 1% AEP so that future development can be set closer to the ground.

ii) The Imminent Failure Flood (**IFF**) for a flood protection levee is equal to its design standard, which in the case of the Town Levee is 5% AEP. During larger flood events, NSW SES would need to evacuate the town as the Town Levee would be deemed to be at significant risk of failure. As identified in the *Narrabri Shire Local Flood Plan* and confirmed by the present study, the local road network which is relied upon for flood evacuation purposes would be inundated by floods that are more frequent than 5% AEP. As a result, it would be necessary to evacuate the whole of Wee Waa should a flood larger than 5% AEP be predicted at the town. As not everyone would self-evacuate in a flood emergency, NSW SES would be forced to air lift those people that remained. As the area internal to the Town Levee is classified as a Low Flood Island, there is insufficient high ground available for people to safely reside while awaiting to be evacuated in the case of a very rare or extreme flood event.

For these reasons there is merit in upgrading the Town Levee to incorporate a 1 m freeboard to peak 1% AEP Namoi River flood levels. **Figure 3.1** shows the sections of the Town Levee which would need to be raised, while **Figure 3.2** shows a typical section of the upgrade requirements. Further details of the upgrade requirements are shown on **Figures F1.1** (7 sheets) and **F1.2** (10 sheets) in **Appendix F**. The capital cost associated with upgrading the Town Levee is estimated to be $7.55 Million, which includes investigation and design. A breakdown of the cost to design and construct the Town Levee upgrade works is given in **Table 3.2**.

The investigation and concept design of the Town Levee upgrade works has been included as **Measure 5**, while its detailed design and construction has been included as **Measure 6** in the LRMP.

While the present study showed that upgrading the existing stormwater drainage system would have a beneficial effect on reducing nuisance flooding in parts of Wee Waa, improvements to the existing drainage system cannot be economically justified given the relatively small flood damages that would be saved by implementing the works. The flooding that occurs internal to the Town Levee is also of a low hazard nature given its relatively shallow and slow moving nature. This also means that the upgrade of the stormwater drainage system at Wee Waa, while beneficial to affected land owners, would not rank highly when competing for funds under the NSW Government's floodplain management program.

5.12 Mitigating Effects of Future Development

While there is presently limited pressure for new development to occur in Wee Waa, it will be necessary for Council to consider the implications the introduction of new hard stand and roof areas would have on internal drainage patterns, as well as the pump capacity requirements of the six stormwater evacuation pumps which are located around the perimeter of the Town Levee when assessing future development applications.

5.13 Implementation Program

The steps in progressing the floodplain management process from this point onwards are:

1. Floodplain Risk Management Committee to consider and adopt recommendations of this study. In particular, the Committee should review the basis for ranking floodplain management measures (as set out in **Table 4.1** of the *LRMS* and the proposed works and measures to be included in the *LRMP* as set out in **Table 5.2**); exhibit the *draft LRMS* and *LRMP* and seek community comment.
2. Consider public comment, modify the document if and as required, and submit to Council.
3. Council adopts the *LRMP* and submits application(s) for funding assistance in the next funding round for qualifying projects. Assistance for funding qualifying projects included in the *LRMP* may be available upon application under the Commonwealth and

State funded floodplain management programs, currently administered by NSW Office of Environment and Heritage.

4. As funds become available from Government agencies and/or Council's own resources, implement the measures in accordance with the established priorities.

The *LRMP* should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding, reviews of Council's planning strategies and importantly, the outcome of some of the studies proposed in this report as part of the *LRMP*. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the *LRMP*.

6 GLOSSARY OF TERMS

Note: For expanded list of definitions, refer to Glossary contained within the NSW Government Floodplain Development Manual, 2005.

TERM	DEFINITION
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, for a flood magnitude having five per cent AEP, there is a five per cent probability that there would be floods of greater magnitude each year.
Australian Height Datum (AHD)	A common national surface level datum corresponding approximately to mean sea level.
Extreme Flood	An extremely rare event analogous to the PMF, which in the case of the present study is assumed to have a peak flow 3 times the 1% AEP flood event.
Flood Frequency Analysis	A statistical methodology to estimate peak flood levels and discharge of design flood events based on a record of historic flood data.
Floodplain	Area of land which is subject to inundation by floods up to and including the Probable Maximum Flood (**PMF**) event, that is, flood prone land.
Flood Planning Area	The area of land that is shown to be in the Flood Planning Area on the *Flood Planning Map*. The Flood Planning Area is the area of land which lies at or below the Flood Planning Level.
Flood Planning Map	The *Flood Planning Map* shows the extent of land on which flood related development controls apply, extracts of which is shown on **Figure 3.7** (2 sheets).
Flood Planning Level (FPL)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans. For land within the Flood Planning Area at Wee Waa, the Flood Planning Level (**FPL**) is the level of the 1% Annual Exceedance Probability (**AEP**) flood event plus 500 mm freeboard.
Flood Prone/Flood Liable Land	Land susceptible to flooding by either the Extreme Flood in the case of riverine type flooding or the PMF in the case of local catchment flooding at Wee Waa. Flood Prone land is synonymous with Flood Liable land.
Floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding a particular flood chosen as the basis for the FPL and setting minimum floor level requirements is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the derivation of the FPL and the setting of minimum floor level requirements.

TERM	DEFINITION
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. For the study area, the extent of the PMF has been trimmed to include depths greater than 100 mm.

7 REFERENCES

BoM (Bureau of Meteorology), 2003. ***"The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method"***.

DECCW (Department of Environment, Climate Change and Water, NSW), 2007. ***"Floodplain Risk Management Guideline – Flood Emergency Response Classification of Communities"***.

DECCW (Department of Environment, Climate Change and Water, NSW), 2007. ***"Floodplain Risk Management Guideline – Practical Considerations of Climate Change"***.

DECCW (Department of Environment, Climate Change and Water, NSW), 2008. ***"Floodplain Risk Management Guideline No 4. Residential Flood Damage Calculation"***.

DIPNR (Department of Infrastructure, Planning & Natural Resources), 2003. ***"Narrabri – Wee Waa Flood Study"***

DNR (Department of Natural Resources), 2005. ***"Narrabri-Wee Waa Floodplain Management Plan"***

EA (Engineers Australia), 2013. **"Project 11 – Blockage of Hydraulic Structures – Stage 2 Report"**

Howells et al, 2004. **"*Defining the Floodway - Can One Size Fit All?*"** FMA NSW Annual Conference, Coffs Harbour, February 2004.

IEAust (The Institution of Engineers Australia), 1987. ***"Australian Rainfall and Runoff – A Guide to Flood Estimation"***, Volumes 1 and 2.

NSWG (New South Wales Government), 2005. ***"Floodplain Development Manual: the Management of Flood Liable Land"***.

NSW SES (NSW State Emergency Service), 2015. ***"Narrabri Shire Local Flood Plan"***

PW (Public Works), 1992. ***"Audit of Flood Levees for New South Wales – Town of Wee Waa"***

URS, 2015. ***"Wee Waa Levee Flood Investigation"***

WRM (WRM Water & Environment), 2016. ***"Narrabri Flood Study – Namoi River, Mulgate Creek and Long Gully"***

APPENDIX A

COMMUNITY CONSULTATION

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ATTACHMENTS

A1. INTRODUCTION

At the commencement of the *LRMS,* the Consultants prepared a *Community Newsletter* and a *Community Questionnaire*, both of which were distributed by Council to the residents and business owners in Wee Waa (refer to **Attachment 1**).

The purpose of the *Community Newsletter* was to introduce the objectives of the study and set the scene on flooding conditions so that the community would be better able to respond to the *Community Questionnaire* and contribute to the study process.

The *Newsletter* contained the following information:

- A plan showing the layout of the existing levee and stormwater drainage system at Wee Waa.
- A statement of the objectives of the *LRMS&P*; namely to assess the requirements for the upgrade of the existing levee in order to ensure that it will protect the town from floods up to the 1% AEP flood event.

The *Community Questionnaire* was structured with the objectives of:

- Obtaining local information on flood experience and behaviour at residents' and business owners' properties.
- Determining residents' and business owners' attitudes to controls over future development in flood liable areas.
- Inviting community views on possible flood management options which could be considered for further investigation in the *LRMS* and possible inclusion in the resulting *LRMP*.
- Obtaining feedback on any other flood related issues and concerns which the residents and business owners cared to raise.

This **Appendix** to the *LRMS&P* report discusses the responses to the 13 questions that were included in the *Community Questionnaire* and comments made by respondents.

Chapter A2 deals with the residents' and business owners' experience with historic flooding, as well as determining their views on the relative importance of classes of development over which flood-related controls should be imposed by Council.

Chapter A3 identifies residents' and business owners' views on the suitability of the various options which could be considered in more detail in the *LRMS*.

Chapter A4 discusses the best methods by which the community could provide feedback to the consultants over the course of the study.

Chapter A5 summarises the findings of the community consultation process.

A2 RESIDENT PROFILE AND FLOOD AWARENESS

A2.1 General

Residents were requested to complete the *Community Questionnaire* and return it to the Consultants by 23 December 2016. The deadline was extended to include any submissions that were received after this date. The Consultants received 59 responses in total out of the 850 that had been distributed.[1]

The Consultants have collated the responses, which are shown in graphical format in **Attachment 2**.

A2.2 Experiences of Flooding

The first four questions of the *Community Questionnaire* canvassed resident information such as length of time at the property, the type of property (e.g. house, unit/flat), whether the respondent had any experience of flooding and if so which particular flood. Of those who replied to the question, nine respondents had lived in Wee Waa for less than 5 years, twenty-one respondents had lived there for between 5 and 20 years and twenty-eight for more than 20 years (**Question 2**).

Forty-six respondents occupied a house, three respondents occupied a unit/flat and five respondents owned a shop / retail property (**Question 3**). Three respondents occupied an industrial unit in a larger complex, while five respondents owned a standalone warehouse or factory.

In response to **Question 4**, thirteen respondents reported that they had experienced flooding on their property. Flooding was reported at respondents properties during flood events that occurred prior to the construction of the levee in 1955 (two), 1970 (one), 1971 (six), 1974 (five) and 1976 (three). Two respondents reported flooding on their property in flood events that occurred after the construction of the levee (1986 and 2011/2012). As the levee did not overtop in these years, the respondents are likely referring to local stormwater issues.

A2.3 Controls over Development in Flood Prone Areas

The respondents were also asked to rank from 1 to 6 the classes of development which they consider should receive protection from flooding (**Question 5**). Rank 1 was the most important and rank 6 the least.

The classes in decreasing order of importance to respondents, ranged from residential property, critical utilities (e.g. medical facilities, emergency services), essential community facilities (e.g. schools, evacuation centres), commercial/business, new residential subdivisions and lastly, minor developments/additions to existing buildings.

[1] Note that two of the respondents were both a resident and business owner in Wee Waa, while one respondent was a caretaker of the property.

Respondents were asked in **Question 6** about the level of control Council should place on new development to minimise flood-related risks. The most popular response (twenty-two) was to advise of the flood risks, but allow the individual the choice as to whether they develop or not provided they take steps to minimise the potential flood risks. The next most favoured responses were placing restrictions on developments to reduce the potential for flood damage (e.g. minimum floor level controls or the use of compatible building materials) (fifteen) and prohibiting all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties (thirteen). Eleven respondents felt that Council should prohibit all development on land with any potential to flood.

In **Question 7**, respondents were asked what notifications Council should give about the flood affectation of individual properties. The community was strongly in favour of advising existing residents and prospective purchasers of the known potential flood threat, with only two residents not in favour of providing flood related notifications.

A2.3 Home and Contents Insurance

Respondents were asked in **Question 8** if they currently maintain a home and contents insurance policy on their property, and what the annual premium was. Thirty-four respondents currently maintain building and contents insurance, while seven maintain building-only insurance and eleven maintain contents-only insurance. The annual premium range generally range between $500 and $5000.

In **Question 9**, respondents were asked if their home and contents insurance premiums had increased significantly in the last few years (since adoption of URS, 2015), and if so, by how much. Of the fifty-two respondents that currently maintain building and/or contents insurance, forty-two have experienced an increase in their premiums in recent years. Their premiums generally increased by less than $1,000.

It was noted that seven of the respondents to the questionnaire are not covered for flood as part of the insurance policy as the insurance company will not cover them or the costs were too high (one respondent's insurer quoted an additional $4,000 for flood insurance). Two respondents do not have building and contents insurance due to the cost of flood cover.

It is noted that one respondent's insurance premiums reduced by $2,000 between 2013 and 2016.

A3 INPUT TO THE STUDY AND FEEDBACK FROM THE COMMUNITY

In **Question 10,** residents were asked for their view on the best methods of their providing input to the study and feedback to the Consultants over the course of the investigation. Articles in the local newspaper was the most popular method, followed by communication via Council's website and public meetings. Other suggestions raised by respondents included a letter drop (similar to the *Community Newsletter* and *Community Questionnaire* distributed as part of the present investigation), and announcements on local radio and Council's Facebook page as methods of community engagement.

A4 POTENTIAL FLOOD MANAGEMENT MEASURES

The respondents were asked for their opinion on potential flood management measures which could be evaluated in the *LRMS* (and if found to be feasible included in the *LRMP*), by ticking a "yes" or "no" to the thirteen potential options identified in **Question 13**.

The options comprised a range of *structural flood management measures* (e.g. programs by Council to manage vegetation in the creek system to maintain hydraulic capacity; improving the stormwater system; levees to contain floodwaters; widening of watercourses; removal of floodplain obstructions), as well as various *non-structural management measures* (e.g. voluntary purchase of residential properties in high hazard areas; raising floor levels of houses in low hazard areas; flood related controls over new developments; improvements to flood warning and evacuation procedures; community education on flooding; flood advice certificates). The options were not mutually exclusive, as the adopted *LRMP* could, in theory, include all of the options set out in the *Community Questionnaire*, or indeed, other measures nominated by the respondents or the FRMC.

The most popular structural measures was the raising of the existing ring levee and the improvement of the internal drainage system within the town.

Of the non-structural measures, improvement of flood warning and evacuation procedures and community flood awareness programs received the strongest support, followed by provision of a Planning Certificate to purchasers in flood prone areas. Other popular measures included specifying controls on future development in flood-prone areas.

A mostly negative response was given to the temporary raising of the ring levee during times of flood and removal of floodplain obstructions. Providing subsidies for raising the floor level of properties and the implementation of a residential Voluntary Purchase scheme were also unpopular.

A5 SUMMARY

Fifty-nine responses were received to the *Community Questionnaire* which was distributed by Council to residents and business owners. The responses amounted to about seven per cent of the total distributed. About twenty per cent of respondents had experienced flooding at their property prior to the construction of the ring levee in the early 1980's.

A5.1 Issues

The issues identified by the responses to the *Community Questionnaire* support the objectives of the study as nominated in the attached *Community Newsletter,* and the activities nominated in the Study Brief. There was strong support amongst the community for raising the existing ring levee.

The main issue facing the community was increased insurance premiums relating to flood insurance. A number of respondents identified that insurance costs had increased by up to $4,000 in recent years, and seven respondents had to forego flood insurance due to the increase in costs.

A5.2 Flood Management Measures

Of the *structural measures* which could be incorporated in the *LRMP*, the most popular were raising the existing ring levee and the improvement to the internal drainage system within the town.

Improvements to flood warning and emergency management measures and community flood awareness programs appeared to be the most popular of the potential *non-structural measures* set out in the *Community Questionnaire*. Planning controls and providing Planning Certificates were also widely popular. There does not appear to be any new measures raised by the respondents.

ATTACHMENT 1

COMMUNITY NEWSLETTER AND QUESTIONNAIRE

Office of Environment & Heritage

WEE WAA LEVEE RISK MANAGEMENT STUDY & DRAFT PLAN

COMMUNITY QUESTIONAIRE

This Questionnaire is part of the *Wee Waa Levee Risk Management Study and Draft Plan*, which is currently being prepared by Narrabri Shire Council with the financial and technical support of the NSW Office of Environment & Heritage. Your responses to the questionnaire will help us determine the flood issues that are important to you.

Please return your completed Questionnaire in the reply paid envelope provided by **Friday 23 December 2016**. No postage stamp is required. If you have misplaced the supplied envelope or wish to send an additional submission the address is:

Lyall & Associates
Reply Paid 85163
NORTH SYDNEY NSW 2060

About your property

1. Please tick as appropriate:

☐	I am a resident
☐	I am a business owner
☐	I own the property
☐	I rent the property
☐	Other (please specify________________)

2. How long have you been at this address?

- ☐ Less than a year
- ☐ 1 year to 5 years
- ☐ 5 years to 20 years
- ☐ More than 20 years (____ years)

3. What is your property?

- ☐ House
- ☐ Villa/Townhouse
- ☐ Unit/Flat/Apartment
- ☐ Vacant land
- ☐ Industrial unit in larger complex
- ☐ Standalone warehouse or factory
- ☐ Shop/Retail
- ☐ Community building
- ☐ Other

4. Have you experienced flooding at your property and if so, in what year(s)?

____

5. Please rank the following development types according to which you think are the most important to protect from floods (1=highest priority to 6= least priority)

- ☐ Commercial
- ☐ Residential
- ☐ Essential community facilities
- ☐ Critical Utilities
- ☐ Minor developments and additions
- ☐ New residential subdivisions

Your attitudes to Council's development controls

6. What level of control do you consider Council should place on new development to minimise flood-related risks?
(Tick only one box)
(In addition to being favoured by the Community, these options would also need to comply with legislation)

- ☐ Prohibit all new development on land with any potential to flood
- ☐ Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties.
- ☐ Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or the use of flood compatible building materials)
- ☐ Advise of the flood risks, but allow the individual a choice as to whether they develop or not, provided steps are taken to minimise potential flood risks
- ☐ Provide no advice regarding the potential flood risks or measures that could minimise those risks
- ☐ Don't know

7. What notifications do you consider Council should give about the potential flood affectation of individual properties?
(Tick one or more boxes)

- ☐ Advise every resident and property owner on a regular basis of the known potential flood threat
- ☐ Advise only those who enquire to Council about the known potential flood threat
- ☐ Advise prospective purchasers of property of the known potential flood threat.
- ☐ Provide no notifications
- ☐ Other (________________________)

Other Information

8. Do you currently maintain a Home and Contents Insurance policy and if so, what is the annual premium (to the nearest $100).

Building Only - Yes / No	$____________
Contents Only - Yes / No	$____________
Building and Contents - Yes / No	$____________

9. Has your Home and Contents Insurance premiums increased substantially in the last few years and if so, by approximately how much? (Circle Yes or No and Write $ Amount)

Building Only - Yes / No	$____________
Contents Only - Yes / No	$____________
Building and Contents - Yes / No	$____________

10. What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study?
(Tick one or more boxes)

- ☐ Council's website
- ☐ Articles in local newspaper
- ☐ Open days or drop-in days
- ☐ Community workshops
- ☐ Public Meetings
- ☐ Through Council's Floodplain Management Committee
- ☐ Other (please specify ______________)

11. If you wish us to contact you so you can provide further information, please provide your details below:

Name: ______________________________

Address: ______________________________

____

Phone: ______________________________

Best time to call is ______________________

Fax No: ______________________________

Email: ______________________________

Other (______________________________)

12. If you have any photographs of historic flooding at Wee Waa you are welcome to drop into Council's office in Maitland Street, Narrabri to have them photocopied. Council will then forward the photocopy onto the Consultant on your behalf.

Your opinions on floodplain risk management measures and controls

13. Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan at back of questionnaire).

This list is not in any order of importance and there may be other options that you think should be considered. For each of the options listed, please indicate "yes", or "no" to indicate if you favour the option or "don't know" if undecided. (In addition to being favoured by the Community, management options would also need to comply with legislation and be capable of being funded).

Option	Yes	No	Don't Know
Raising of the existing earthen levee using the same construction methodology			
Raising of the existing earthen levee during times of flood using temporary/relocatable flood barriers			
Improvements to the internal drainage system (e.g. upgrade of the stormwater evacuation pumps which are located around the perimeter of the existing levee)			
Removal of floodplain obstructions, such as rural levees			
Voluntary purchase of the most severely affected flood-liable properties			
Provide funding or subsidies to raise houses above major flood level in low hazard areas.			
Flood proofing of individual properties by waterproofing walls, putting shutters across doors, etc.			
Improve flood warning and evacuation procedures both before and during a flood.			
Community education, participation and flood awareness programs.			
Ensuring all residents and business owners have Flood Action Plans - these outline WHAT people should do, WHERE they should go and WHO they should contact in a flood			
Specify controls on future development in flood-liable areas (e.g. controls on extent of filling, minimum floor levels, etc.)			
Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected.			
Ensuring all information about the potential risks of flooding is available to all residents and business owners			

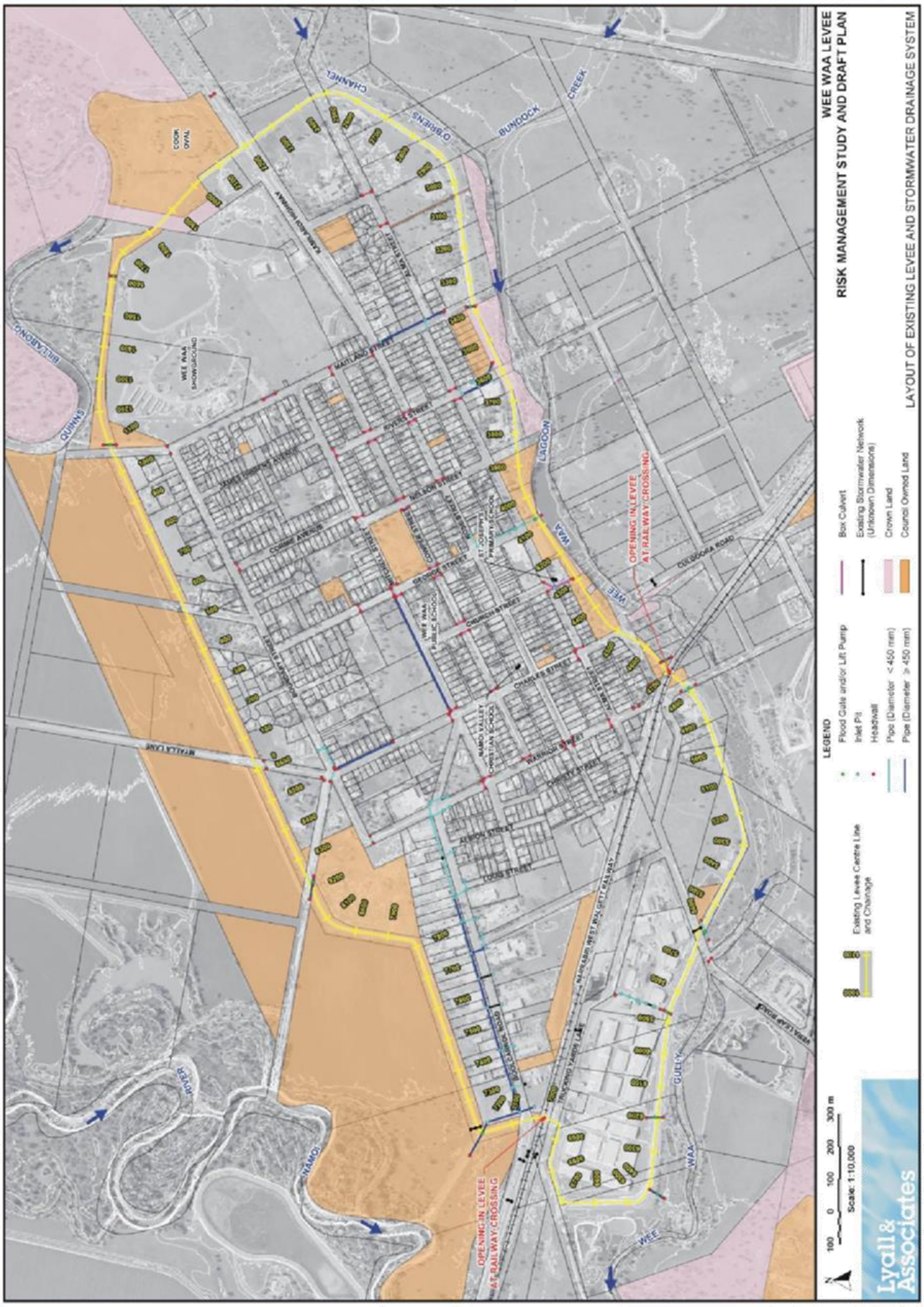
Who can I contact for further information?

Narrabri Shire Council
Cara Stoltenberg – Town Planner
Phone: (02) 6799 6817
Email: caras@narrabri.nsw.gov.au

Copies of this Questionnaire can be obtained from:
www.narrabri.nsw.gov.au

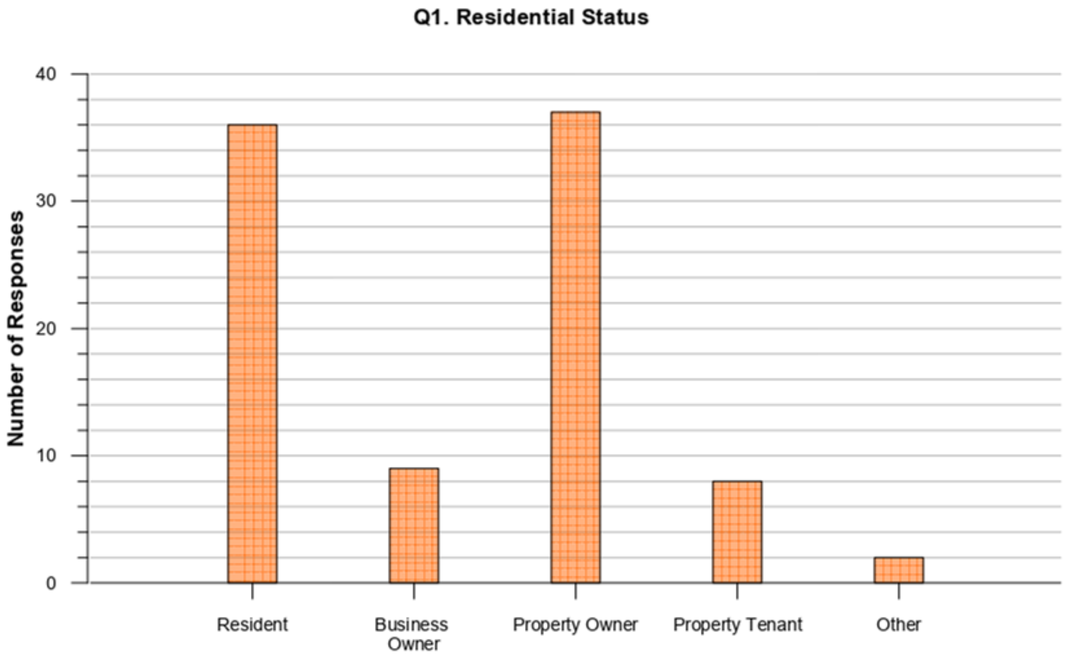
COMMENTS

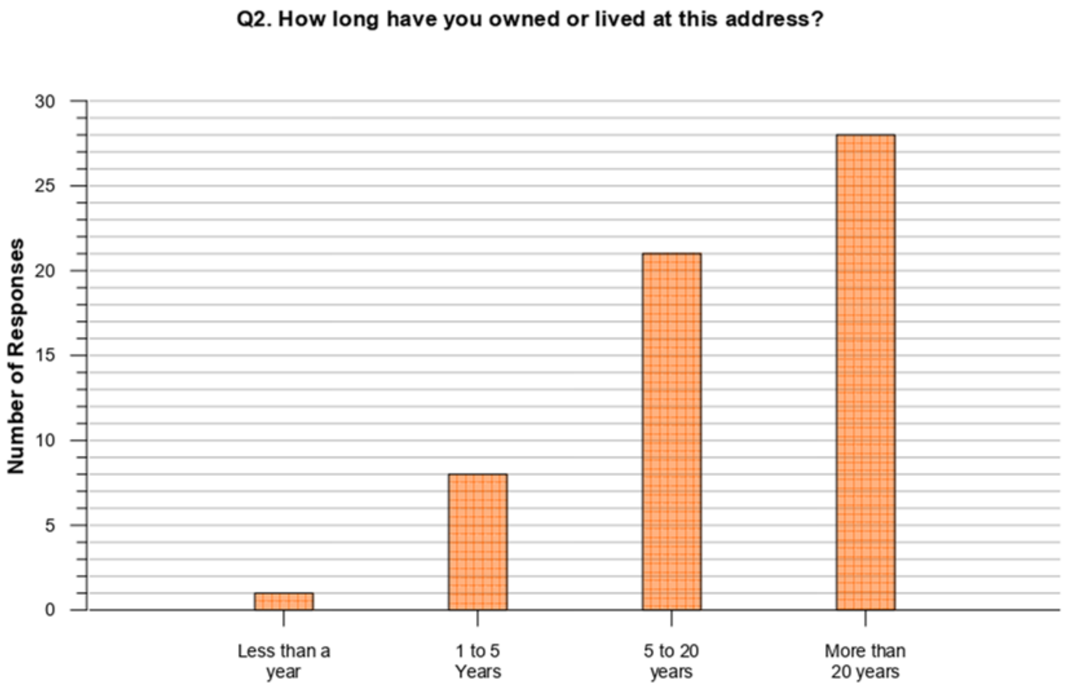
Please write your comments here:


WEE WAA LEVEE
RISK MANAGEMENT STUDY AND DRAFT PLAN
LAYOUT OF EXISTING LEVEE AND STORMWATER DRAINAGE SYSTEM
LEGEND
Existing Levee Centre Line and Chainage
Flood Gate and/or Lift Pump
Inlet Pit
Headwall
Box Culvert
Crown Land
Council Owned Land
OPENING IN LEVEE AT RAILWAY CROSSING
Scale 1:10,000
Lyall & Associates

ATTACHMENT 2

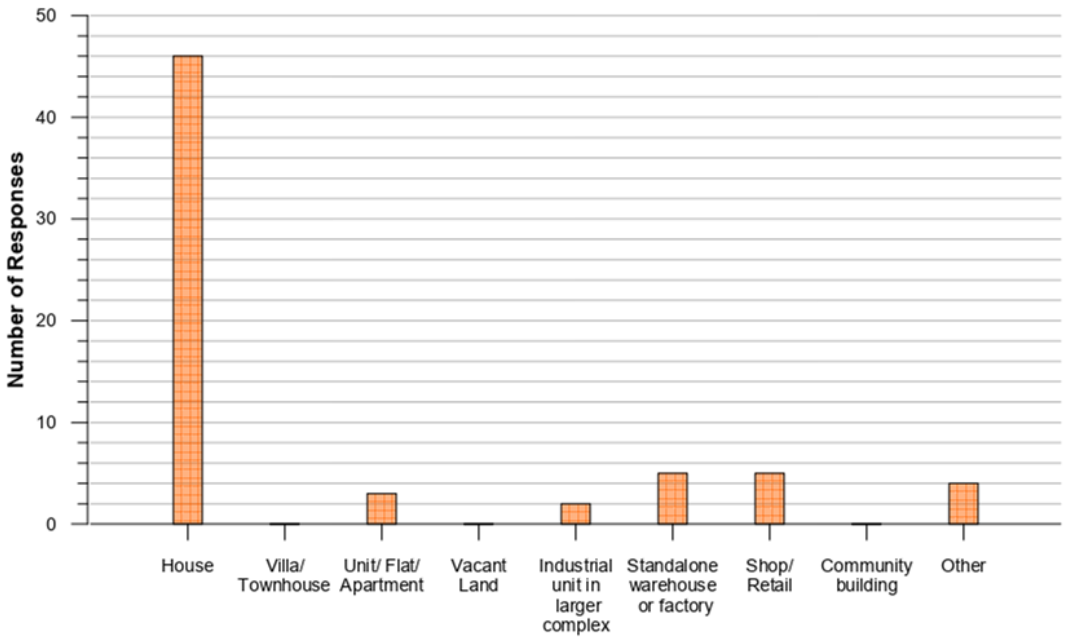
RESPONSES TO COMMUNITY QUESTIONNAIRE



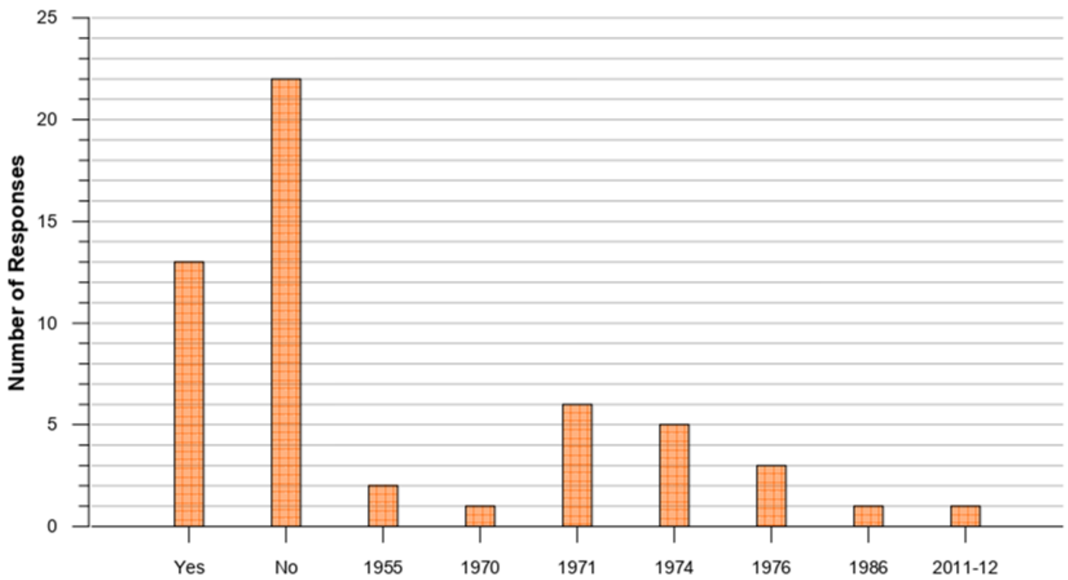


RESPONSE TO COMMUNITY QUESTIONNAIRE

Q3. Type of Property?

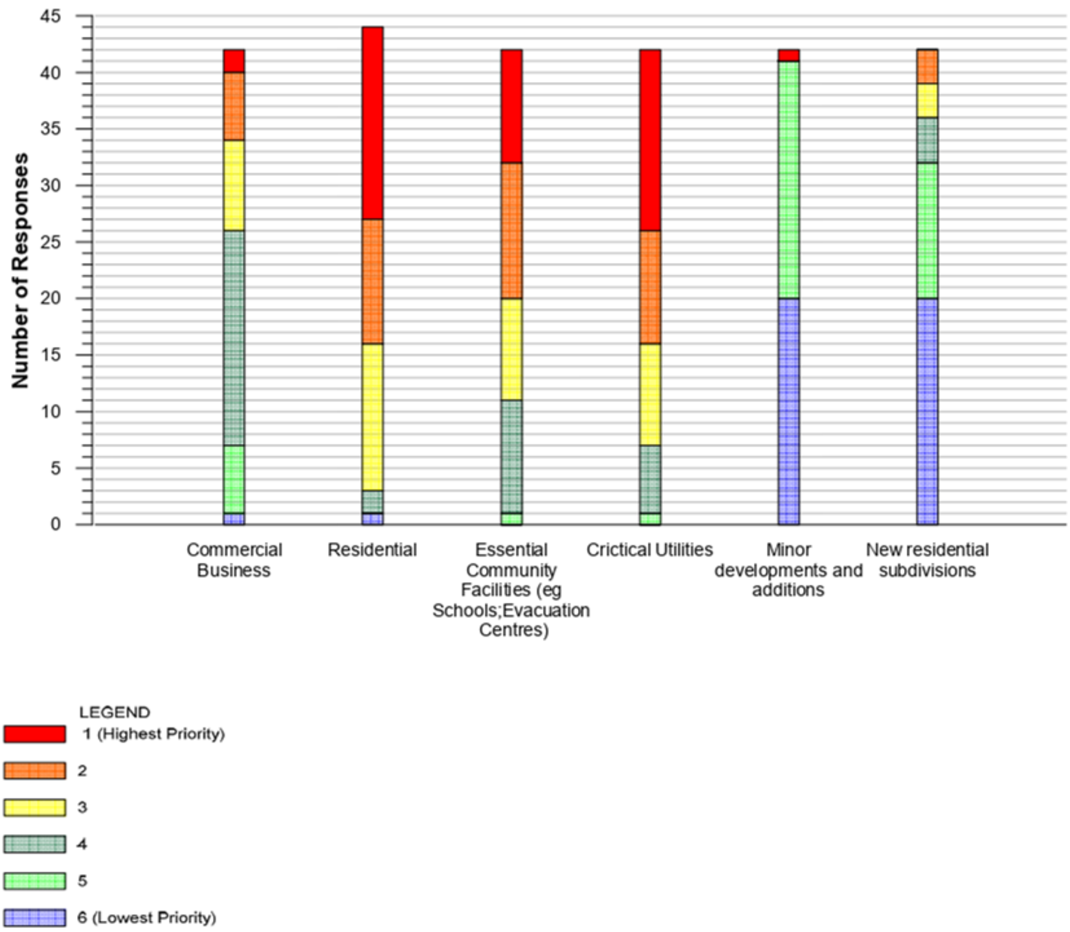


Q4. Have you experienced flooding at the property?

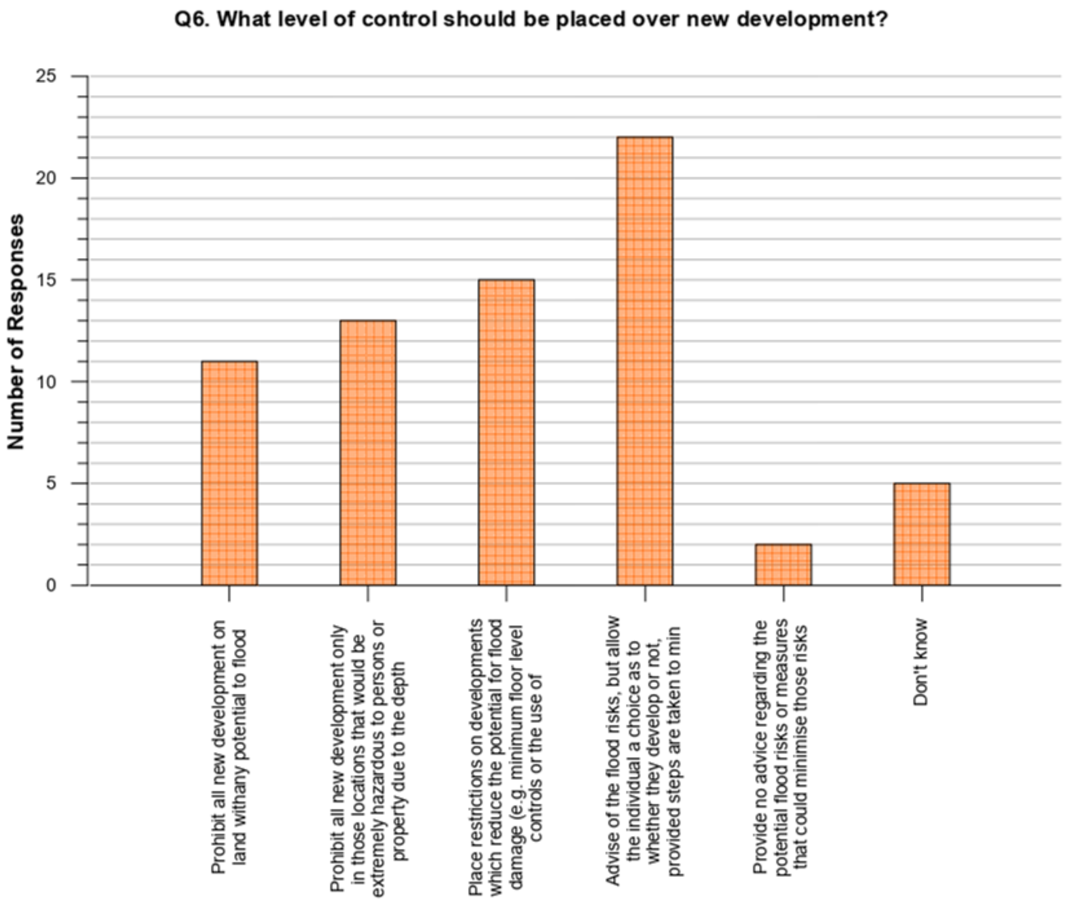


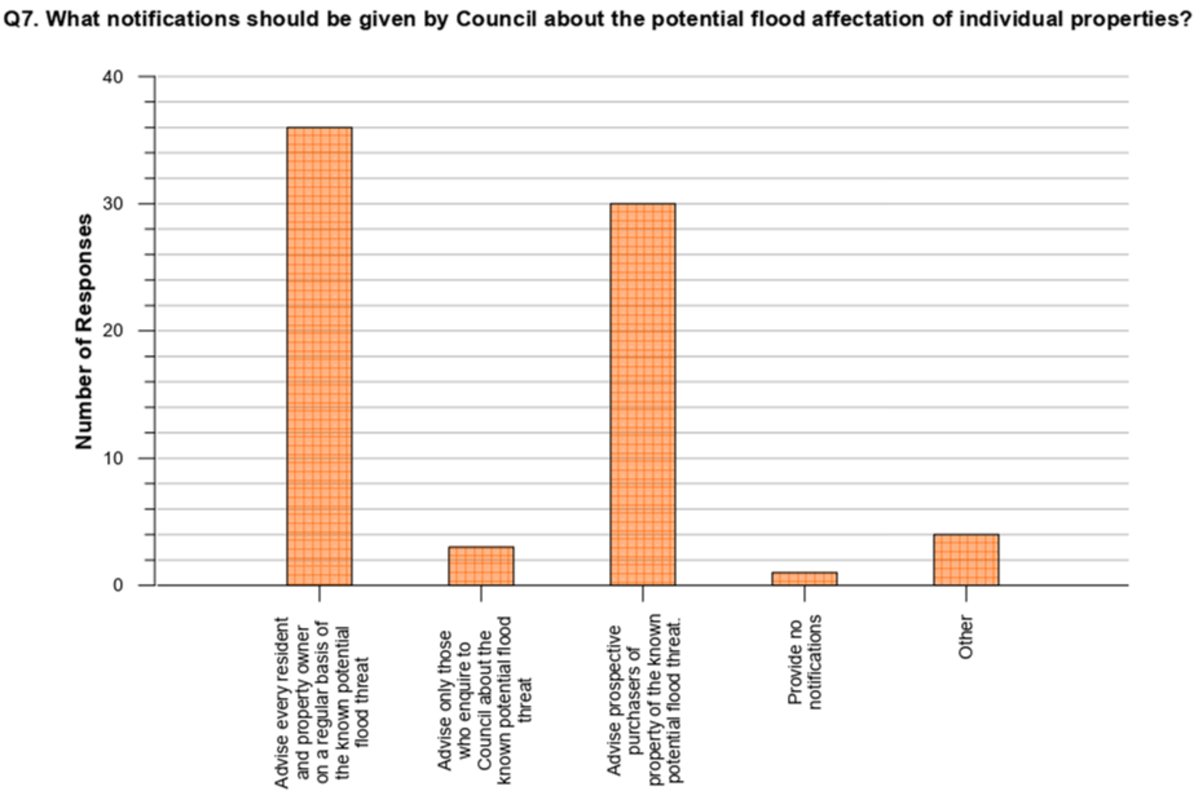
RESPONSE TO COMMUNITY QUESTIONNAIRE

Q5. Ranking of development types most important to protect from floods.

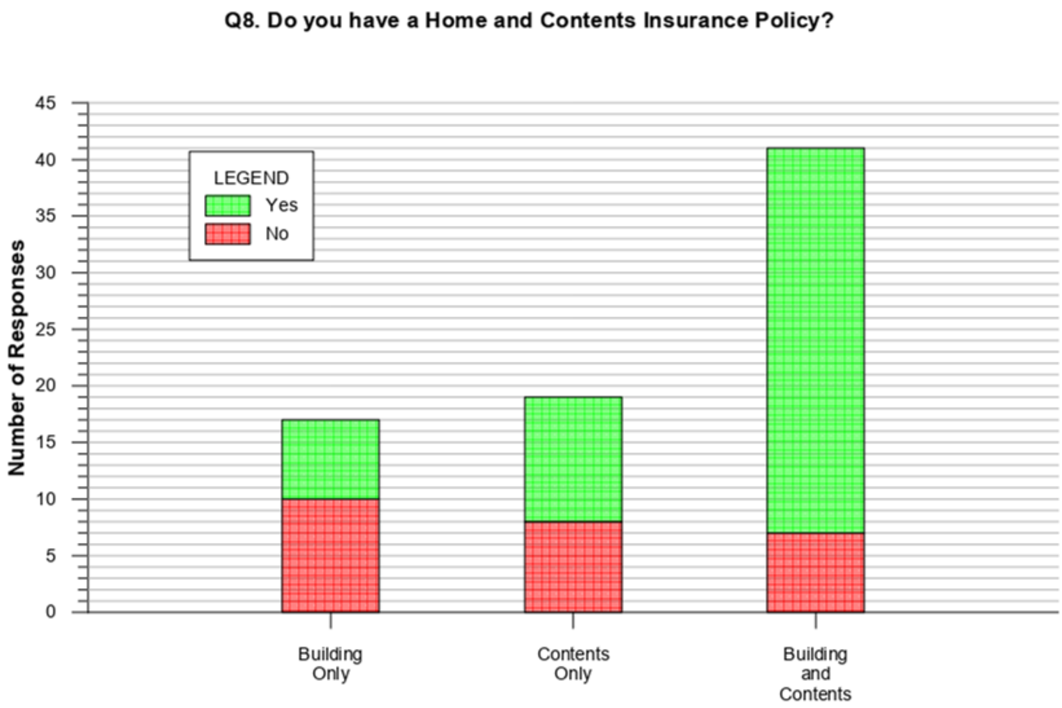


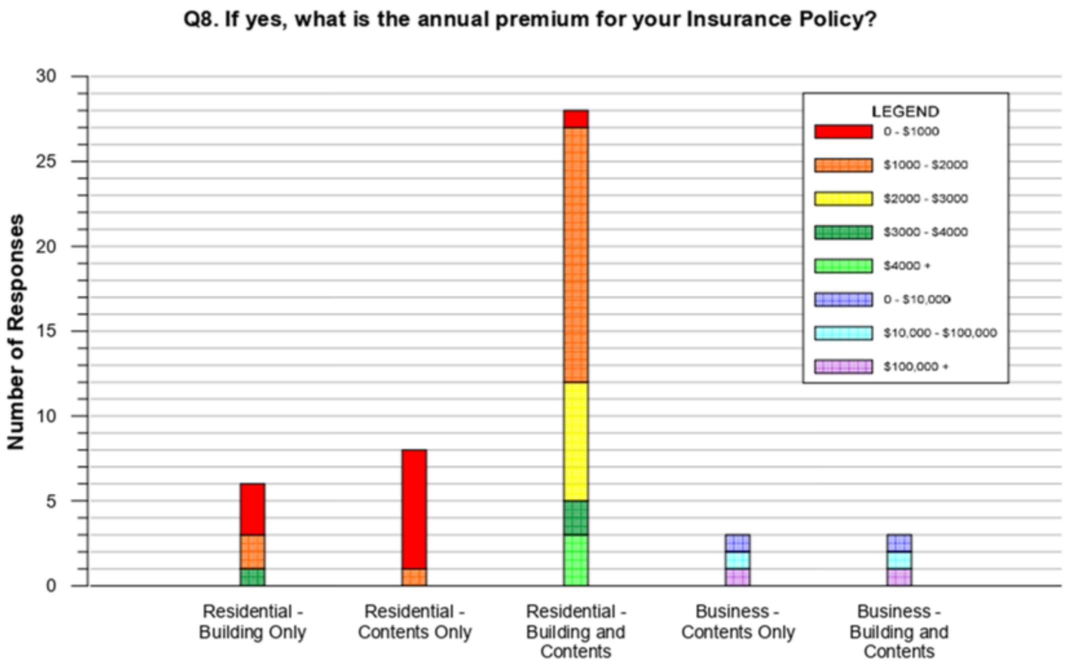
RESPONSE TO COMMUNITY QUESTIONNAIRE





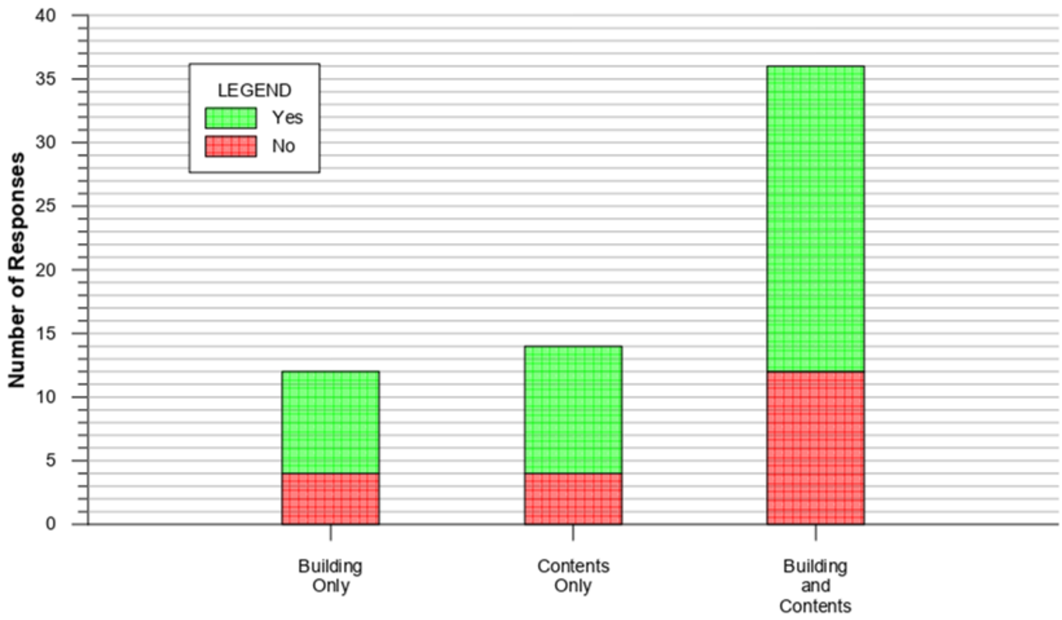
RESPONSE TO COMMUNITY QUESTIONNAIRE



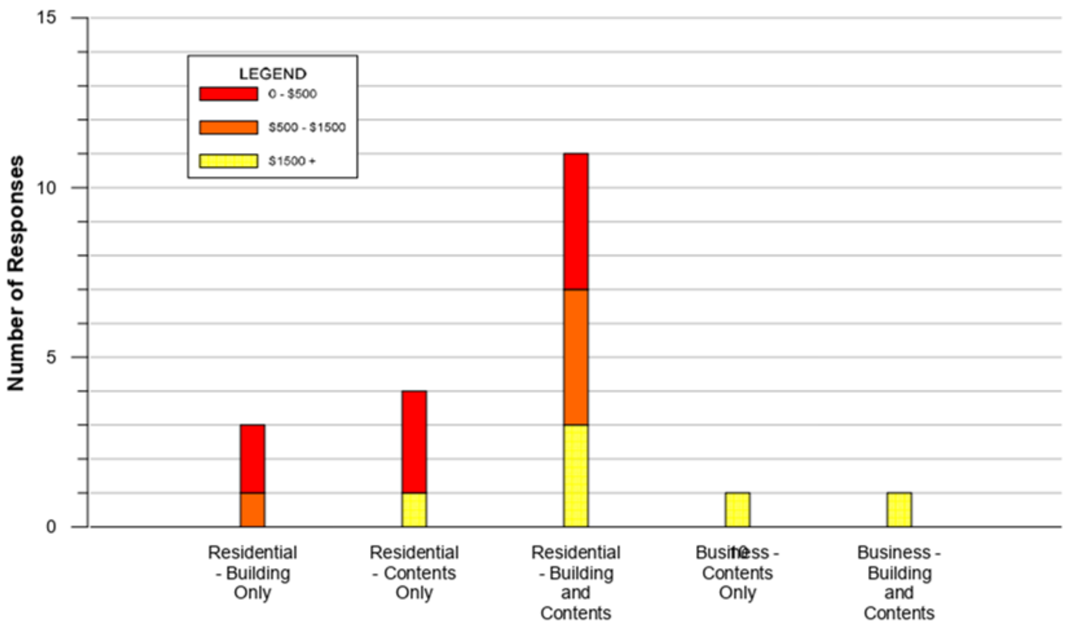


RESPONSE TO COMMUNITY QUESTIONNAIRE

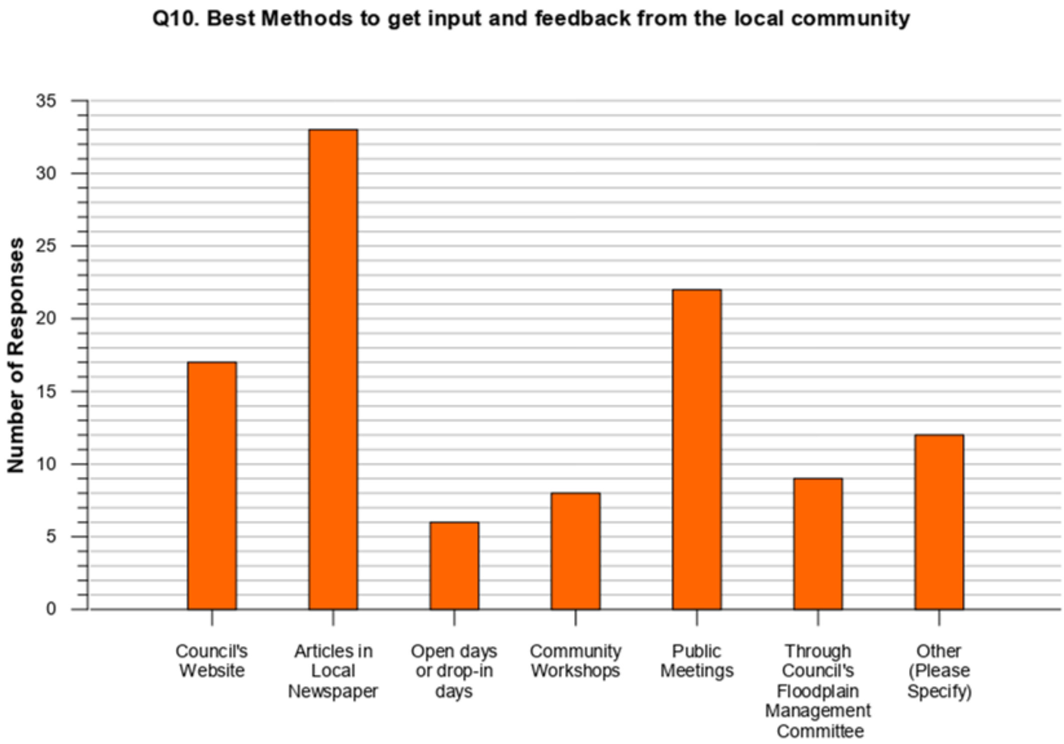
Q9. Have your Home and Contents Insurance premiums increased substantially in the last few year?



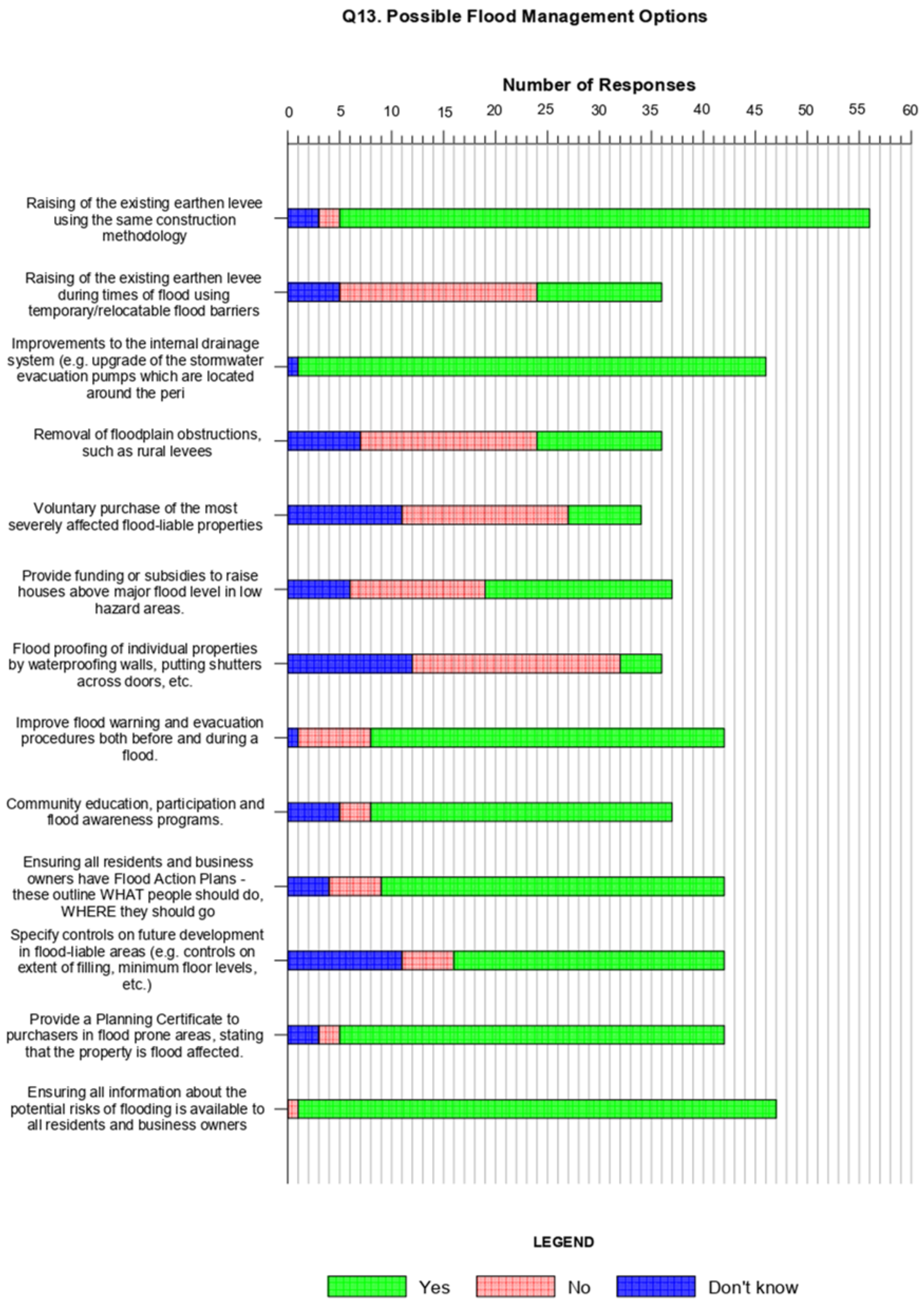
Q9. If yes, how much have premiums increased by?



RESPONSE TO COMMUNITY QUESTIONNAIRE



RESPONSE TO COMMUNITY QUESTIONNAIRE



RESPONSE TO COMMUNITY QUESTIONNAIRE

APPENDIX B

PRELIMINARY GEOTECHNICAL ASSESSMENT

MICHAEL ADLER AND ASSOCIATES
Consulting Geotechnical Engineer

PO Box 91
Church Point, NSW 2105
AUSTRALIA

Tel: +61 412 904 349
Fax: (02) 9999 5770
Mobile: 0412 904 349
EMAIL: michael@madler.com.au

Thursday, July 19, 2018
Our Reference: 15/03650

Lyall and Associates
Level 1, 26 Ridge Street
NORTH SYDNEY, NSW 2060

Attention: **Tom Rooney**

Dear Sir

Preliminary Geotechnical Assessment for
Wee Waa Levee Risk Management Study & Draft Plan
Proposed Raising of Levee
Wee Waa, New South Wales

1) Introduction

This report presents the results of a preliminary geotechnical assessment undertaken as part of the preparation of the Wee Waa Levee Risk Management Study & Draft Plan. The draft plan includes concept design for the proposed raising of various sections of the levee at Wee Waa, north western New South Wales.

Lyall and Associates (LA) are preparing this study and draft plan for the Narrabri Shire Council. They have commissioned Michael Adler and Associates (MAA) to undertake a preliminary geotechnical assessment for the proposed new works.

It is important to note that no subsurface investigations have been undertaken to date. This report is solely based on a walk over inspection of the existing levee, available reports and our experience with similar structures.

The purpose of the investigation was to provide *preliminary* information on:

- The condition of the existing levee
- Methodology for the proposed raising of the structure
- Geotechnical related specifications for the new works
- Further geotechnical investigation requirements.

A number of photographs of the existing levee are attached in the appendices to this report and referred to in the following text. When referring to individual photographs, the appendix letter is quoted first before the photo number, e.g., Photo B7418 refers to a Photo No. 7418 in Appendix B.

It should be noted that this is not a contamination assessment.

2) Background

Wee Waa is a small country town on the north western slopes of New South Wales. It is 30 km west of Narrabri and approximately 420 km north west of Sydney. It has a population of just over 2000. The immediate general area is a relatively flat flood plain.

Wee Waa is situated on the Namoi River catchment, see Figure 1. The Namoi River flows in a general south west direction on the north side of the town. The Wee Waa Gully forms the towns south western boundary with the Wee Waa Lagoon to the south. Obriens Channel is on the eastern side of Wee Waa with Quinns Billlabong to the north.

There is an existing levee running around the entire perimeter of the town. Appendix A presents a series of Photographs of the general condition of the structure. These are taken at between 150 and 500 m intervals along the levee alignment. Figure 2 details the chainage locations noted on the photographs. The levee was originally constructed in 1976. There was a 'significant' upgrade in 1995, *though the exact details of the work undertaken are not clear at this time ???*. Narrabri Shire Council owns, controls and maintains this structure

The levee is 8.6 km in length and varies in height from 2.5 m to 7.0 m. It is an earth embankment. The upstream/river side slopes vary from 2:1 to 3.5:1 (Horizontal:Vertical), generally at 3:1, down stream slopes are in the order of 1.6:1 to 5:1, generally 2:1 with a typical crest width of 3 m. The side slopes are grassed and the crest typically has a gravel surface.

There are a number of road and railway crossings over and through the levee. Appendix B presents photographs of each crossing, they are detailed below;

Type of Crossing	Details	Approx. Chainage.
Sealed Roads	Kamilaroi Highway	2200
	Culgoora Road	4550
	Leaps Road	5600
	Western Narrabri Walgett Road	6900
	Boolcarrol Road	7100
Unsealed Roads	Substation access	2150
	Alama Road	2450
	Myalla Lane	8600
Unformed Crossings		1250, 3600, 6700 & 8200
Railway Cuttings	Removable flood gates	4700 & 6900

The removable flood gates (Photos B7390 & B7421) are stored adjacent to the rail cuttings. During a flood event they are lowered into slots in the concrete abutment walls either side of the railway line (Photos B7391 & B7420).

We understand that there are no spillways either designed for, or constructed along the length of the levee.

3) Local Geology

Reference to Geological Sheet SH 55-12, Narrabri, 1971 at a scale of 1:250,000 indicates that the site is underlain by Quaternary age alluvium. The map states that these materials comprise gravel, sand, silt and clay.

Our experience in the general Wee Waa area is that these alluvial deposits can extend to considerable depth. They typically comprise high plasticity silty clays that are potentially highly dispersive and usually reactive. There are also some clayey sands and sandy clays.

4) D J Douglas Investigation, 1993

The only available report that is particularly relevant to this geotechnical assessment is a geotechnical investigation carried out by D J Douglas & Partners Pty. Ltd (Consulting Geotechnical Engineers) in 1993 (Ref. No. 18045, 22 September, 1993). Eight test pits, two pits at four different locations, were excavated through the levee fill and the underlying insitu soils. Laboratory testing was undertaken on samples taken from the pits.

The results indicate that at the four test locations the levee in its then condition comprised an outer 0.3 m to 0.7 m thick layer of poorly compacted silty clay over an inner core of 'relatively well compacted' clay. In one pit 0.6 m of dense clayey sand was encountered. The natural soils below the levee comprised similar silty clay to the levee filling. This insitu soil was hard.

Laboratory dispersion testing indicated that the clays are all either dispersive or potentially dispersive.

The Douglas report discussed the work required for the then proposed raising of the levee by up to approximately 0.3 m. Construction methodology and specifications were presented for this work. Essentially this involved forming a new skin of well compacted clay fill over the river side slope with a 1 m deep key excavated into the natural ground out the front. A minimum thickness of 1.5 m was recommended for this new skin. It was also recommended that the new clay fill should be stabilised with 3 to 5% gypsum. This was to minimise the potential for adverse dispersive type erosion through the embankment.

It is reported that there was a significant upgrade of the levee two years later, in 1995. The type or extent of these works is not known, or if the recommendations made by Douglas were followed.

5) Proposed New Works

The proposal is to ensure that the entire levee is provided with a minimum 1m of free board above the 100 year ARI flood level, and with a minimum crest width of 3 m. In places the existing crest level will be raised by up to 0.6 m. This will result in an increased in height of up to 1 m above the side slopes at some locations. In other locations the height is at or above the required level. The present proposal is not to lower the height of the sections that are above the required level.

The basic assumption being made is that the internal condition of the existing embankment, especially in areas where no new work is proposed, is in an acceptable state from a geotechnical stability point of view. As already noted this current preliminary geotechnical assessment has not involved any subsurface investigation and hence this basic assumption must be read in that light. Unless there is recorded information about the state of the levee from the 1995 upgrade works, the internal condition of the embankment is currently only known at the four individual locations investigated in 1993. It worth noting that the levee has experienced significant flood events on at least *XXX (????)* occasions and there have been no collapses or adverse behaviour reported *(????)*.

Figure 4 presents details of the proposed works in the areas where the embankment needs to be raised. A 1.5 m thick skin of well compacted gypsum stabilised clay will be formed on the river side face. A 1 m deep key will extend into the natural soils below the upstream toe. The new face will be formed at a slope of 2.5:1 with a 3 m width crest. Further comment on the construction of this skin is presented late in this report.

6) Existing Levee Condition

The following comments only address the condition of the existing levee from a geotechnical stability point of view. No comment is made at this time regarding the various hydraulic structures which pass through the embankment or any erosion adjacent to or in the vicinity of these structures. A recent visual audit by Public Works in late 2017 identifies some possible defects associated with these structures as well as elsewhere along the levee ('Visual Audit of Wee Waa Levee', Public Works, Report No. DO/17/07, dated 20/11/2017). Some of the identified defects/issues may need to be assessed at a later date if they have not already been rectified by Council.

We inspected the levee on March 9, 2018. The general conditions observed are shown in the series of photographs in Appendix A. In summary, we consider from a visual inspection that the embankment appears to be in good condition. There are no obvious signs of instability, generally it is well maintained and appears from a geotechnical point of view to be fit for purpose. The sealed road crossings and the railway cuttings are currently performing as expected (Photos B7348, B7386, B7391, B7430, B7418 & B7420). There is Reno mattress toe protection along the river side of the embankment adjacent to the Wee Waa Lagoon in the vicinity of Ch. 4050 (Photos D7372 to D7374). This appears to be performing adequately.

Some minor defects or aspects requiring attention are discussed below. A number of these recommendations may be superfluous if the new works are proposed in the immediate area.

There are a number of unformed crossing used by local vehicles. These are detailed in Section 2) above and shown in Appendix B. There is the potential that these uncontrolled vehicle movements will over time damage the levee locally. Photo B7352 shows the early stages of the type of damage that can occur where there is an uncontrolled crossing adjacent to a formed road. It would be appropriate to either close off these crossings or possibly control the movements so that vehicles cross over a formed/engineered surface such as a gravel pavement or even a sealed roadway. There are also some unsealed crossings that appear to formed/engineered gravel pavements. These are also detailed in Section 2) and shown in Appendix B. These should be checked on regular basis for damage and repaired if required. Vehicles using these should be restricted to using only the formed gravel pavement. Consideration could be given to sealing these crossings, this may reduce the maintenance costs.

In some locations obvious tension cracks have formed along the crest, examples are Ch. 0 to 200, 400 to 450, 1400 to 2150, 2500 to 2600, 4200 to 4250 & 8200 to 8600. Appendix C presents examples of the some significant cracking. Tension cracking in the highly reactive clays found in this area can develope to considerable depth. Such cracking is usually not acceptable in a water retaining structure. It would be good practice to scarify these cracks, and any damage caused by vehicle or cattle movements, down to a depth of at least 300 mm and recompact the fill to the specifications discussed below. A good well maintained vegetation cover helps reduce the cracking.

In some areas the vegetation on the side slopes is starting to become significant. Examples are shown on Photos D7343, D7363, D7372, D7393 & D7395. These should be removed before the roots start to form potential drainage pipes.

There was water observed ponding at the toe of the town side of the embankment at three locations, Ch. 2900, 3400 and 7500 (Photos D7358, D7363 & D7315). It would be good practice to clear the local drainage system in these area to allow the water to drain.

7) Comments on Proposed New Construction

Both the assumed condition of the existing Wee Waa levee and the natural subgrade below are typical of those found in this part of north western New South Wales. The vast majority of the soils likely used to form levees in this area will essentially behave as a fine grained clayey soil. We consider that they can be successfully used for construction of the new works as long as good engineering practice is followed as discussed below. Attention to compaction and moisture conditions is vital, this is discussed below.

7.1) DISPERSION

This western part of the state is sometimes referred to as "black soil country" because it is prone to large shrink/swell reactive soil movements due to seasonal changes in soil moisture conditions (when the clayey soils wet up and dry out on a cyclic seasonal basis). The depth of these changes can be over 4 m. During the "drying out cycle" of the seasonal change, cracking and fissures can therefore extend to significant depths. This can occur not only in natural soil deposits, but also in fill placed above the ground.

The concept of dispersive behaviour in geotechnical terms, originated with the study of piping failures of small earth dams in Australia in about 1963. These dams constructed of homogeneous fill with minimal or no compaction control generally failed within a short period. The average failure rates of about 20% – 25% have been reported for such dams built in dispersive areas.

The failure mechanism is an interaction of certain chemical properties of the clay fraction of the soil and seepage water (causing dispersion) with the existence of macro (or micro) channels in the embankment soil. The process involves the stored/retained water seeping through the channels in the embankment, contacting the dispersive clay that then breaks down to colloidal sized particles (disperses) and the resulting suspension moving with the flow. In this manner the macro channel, or 'pipe', rapidly increase in size (erodes) until complete piping failure occurs.

If dams and levees are designed and built to acceptable engineering standards, with both material and compaction control, then the incidence of dispersive failure is very much smaller, probably less than 1%. This is mainly due to the fact that controlled compaction of clayey soil results in a relatively impermeable mass that does not facilitate movement of dispersed particles. Furthermore, these 'properly' engineered structures generally exhibit a self healing property whereby swelling of the clay fabric closes any small channels that may exist. Failures of well engineered dams have generally been associated with interface problems, such as leakage along culverts or foundations, which can be minimised by appropriate design measures.

In summary, dispersive soils are particularly prone to erosion if there is a flow path through the material in its natural state, say when placed as a fill in a water retaining embankment. These flow paths can be formed by cracking in the soil due to drying out or by fissures. They can also form in poorly compacted soil, especially when it has been placed relatively dry of optimum. The optimum moisture content is the moisture condition at which it is possible to obtain the maximum level of compaction when placing the soil as a fill, such as in a dam embankment.

7.2) DEALING WITH DISPERSIVE SOILS

One of the best ways of dealing with dispersive soils in a fill situation is to mix in lime or gypsum when placing the clay. Typically only some 0.5% is required, but because of the extreme difficulty of obtaining a consistent well mixed material, 1% to 2% has to be added, and well mixed in, to ensure any success. On levees the treated soil often only needs to extend over a horizontal width of say 2 m from the upstream face. Given the minimal size of the Wee Waa levee the most practical solution would be to treat all the new fill. Of course the treated soil must be properly compacted.

Another less certain method that has been used on dams is to place and compact the soil wet of optimum, say between 0 and +2% or +3%. In this situation it is even more vital to ensure that all soil is well and thoroughly compacted in order to form a consistent mass of impervious fill.

7.3) NEW LEVEE WORKS

The proposed cross section details shown on Figure 3 are considered reasonable. Given the typical size of available earth moving equipment, in some locations it may be more practical to remove the entire embankment and rebuild it, rather that attempting to form a well engineered skin using conventional construction equipment. It will not be practical to construct a zoned embankment. The structure will likely be built of one homogeneous fill material. This material must be clayey in nature and won from a local borrow area. In some situations it may be practical to reuse existing levee material as long as all vegetation, deleterious material and topsoil are discarded.

A large proportion of the new fill will be highly dispersive. It is recommended that serious consideration is given to gypsum stabilising all new engineered fill placed in the new works. A minimum of 2% lime or gypsum should be added and well mixed prior to placing the fill. A 300 mm thick topsoil skin can be provided over the top of the levee to allow vegetation to establish. This should be appropriately vegetated to ensure that there is no unacceptable erosion during flood events.

7.4) CONSTRUCTION

The following present the minimum work that is required to meet the level of good engineering construction discussed above:

- Only clayey fill can be used to construct the new works. An engineer should ensure that acceptable material is used.
- All structural fill should be lime or gypsum stabilised with a minimum of 2%.
- **All** structural filling should compacted to at least 98% of the maximum Standard dry density at a moisture content between Standard optimum and optimum +3%. A sheep or pad foot roller must be used, it is expected that eight to ten passes of a suitable sized roller may be sufficient. A smooth drum roller should not be used.
- All fill must be placed in thin layers. The maximum loose layer thickness should not exceed 200 mm.
- All new fill must be benched in layers into the sides of the existing embankment for a horizontal distance of at least 1 m.
- Prior to building any part of the embankment all vegetation, topsoil, loosened or soft soil should be removed before placing any fill. The exposed surface is to be scarified to a depth of at least 300 mm and compacted as noted above. This includes the sides of the existing levee.
- A cut off trench should be formed into the natural soils below the river side toe as shown on Figure 3. An experienced engineer will need to inspect the exposed subgrade at the bottom of the toe.

- All pipe work through the embankment is to be provided with cut off collars. All trenches are to be back filled with compacted clayey fill well mixed, with 2% lime or gypsum. Sand backfill must **not** be used.

It would be normal practice on a civil engineering project of a similar magnitude to undertake full time supervision and earth works testing during the construction. Consideration could be given to carrying out similar testing while building the proposed new works at Wee Waa.

8) Additional Investigation

Given that there is very little information available about the internal conditions of the existing levee it is recommended that a detailed subsurface investigation is carried during the detailed design phase particularly for the sections of embankment where there will be no new earthworks undertaken, or where the new works do not form an impervious skin for the full height of the levee.

This investigation will likely include boreholes at say 500 m centres along these sections together with appropriate laboratory testing.

It may also be necessary to investigate the proposed borrow pit area to ensure that the new fill is acceptable. Discussions will need to be held with Council regarding potential borrow areas.

9) Concluding Remarks

To date only an extremely limited subsurface investigation was undertaken in 1993. Significant works were undertaken in 1995 but the type and extent is unknown. The above preliminary geotechnical assessment has been provided on the basis that little is known about the internal condition of the existing level. It has been assumed that is in an acceptable condition.

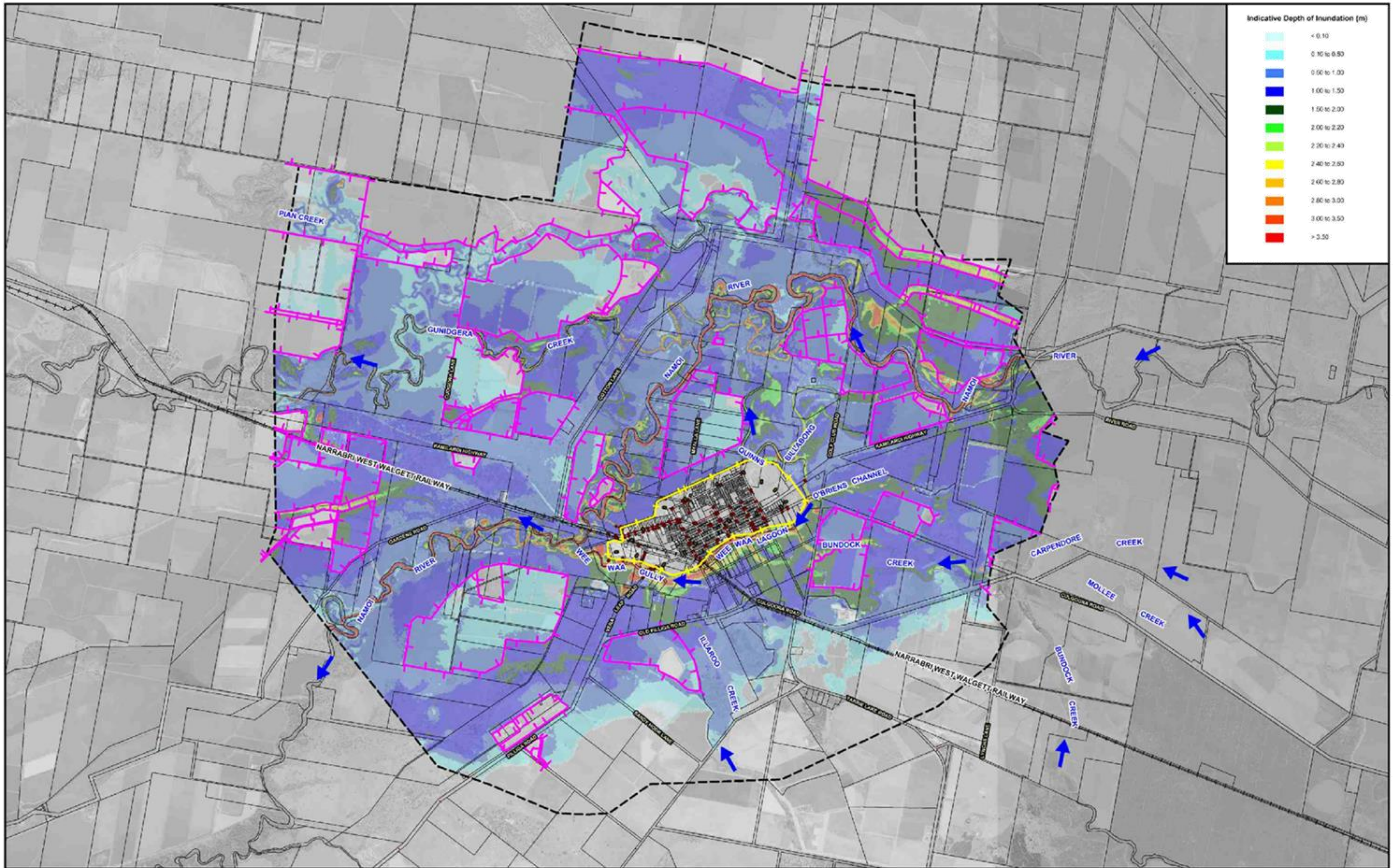
Our observation of the external condition of the levee suggests that it is in good condition. There are some minor defects/aspects that will need rectification. The proposal to form a new engineered skin in areas where the levee needs to be raised is considered reasonable as long as the works follow the recommendations presented in this report.

The attached *Notes Relating To Geotechnical Report* are an intrinsic part of this report.

We do note that we have assumed in our costing for this investigation that you, the client, will contact us by phone on a number of occasions to discuss the proposed works, especially in regards to the finding presented in this report. Please do not hesitate to ring our office.

Yours Sincerely

Michael A Adler BSc, BE, MSc, DIC, MIEAust, CPEng



N 600 0 600 1200 1800 m
Scale: 1:60,000

Lyall & Associates

LEGEND

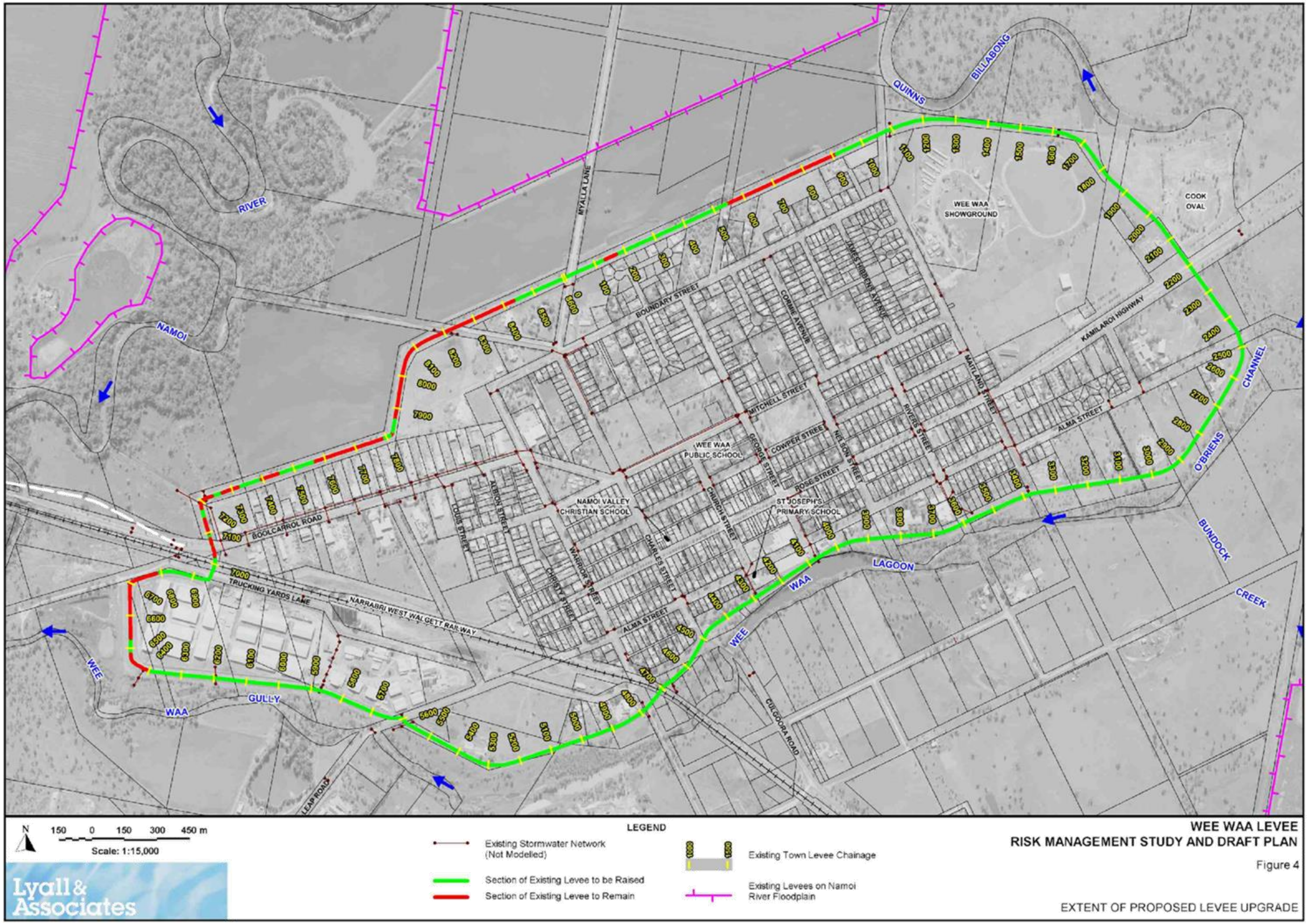
Existing Stormwater Network (Not Modelled)

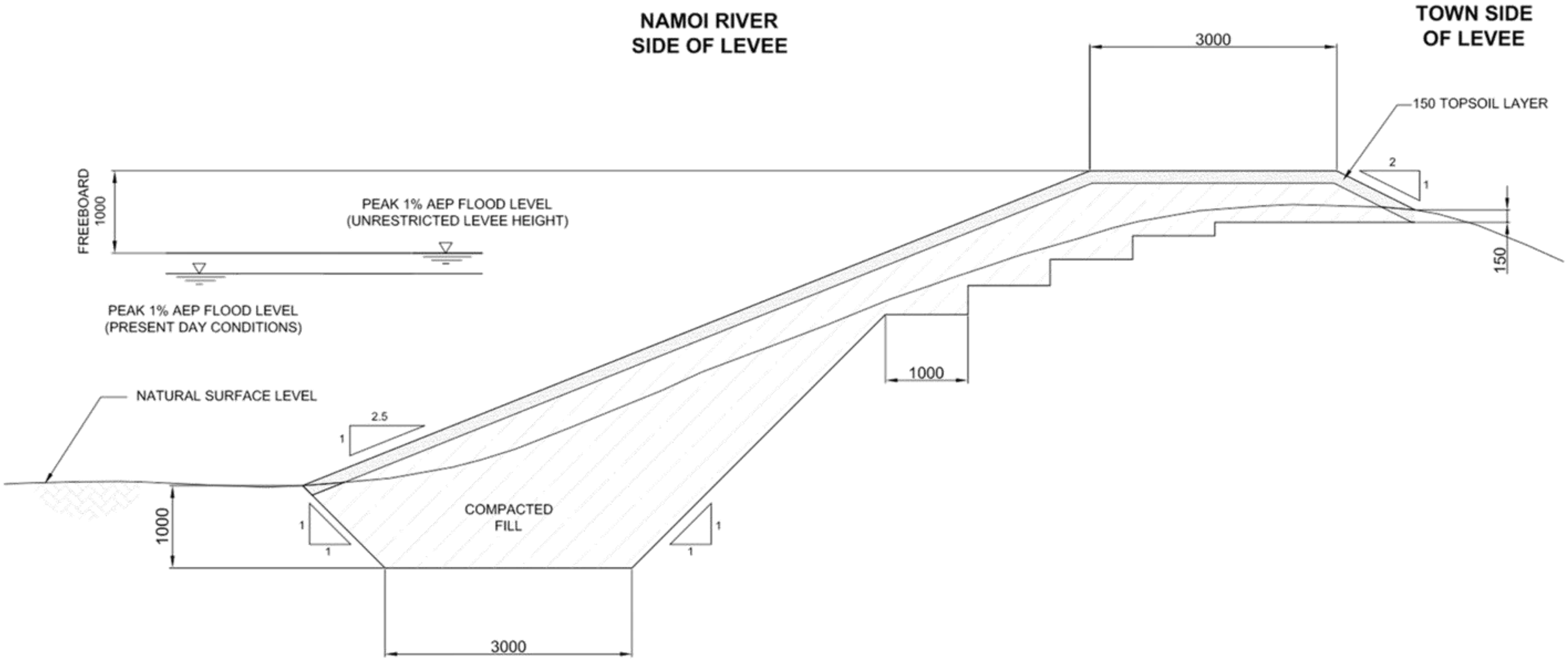
Existing Town Levee Centre Line and Chainage

Existing Levees on Namoi River Floodplain

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND DRAFT PLAN
Figure 1

INDICATIVE EXTENT AND DEPTHS OF INUNDATION
1% AEP - EXISTING RURAL LEVEE HEIGHTS


LEGEND
Scale: 1:15,000
Existing Stormwater Network (Not Modelled)
Section of Existing Levee to be Raised
Section of Existing Levee to Remain
Existing Town Levee Chainage
Existing Levees on Namoi River Floodplain
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND DRAFT PLAN
Figure 4
EXTENT OF PROPOSED LEVEE UPGRADE



Note:
Vertical Scale: 1:50
Horizontal Scale: 1:50
All dimensions in millimetres.

Figure 3

TYPICAL SECTION SHOWING TOWN LEVEE UPGRADE REQUIREMENTS

APPENDIX A

General Photographs

Ch. 0 – Looking North East

Ch 500 – Looking South West

Ch. 500 – Looking North East

Ch 800 – Looking South West

Ch. 800 – Looking North East

Ch 950 – Looking South West

Ch. 950 – Looking North East

Ch. 1100 – Looking South West

Ch. 1100 – Looking East

Ch 1250 –Looking East

Ch. 1250 – Looking West

Ch 1650 –Looking East

Ch. 1650 – Looking West

Ch 2100 – Looking North West

Ch 2100 – Looking South East

Ch 2150 – Looking South East

Ch. 2150 – Looking South East

Ch 2250 – Looking South East

Ch. 2450 – Looking North West

Ch 2450 – Looking South East

Ch. 2500 – Looking South

Ch 2600 – Looking North East

Ch. 2900 – Looking North East

Ch 2900 – Looking South West

Ch. 2900 – Looking North East

Ch 2900 – Looking South West

Ch. 3100 – Looking West

Ch 3100 – Looking East

Ch. 3400 – Looking North East

Ch 3400 – Looking South West

Ch. 3600 – Looking South West

Ch 3650 – Looking North East

Ch. 3650 – Looking West

Ch 4000 – Looking North East

Ch. 4000 – Looking South West

Ch 4100 – Looking South West

Ch. 4100 – Looking North East

Ch 4200 – Looking South West

Ch. 4200 – Looking North East

Ch 4300 – Looking South West

Ch. 4250 – Looking South West

Ch 4250 – Looking North East

Ch. 4300 – Looking South West

Ch 4300 – Looking North East

Ch. 4400 – Looking South West

Ch 4400 – Looking North East

Ch. 4550 – Looking South West

Ch 4700 – Looking South West

Ch. 4700 – Looking North East

Ch 4770 – Looking South West

Ch. 4800 – Looking South West

Ch 4900 – Looking South West

Ch. 4900 – Looking North East

Ch 5200 – Looking North East

Ch. 5200 – Looking South West

Ch 5350 – Looking North West

Ch. 5350 – Looking East

Ch 5600 – Looking West

Ch. 5600 – Looking East

Ch 5900 – Looking East

Ch. 5900 – Looking West

Ch 6200 – Looking East

Ch. 6200 – Looking West

Ch 6400 – Looking East

Ch. 6400 – Looking North

Ch 6650 – Looking South

Ch. 6650 – Looking North

Ch 6700 – Looking South

Ch. 6700 – Looking East

Ch 6900 – Looking East

Ch. 6900 – Looking West

Ch 6900 – Looking North

Ch. 6950 – Looking West

Ch 7050 – Looking North

Ch. 7100 – Looking North

Ch 7150 – Looking South

Ch. 7150 – Looking North

Ch 7200 – Looking North East

Ch. 7200 – Looking North East

Ch 7350 – Looking South West

Ch. 7350 – Looking North East

Ch 7500 – Looking North East

Ch. 7500 – Looking South West

Ch 7800 – Looking South West

Ch. 7800 – Looking North East

Ch 8100 – Looking North East

Ch. 8100 – Looking South West

Ch 8600 – Looking South West

APPENDIX B

Crossing Photographs

Ch. 1250 – Unformed Crossing

Ch 2150 – Access to Substation, Formed Crossing

Ch. 2150– Access to Substation, Formed Crossing

Ch 2200– Kamilaroi Highway, Sealed Crossing

Ch. 2450 – Alama Road Unsealed Crossing

Ch 2450 – Damage Adjacent to Alama Road

Ch. 3600 – Unformed Crossing, S End of River Rd.

Ch. 3600 – Unformed Crossing, S End of River Rd.

Ch. 4550 – Culgoora Road, Sealed Crossing

Ch 4700 –Eastern Narrabri/Walgett Rail Crossing

Ch. 4700– Flood Gate for Eastern Rail Crossing

Ch 4700 –Eastern Narrabri/Walgett Rail Crossing

Ch. 5600 – Leap Road, Sealed Crossing

Ch 6700 – Trucking Yard Lane, Unsealed Crossing

Ch 6700 – Trucking Yard Lane, Unsealed Crossing

Ch 6900 – Western Narrabri Walgett Rail Crossing

Ch 6900 – Western Narrabri Walgett Rail Crossing

Ch 6900 – Western Narrabri Walgett Rail Crossing

Ch. 6700 – Flood Gate for Western Rail Crossing

Ch. 7100 – Boolcarrol Road, Sealed Crossing

Ch. 8200 – Unformed Crossing

Ch 8200 –Unformed Crossing

Ch. 8600 – Myalla Lane, Unformed Crossing

APPENDIX C

Cracking Photographs

Ch. 7950 – Crack River Side of Crest

Ch 50.– Crack Town Side of Crest

Ch. 50 – Crack River Side of Crest

Ch. 1600 – Crack Town Side of Crest

APPENDIX D

Vegetation Photographs

Ch. 2000 – Large Vegetation

Ch 2900 – Ponding Water at Town Side Toe

Ch. 3400 – Ponding Water at Town Side Toe

Ch 4030 – Lagoon at River Side Toe

Ch. 4050 – Reno Mattress at River Side Toe

Ch 4050 – Lagoon at River Side Toe

Ch. 4770 – Large Vegetation

Ch. 4900 – Large Vegetation

Ch. 7500 – Ponding Water on Town Side Toe

APPENDIX C

UPDATED FLOOD MODELLING

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ANNEXURES

FIGURES
(BOUND IN VOLUME 2)

C1. BACKGROUND INFORMATION

C1.1. Summary of Available Data

Data collected for the purpose of the present study included:

- Stream flow data recorded at seven telemetered stream gauges that are operated by WaterNSW. The location of the seven stream gauges are shown on **Figure 1.1** of the Main Report, while their commencement dates are set out in **Table C1.1**. **Annexure A** of this Appendix contains annual maximum peak flow data for the Mollee stream gauge.

TABLE C1.1
DETAILS OF AVAILABLE STREAM FLOW GAUGES

Gauge Number	Gauge Name	Commencement Date
419002	Namoi River at Narrabri	January 1982
419003	Narrabri Creek at Narrabri	August 1891
419039	Namoi River at Mollee	September 1965
419900	Namoi River at Glencoe	May 1995
419060	Namoi River at Gunidgera Weir – Storage Gauge	November 1975
419059	Namoi River at Downstream Gunidgera Weir	April 1976
419061	Gunudgera Creek at Downstream Regulator	July 1975

- **Figure 1.1** of the Main Report shows the extent of the five sets of LiDAR survey data that were relied upon as part of the present study, the capture dates of which are set out in **Table C1.2**. The data comprising each set were captured to the *International Committee on Surveying and Mapping Level 3* standard with a 95% confidence interval on horizontal accuracy of ±800 mm and a 95% confidence interval on vertical accuracy of ± 150 mm.

TABLE C1.2
LiDAR SURVEY DATA SPECIFICATIONS

Data Set	Date of Capture
Wee Waa Town	July 2012
AAMHATCH(1)	February 2009
Narrabri North West	June 2014
GA_5m(2,3)	October 2013
GA_1m(2,3)	

1. The AAMHATCH LiDAR survey data was used to defined natural surface levels as part of URS, 2015.
2. Geoscience Australia LiDAR survey data provided by OEH at commencement of study.
3. The GA_5m and GA_1m LiDAR survey data were raised by 270 and 290 mm, respectively in order to provide a better fit with the Wee Waa Town, AAMHATCH and Narrabri North West data sets.

- Field survey provided by Council which was undertaken in 2002 along the crest of the Town Levee. The survey was used to set the crest elevation of the Town Levee in the Flood Study TUFLOW Model. Field survey along the crest undertaken by Public Works in 2013 was also provided by OEH.

  A review of the data found that the crest levels captured by the 2002 field survey are about 200 mm lower when compared with the Wee Waa Town and AAMHATCH LiDAR survey data, while the crest elevations contains in the 2013 field survey closely match the LiDAR survey data. Based on this finding, the 2002 field survey is not considered suitable for use in defining the crest level of the Town Levee.
- Aerial photography provided by Council covering a 240 km^2 area of the Namoi River floodplain in the vicinity of Wee Waa captured on 24 July 1998 when water levels reached RL 7.39 m of the Glencoe stream gauge.
- GIS based data sets including cadastre and watercourse information that were extracted from the NSW Government's *Spatial Information Exchange* website. **Figure 1.1** of the Main Report shows the layout of the drainage system in the vicinity of Wee Waa.
- GIS based data sets including land ownership and stormwater pit and pipe data as compiled by Council. **Figure 2.1** (2 sheets) of the Main Report shows the layout of the drainage system at Wee Waa, as well as the extent of Crown and Council Owned land.
- A number of previous studies which contain flood related information at Wee Waa (refer **Section C2.2** for further details).

C1.2. Previous Investigations

C1.2.1. General

A number of reports which deal with flooding on the Namoi River floodplain in the vicinity of Wee Waa have been commissioned by the NSW Government and Council. **Sections C1.2.2** to **C1.2.5** provide a brief summary of the reports that were relied upon for the hydrologic and hydraulic modelling undertaken as part of the present study.

Additional reports reviewed as part of the study include:

- *NSW Inland Rivers Flood Plain Management Studies - Namoi Valley* (Laurie, Montgomerie & Pettit Pty. Ltd. (**LM&P**), 1982)
- *Audit of Flood Levees for NSW – Town of Wee Waa* (PW, 1992)
- *Report on Geotechnical Investigation – Wee Waa Flood Levee* (Douglas & Partners (**D&P**), 1993)
- *Wee Waa Levee Rehabilitation* (DWR, 1994)
- *Wee Waa Flood Levee – Review of Levee Design* (Patterson Consulting Pty. Ltd., 1995)
- *Narrabri - Wee Waa Floodplain Management Study* (Department of Infrastructure, Planning & Natural Resources (**DIPNR**), 2005)
- *Wee Waa Inspection Report* (PW, 2012)
- *Visual Audit of Wee Waa Levee* (PW, 2013)

C1.2.2. Narrabri - Wee Waa Flood Study (DIPNR, 2003)

The *Narrabri – Wee Waa Flood Study* (DIPNR, 2003) contains a detailed description of flooding patterns on the Namoi River floodplain between the Mollee stream gauge and a location about 14 km west (downstream) of Wee Waa based on the results of modelling that was developed using the MIKE 11 Software.

The MIKE 11 model was run for the February 1955, January 1964, February 1971, February 1984 and July 1998 flood events, as well as a design flood event with an AEP of1 per cent.[1]

C1.2.3. Wee Waa Levee Flood Investigation (URS, 2015)

The *Wee Waa Levee Flood Investigation* prepared by URS in 2015 (***Flood Study***) defined flooding patterns along a 16 km reach of the Namoi River in the vicinity of Wee Waa in order to assess the level of protection that the Town Levee provides the town. **Figure 1.1** of the Main Report shows the extent of Flood Study TUFLOW Model. Discharge hydrographs were extracted from the MIKE 11 model that was developed as part of DIPNR, 2003 and input at the upstream boundary of the Flood Study TUFLOW Model.

The Flood Study TUFLOW Model was calibrated to flood marks that were recorded during the February 1971, February 1984 and July 1998 floods. The calibrated Flood Study TUFLOW Model was then used to define flooding patterns at Wee Waa for the 1% AEP and Extreme Flood events. The hydraulic modelling that was undertaken as part of the Flood Study assumed that the existing rural levees on the Namoi River floodplain were elevated above the Extreme Flood level.

Table C1.3 sets out the peak flow estimates at Mollee and Wee Waa for the historic and design flood events modelled as part of the *Flood Study*. For comparative purposes the corresponding peak flows relied upon for the present study are also given.

The *Flood Study* found that crest of the Town Levee would be overtopped at multiple locations during a 1% AEP flood event, with floodwater shown to pond at the western end of the township to depths of up to about 1.0 m.

C1.2.4. Narrabri Flood Study – Namoi River, Mulgate Creek and Long Gully (WRM, 2016)

The *Narrabri Flood Study – Namoi River, Mulgate Creek and Long Gully* (WRM, 2016) defines flooding behaviour along the Namoi River and its anabranch at Narrabri (known as Narrabri Creek), as well as the Mulgate Creek and Long Gully tributaries.

WRM, 2016 derived an annual series of total peak flows for a 116 year period between 1890 and 2015[2] at Narrabri by combining the recorded peak flows at the Narrabri Creek and Namoi River at Narrabri stream gauges. **Table C1.4** gives the design peak flow estimates that were derived by a flood frequency analysis that was undertaken as part of WRM, 2016 for the total peak flow at Narrabri using the aforementioned 116 years of annual peak flow data.

[1] Note that DIPNR, 2003 doesn't provide any background to the derivation of the 1% AEP discharge hydrograph at the Mollee stream gauge. Based on DIPNR, 2003, a flow rate of 6,672 m³/s was adopted as the peak 1% AEP flow on the Namoi River at Mollee.

[2] Annual peak flows were not derived for the period between 1900 and 1907, as well as 1909 and 1911.

TABLE C1.3
PREVIOUSLY DERIVED DESIGN PEAK FLOW ESTIMATES
AT MOLLEE AND WEE WAA

Flood Event	*Flood Study*		Present Study	
	Mollee Stream Gauge(1)	Wee Waa(2)	Mollee Stream Gauge(1)	Wee Waa(3)
February 1971	2,847	2,022	2,898(4)	-
February 1984	2,234	1,655	1,884(4)	-
July 1998	2,280	1,681	1,807(4)	-
1% AEP	6,672	4,302	4,400(5)	2,935
Extreme Flood(6)	20,016	12,907	13,200	8,805

1. Derived as part of DIPNR, 2003.
2. Derived using the MIKE 11 model that was developed as part of DIPNR, 2003.
3. Derived using the MIKE 21 model that was developed as part of DPIW, 2017.
4. Derived using the OEH Derived Rating Curve shown on **Figure C1.2** (refer **Section C1.3.1** for discussion).
5. Peak 1% AEP discharge at Mollee derived from flood frequency analysis undertaken as part of present study (refer **Section C1.3.2** for discussion).
6. Derived by increasing the 1% AEP peak flow by factor of three.

TABLE C1.4
PREVIOUSLY DERIVED DESIGN PEAK FLOW ESTIMATES
AT NARRABRI AND MOLLEE

AEP (%)	Narrabri (WRM, 2016)	Mollee Stream Gauge (Present Study)
20	1,070	910
10	1,980	1,740
5	2,920	2,600
2	4,090	3,700
1	4,860	4,400
Extreme Flood	14,580	13,200

A set of design discharge hydrographs were then generated by factoring the ordinates of the discharge hydrograph that was recorded during the January 1974 flood. The design discharge hydrographs were input to a MIKE Flood FM model that was developed as part of the study and routed along a 23 km reach of the Namoi River to the location of the Mollee Stream gauge.

Figure C1.1 shows the relationship of annual peak flows at Narrabri and Mollee for the period 2015 to 1971. Also included on the figure is a comparison of the peak flow that was recorded for the February 1955 flood. By inspection, with the exception of a few years, in general the peak flow in the Namoi River at Mollee is less than that at Narrabri for a given flood event. Based on the findings of WRM, 2016 which estimated the peak 1% AEP flow at Narrabri to be 4,860 m^3/s, it follows that the peak 1% AEP flow at Mollee should be less than this value. This finding indicates that the previously adopted peak 1% AEP flow rate of 6,672 m^3/s at Mollee is too high, which in turn has resulted in an over-estimate of peak 1% AEP flood levels along the Town Levee. Based on this finding, OEH requested that a flood frequency analysis be undertaken as part of the present study for the Mollee stream gauge (refer **Section C2.3** for details).

C1.2.5. Floodplain Management Plan for the Lower Namoi Valley Floodplain 2018 (DPIW, 2017)

The *Floodplain Management Plan for the Lower Namoi Valley Floodplain* (Department of Primary Industries – Water (**DPIW**), 2017) was undertaken to inform local landholders and the wider community about how the rural floodplain management planning approach presented in the *Rural Floodplain Management Plans: Technical manual for plans developed under the Water Management Act 2000* has been applied across the Lower Namoi Valley floodplain.

The MIKE 11 model developed as part of DIPNR, 2003 was updated using the MIKE 21 software and extended about 120 km west (downstream) along the Namoi River to Walgett. OEH provided the MIKE 21 results for the February 1984 flood, as well as a flood that occurred in December 2004 which was equivalent to about a 13% AEP flood at Mollee. The MIKE 21 results were used to determine the downstream boundary condition (i.e. flood slope) of the Namoi River TUFLOW Model that was developed as part of the present study.

C1.3. Analysis of Available Stream Gauge Data

C1.3.1. General

A manually-read stream gauge was first installed on the Namoi River at Mollee in September 1965, while WaterNSW installed a telemetered stream gauge at the same location in October 1972. Annual maximum data for the February 1955 and February 1971 floods were provided by OEH at the commencement of the present study, while the correlation between annual flood peaks at Narrabri and Mollee (refer **Figure C12.1**) was used to derive the annual maximum flow data for the 63 years between 1908 and when the telemetered gauge was first installed.

Figure C1.2 shows historic rating tables representing pre- and post-1971 floodplain conditions in the vicinity of the stream gauge which were derived from the MIKE 21 model developed as part of DPIW, 2017. **Figure C1.2** also shows the then current rating table which was downloaded from WaterNSW's website (WaterNSW Rating Table No. 314.05). The pre- and post-1971 rating curves were used to derive annual maximum flows from the recorded heights at the stream gauge.

Figure C1.2 also shows the 429 gaugings that have been undertaken at the gauge site since 1965. The highest gauged height at the site was taken on 2 February 2012 when the water level reached RL 7.84 m, when the gauged flow in the river at the time was 1,169 m^3/s. However, the highest gauged discharge of 1,574 m^3/s was recorded on 24 November 2000 when the water level reached RL 7.63 m on the gauge.

Table 2.3 in the Main Report lists the ten largest floods that have occurred in the Namoi River at Narrabri and Mollee since records commence in 1890. Included in the table are the corresponding peak flows based on the rating curve that was current at the time of the flood, as well as the OEH rating curves shown on **Figure C1.2** and the correlation shown on **Figure C1.1**.[3] **Table 2.3** shows that three of the five largest floods to occur in the Namoi River occurred prior to the commencement of records at the Mollee stream gauge.

C1.3.2. Annual Flood Frequency Analysis

A log-Pearson Type 3 (**LP3**) distribution was fitted to the annual series of flood peaks for the 46 year period of continuous record since installation of the telemetered stream gauge at Mollee (i.e. 1971-2016) using the FLIKE software. The resulting frequency curves, along with 5% and 95% confidence limits are shown on **Figure C1.3** (refer left hand side (**LHS**) of Sheet 1).

As the recorded flood peaks are only a small sample of peaks actually occurring over a longer period, an expected probability adjustment was made using the procedure set out in *Australian Rainfall and Runoff* (***ARR***) (Geoscience Australia (**GA**), 2016). GA, 2016 recommends implementing the expected probability adjustment to remove bias from the estimate. **Column B** in **Table C1.5** at the end of this chapter gives the peak flow estimates for a range of AEP's as derived from the above analysis.

Values at the low end of the observed range of flood peaks can distort the fitted probability distribution and affect the estimates of large floods. Deletion of these low values may improve the fit to the remaining data. The right hand side (**RHS**) of **Figure C1.3**, sheet 1 and **Column C** in **Table C1.5** shows the results of omitting the 32 annual flows less than 500 m^3/s from the analysis and applying the expected probability adjustment to the remaining data.

The flood of record at the gauge site occurred prior to the establishment of the telemetered gauge in February 1955. The inclusion of this flood in the flood frequency analysis increased the estimate of the 1% AEP flood from 5,800 m^3/s to 7,700 m^3/s (refer LHS of **Figure C1.3**, sheet 2 and **Column D** of **Table C1.5**). The RHS of **Figure C1.3**, sheet 2 and **Column E** of **Table C1.5** show the result of omitting flows less than 500 m^3/s from the data set that includes the February 1955 flood event.

It is noted that estimates of the peak 1% AEP flow at Mollee set out in columns B, D and E of **Table C1.5** are higher than the peak 1% AEP flow estimate that was derived as part of WRM, 2016 at Narrabri. This finding is inconsistent with the historic flow record which shows that the flood wave is typically attenuated between Narrabri and Mollee, resulting in lower peak flows at the downstream gauge site. The reason for the higher flow estimate at Mollee is attributed to the relatively short period of record and the fact that three of the five largest floods to have occurred in the Namoi River in the past 100 plus years occurred prior to the February 1955 flood event.

[3] Refer **Annexure A** which contains a list of the adopted annual series of flood peaks. Note that the "*Pre-1971 OEH Rating Curve*" in **Figure C1.2** has been used for deriving peak flow estimates for 1955 and 1971 and the "*Post-1971 OEH Rating Curve*" has been used for the period between 1972 and 2016. The correlation between peak flows at Narrabri and Mollee shown on **Figure C1.1** was used to derive peak flow estimates for the remaining years between 1908 and 1970.

Estimates were derived of the peak flow at Mollee based on the recorded flow at Narrabri and the relationship shown in Figure C2.1 for the period 1908 to 1970. The LHS of **Figure C1.3**, sheet 3 and **Column F** of **Table C1.5** shows that including the annual series of flood peaks for the 109 year period of continuous record from 1908 to 2016 reduced the peak 1% AEP flow estimate to 4,800 m^3/s. Omission of the 73 annual flows less than 500 m^3/s from the analysis and applying the expected probability adjustment to the remaining data further reduced the peak 1% AEP flow estimate to 4,400 m^3/s (refer RHS of **Figure C1.3**, sheet 3 and **Column G** of **Table C1.5**).

The results of the LP3 analysis show that the inclusion of low flows leads to a degree of positive skew in the fitted distribution which increases the estimate of peak flows for the larger, less frequent floods. By comparison, the fitted probability distribution for the case where low flows were omitted provides a better fit to the historic data.

An analysis was also carried out by fitting the annual series of flood peaks to the General Extreme Value (**GEV**) distribution using LH moments. **Figure C1.4** shows the results for both the 109 year period of record and after the 73 annual flows less than 500 m^3/s are omitted from the analysis.

The GEV distribution was found to be very sensitive to the inclusion of low flows for the larger, less frequent floods. The estimated peak discharge when low flows are included (refer **Column H** of **Table C1.5**) are almost double those derived when the 73 annual flows less than 500 m^3/s are omitted (refer **Column I** of **Table C1.5**) for AEP's less than 1 per cent. Comparison of **Columns G** and **I** of **Table C1.5** show that fitting the annual series of flood peaks for the 109 year period of record but omitting flows less than 500 m^3/s to the LP3 and GEV distribution gives similar design peak flow estimates at Mollee.

Based on the above findings, the peak flow estimates given in **Column G** of **Table C1.5**, as well as those derived from the relationship shown on the RHS of **Figure C1.3**, sheet 3 have been given greatest weight when deriving design discharge hydrographs for input to the hydraulic model. **Table C1.2** shows that the peak 1% AEP flow estimate derived as part of the present study is two-thirds that derived as part of DIPNR, 2003 and utilised in the *Flood Study*.

TABLE C1.5
ESTIMATES OF DESIGN PEAK FLOWS AT MOLEE STREAM GAUGE
VALUES IN m^3/s

Annual Exceedance Probability % AEP	LP3 Distribution						GEV Distribution	
	1971-2016 Full Period of Record	1971-2016 Low Flows Omitted(1)	1971-2016 Plus Historic (1955) Full Period of Record	1971-2016 Plus Historic (1955) Low Flows Omitted(1)	1908-2016(2) Full Period of Record	1908-2016(2) Low Flows Omitted(1)	1908-2016(2) Full Period of Record	1908-2016(2) Low Flows Omitted(1)
[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]	[I]
20	870	940	920	940	910	910	870	990
5	2,300	2,500	2,750	3,100	2,200	2,600	2,400	2,450
2	3,900	3,300	4,950	4,900	3,500	3,700	4,600	3,450
1	5,800	3,850	7,700	6,700	4,800	4,400	7,400	4,300
0.5	8,600	-	11,700	9,300	6,600	5,000	11,900	5,300
0.2	14,700	-	21,000	14,500	9,750	5,850	23,000	7,000

1. Peak flows lower than 500 m^3/s omitted.
2. Peak discharge for the period 1908 to 1971 (excluding 1955) derived from the correlation between peak flows at Narrabri and Mollee shown on **Figure C1.1**.

C2. HYDROLOGIC MODEL DEVELOPMENT AND CALIBRATION

C2.1. Hydrologic Modelling Approach

The present study required the use of a hydrologic model that is capable of representing the rainfall-runoff processes that occur within the area that is protected by the Town Levee. Given its flat nature and the ill-defined nature of the existing drainage paths, the hydrologic response of the protected area was simulated using the direct-rainfall-on-grid approach which is built into the TUFLOW software.

C2.2. Hydrologic Model Tuning

There were no historic data on peak flows and flood levels that have been experienced in the protected area post the construction of the Town Levee to allow the TUFLOW model to be calibrated. The procedure adopted for the testing of the hydrologic model therefore involved an iterative process sometimes referred to as "tuning".

The process usually involves adjusting the hydrologic parameters until the peak flows generated by the model give a good match to those derived using the Probabilistic Rational Method (**PRM**) Model, procedures for which are set out in IEAust, 1987. However, as the protected area is so flat, it was not possible to obtain a reasonable match with peak flow estimates derived using the PRM.

As a result, an initial loss of 15 mm and a continuing loss of 2.5 mm/hr were adopted in order to derive discharge hydrographs for design storms which were then used as input to the TUFLOW model.

C3. HYDRAULIC MODEL DEVELOPMENT AND CALIBRATION

C3.1. General

The present study required the use of a hydraulic model which is capable of analysing the time varying effects of flow in the Namoi River and the local stormwater drainage system and the two-dimensional nature of flow on both the floodplain and in the area behind the Town Levee. The TUFLOW modelling software was adopted as it is one of only a few commercially available hydraulic models which contain all the required features.

This chapter deals with the development of the Namoi River and Wee Waa TUFLOW Models that were used to define flooding behaviour on either side of the Town Levee.

C3.2. Brief Review of TUFLOW Modelling Approach

TUFLOW is a true two-dimensional hydraulic model which does not rely on a prior knowledge of the pattern of flood flows in order to set up the various fluvial and weir type linkages which describe the passage of a flood wave through the system.

The basic equations of TUFLOW involve all of the terms of the St Venant equations of unsteady flow. Consequently the model is "fully dynamic" and once tuned will provide an accurate representation of the passage of the flood wave through the drainage system (both surface and piped) in terms of extent, depth, velocity and distribution of flow.

TUFLOW solves the equations of flow at each point of a rectangular grid system which represent overland flow on the floodplain. The choice of grid point spacing depends on the need to accurately represent features on the floodplain which influence hydraulic behaviour and flow patterns (e.g. buildings, streets, changes in channel and floodplain dimensions, hydraulic structures which influence flow patterns, etc.).

Pipe drainage and channel systems can be modelled as one-dimensional elements embedded in the larger two-dimensional domain which typically represents the wider floodplain. Flows are able to move between the one and two-dimensional elements of the model depending on the capacity characteristics of the drainage system being modelled.

The Namoi River and Wee Waa TUFLOW Models also allow for the assessment of potential flood management measures, such as the upgrade of the Town Levee and the existing stormwater drainage system.

C3.3. TUFLOW Model Setup

The extent of the Flood Study TUFLOW Model matched that of the AAMHATCH LiDAR survey data which only covered Wee Waa and its immediate environs. The plan extent of the Flood Study TUFLOW Model was increased to form the Namoi River TUFLOW Model as follows:

- The two-dimensional model boundary was extended approximately 1.0 km to the east and 4.0 km to the north so that the flow in the flood runners to the north of Wee Waa were included in the model.
- The two-dimensional model boundary was extended approximately 3.5 km to the west in order to reduce the impact the downstream boundary condition has on flooding patterns nearer the town.

The layout of the Namoi River TUFLOW Model is shown on **Figure C3.1**. The model comprises a 26 km reach of the Namoi River within the two-dimensional (in plan) model domain using a grid based approach. A 40 m grid spacing was found to provide the appropriate balance between the need to define features along the various flow paths versus model run times.

The layout of the Wee Waa TUFLOW Model is shown on **Figure C3.2**. The model comprises the area which lies on the protected side of the Town Levee. A 5 m grid spacing was adopted for the Wee Waa TUFLOW Model in order to more accurately define the passage of overland flow through the urbanised parts of town.

Ground surface elevations for model grid points were initially assigned using a Digital Terrain Model (**DTM**) derived from the LiDAR survey data sets out in **Table C1.2**. Ridge and gully lines were added to the model where the grid spacing was considered too coarse to accurately represent important topographic features. Ridge lines were added to the model to define the crest elevations of the Town Levee, as well as those of the network of rural levees.[4]

The footprints of a large number of the individual buildings protected by the Town Levee were incorporated in the Wee Waa TUFLOW Model and assigned an artificially high hydraulic roughness value which accounted for their blocking effect on flow while maintaining storage in the model. Individual allotments where development is present were also digitised and assigned an artificially high hydraulic roughness value (although not as high as for individual buildings) to account for the reduction in conveyance capacity which will result from fences and other obstructions stored on these properties.

Figure C3.2 shows the piped drainage system that were incorporated in the Wee Waa TUFLOW Model based on information contained in Council's asset database. The dimensions of the piped elements were taken from the Council's database where available and supplemented by field measurements. Limited information was available on pipe invert levels. Therefore an assumed cover of 700 mm was adopted for those drainage elements where invert levels or depth measurements were not available. Adjustments were made to the assumed invert levels where this approach resulted in a negatively graded reach of pipe or culvert.

Several types of pits are also identified on **Figure C3.2**, including junction pits which have a closed lid and inlet pits which are capable of accepting overland flow. Council's asset database did not contain any information in regard to inlet pit types and dimensions. Therefore, inlet capacity relationships for incorporation in the TUFLOW model were derived based on visual inspection of the pit.

Pit losses throughout the various piped drainage networks were modelled using the Engelhund approach in TUFLOW. This approach provides an automatic method for determining time-varying energy loss coefficients at pipe junctions that are recalculated each time step based on a range of variables including the inlet/outlet flow distribution, the depth of water within the pit, expansion and contraction of flow through the pit, and the horizontal deflection and vertical drop across the pit.

Table C3.1 summarises the pit and pipe data that were incorporated into the TUFLOW model.

[4] The majority of the licences held by the landowners on the rural floodplain do not place height restrictions on the elevation of the rural levees. Therefore it is possible that these levees could be raised above the height of the PMF in the future. A sensitivity analysis to assess the impact that the potential raising of these levees would have on peak flood levels at Wee Waa is presented in **Section 2.9** of the Main Report.

TABLE C3.1
SUMMARY OF MODELLED DRAINAGE STRUCTURES

Element	Number	Length (m)
Pipes	148	4000
Box Culverts	59	950
Headwalls	246	-
Inlet Pits	58	-
Junction Pits	24	-

Figure C3.2 shows the plan location of the fourteen (14) penstock gates and six (6) permanent stormwater evacuation pumps that were also incorporated in the Wee Waa TUFLOW Model.[5]

C3.4. Model Boundary Conditions

The design discharge hydrographs derived as part of the present study at the Mollee stream gauge were run through the MIKE 21 model that was developed as part of DPIW, 2017 (refer **Chapter C4** for details). The locations where discharge hydrographs were extracted from the MIKE 21 model results and input to the Namoi River TUFLOW Model is shown on **Figure C3.1**.

As mentioned, rainfall was directly applied to the grid of the Wee Waa TUFLOW Model. TUFLOW converted the rainfall to runoff and routed the resulting overland flow to the fourteen (14) penstock gated pipes which extend through the Town Levee. Direct application of rainfall to the natural surface is a recent development and is part of the TUFLOW modelling system. While direct application should be used with caution as it has the potential to over-attenuate overland flows, it has considerable advantages in situations where the flow paths are relatively indistinct and are difficult to "map" by eye. In effect, the grid of the TUFLOW geometric model of the floodplain defines the flow paths automatically.

The downstream boundaries of the two models comprised a "free discharge" outlet, where a TUFLOW derived normal depth calculation was used to define hydraulic conditions at the outlet of both models.

C3.5. Model Roughness

The main physical parameter for TUFLOW is the hydraulic roughness. Hydraulic roughness is required for each of the various types of surfaces comprising the overland flow paths. In addition to the energy lost by bed friction, obstructions to flow also dissipate energy by forcing water to change direction and velocity and by forming eddies. Hydraulic modelling traditionally represents all of these effects via the surface roughness parameter known as "Mannings n".

[5] The effect of that trailer mounted pumps which are mobilised on an as needs basis during local catchment flood events have on flooding patterns in Wee Waa was not assessed as part of the present investigation.

Table C3.2 presents the set of hydraulic roughness values that were found by the *Flood Study* to give reasonable correspondence with observed flood behaviour for the February 1971, February 1984 and July 1998 floods. These same values have been applied to the Namoi River TUFLOW Model.

In regards the definition of flooding behaviour in the protected area of Wee Waa, hydraulic roughness values that have been found to give reasonable correspondence with observed flooding behaviour in other rural towns were used as input to the Wee Waa TUFLOW Model (refer **Table C3.2** for values).

TABLE C3.2
"BEST ESTIMATE" OF HYDRAULIC ROUGHNESS VALUES
ADOPTED FOR TUFLOW MODELLING

TUFLOW model	Surface Treatment	Mannings n Value
Flood Study TUFLOW Model and Namoi River TUFLOW Model	Bushes	0.15
	Namoi River Floodplain	0.075
	Namoi River and Watercourses	0.05
	Wetlands / Lagoons	0.045
Wee Waa TUFLOW Model	Grassed Areas	0.045
	Roads	0.02
	Grassed / Paved Inter Allotment Area	0.1
	Buildings	10

Figure C3.3 is a typical example of flow patterns derived from the above roughness values. This example applies for the 1% AEP flood event and shows flows through existing development in the vicinity of Charles Street and Boundary Street.

The left hand side of the figure shows the roads and inter-allotment areas, as well as the outlines of buildings, which have been individually digitised in the model. The right hand side shows the resulting flow paths in the form of scaled velocity vectors and the depths of inundation. The buildings with their high values of hydraulic roughness block the passage of flow, although the model recognises that they store floodwater when inundated and therefore correctly accounts for flood storage. The flow is conveyed via the road reserves and through the open parts of the allotments. Similar information to that shown on **Figure C3.3** may be presented at any location within the model domain (which is shown on **Figures C3.1** and **C3.2**) and will be of assistance to Council in assessing individual flooding problems in the floodplain.

C4. DERIVATION OF DESIGN DISCHARGE HYDROGRAPHS

C4.1. Namoi River Flooding

A set of design discharge hydrographs at Mollee (refer **Figure C4.1**) were derived by factoring the ordinates of the 1% AEP design discharge hydrograph presented in DIPNR, 2003 so that their peaks matched the values given in **Column G** of **Table C2.5**. The design discharge hydrographs were then input to the MIKE 21 model that was developed as part of DPIW, 2017 and routed downstream to Wee Waa. **Figure C4.2** shows the design discharge hydrographs that were extracted from the MIKE 21 model and used as input to the Namoi River TUFLOW model. The locations where these hydrographs were input to the Namoi River TUFLOW Model are shown on **Figure C3.1**, sheet 1.

As required by the Study Brief, the Extreme Flood was assumed to have a peak flow three (3) times that of the 1% AEP flood at Wee Waa.

C4.2. Local Catchment Flooding

C4.2.1. Rainfall Intensity

The procedures used to obtain temporally and spatially accurate and consistent Intensity-Frequency-Duration (**IFD**) design rainfall curves for the assessment of local catchment flooding behind the Town Levee are presented in IEAust, 1987. Design storms for frequencies of 5, 2, 1, 0.5 and 0.2% AEP were derived for storm durations ranging between 25 minutes and three days. The IFD dataset was downloaded from the BoM's *1987 Rainfall IFD Data System*.

C4.2.2. Areal Reduction Factors

The rainfalls derived using the processes outlined in IEAust, 1987 are applicable strictly to a point. In the case of a catchment of over tens of square kilometres area, it is not realistic to assume that the same rainfall intensity can be maintained. An Areal Reduction Factor (**ARF**) is typically applied to obtain an intensity that is applicable over the entire catchment.

However, as the local catchment at Wee Waa is relatively small, the reduction in rainfall intensity would be quite small. Accordingly, no reduction in design point rainfalls was made for this present study (i.e. an ARF of 1.0 was adopted).

C4.2.3. Temporal Patterns

Temporal patterns for various zones in Australia are presented in IEAust, 1987. These patterns are used in the conversion of a design rainfall depth with a specific AEP into a design flood of the same frequency. Patterns of average variability are assumed to provide the desired conversion. The patterns may be used for AEP's up to 0.2 per cent where the design rainfall data is extrapolated for storms with an AEP less than 1 per cent.

The derivation of temporal patterns for design storms are discussed in Volume 1 of IEAust, 1987 and separate patterns are presented in Volume 2 of IEAust, 1987 for AEP's ≥ 3.3 per cent and AEP's < 3.3 per cent. The second pattern is intended for use for rainfalls with AEP's down to 1 per cent, and down to 0.2 per cent in those cases where the design rainfall data in IEAust, 1987 are extrapolated for larger AEP's.

C4.2.4. Probable Maximum Precipitation

Estimates of PMP were made using the Generalised Short Duration Method (**GSDM**) as described in BoM, 2003. This method is appropriate for estimating extreme rainfall depths for catchments up to 1,000 km^2 in area and storm durations up to six hours.

The steps involved in assessing PMP for each study catchment are briefly as follows:

- Calculate PMP for a given duration and catchment area using depth-duration-area envelope curves derived from the highest recorded US and Australian rainfalls.
- Adjust the PMP estimate according to the percentages of the catchment which are meteorologically rough and smooth, and also according to elevation adjustment and moisture adjustment factors.
- Assess the design spatial distribution of rainfall using the distribution for convective storms based on US and world data, but modified in the light of Australian experience.
- Derive storm hyetographs using the temporal distribution contained in BoM, 2003, which is based on pluviographic traces recorded in major Australian storms.

C5. REFERENCES

BoM (Bureau of Meteorology), 2003. ***"The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method"***.

DECCW (Department of Environment, Climate Change and Water, NSW), 2007b. ***"Floodplain Risk Management Guideline – Practical Considerations of Climate Change"***.

D&P (Douglas & Partners), 1993. ***"Report on Geotechnical Investigation – Wee Waa Flood Levee"***

DIPNR (Department of Infrastructure, Planning and Natural Resources), 2003. ***"Narrabri-Wee Waa Flood Study"***

DIPNR, 2005. ***"Narrabri - Wee Waa Floodplain Management Study"***

DPIW (NSW Department of Primary Industries – Water), 2018. ***"Floodplain Management Plan for the Lower Namoi Valley Floodplain"***

Department of Water Resources (DWR), 1994. ***"Wee Waa Levee Rehabilitation"***

EA (Engineers Australia), 2013. ***"Australian Rainfall & Runoff - Revision Projects – Project 11 – Blockage of Hydraulic Structures"***. Stage 2 Report P11/S2/021 dated February 2013.

IEAust (The Institution of Engineers Australia), 1987. ***"Australian Rainfall and Runoff – A Guide to Flood Estimation"***, Volumes 1 and 2.

GA (Geoscience Australia), 2016. ***"Australian Rainfall and Runoff, A Guide to Flood Estimation"***.

LM&P (Laurie, Montgomerie & Pettit Pty. Ltd.), 1982. ***"NSW Inland Rivers Flood Plain Management Studies - Namoi Valley"***

O'Loughlin, 1993. ***"The ILSAX Program for Urban Stormwater Drainage Design and Analysis (User's manual for Microcomputer Version 2.13)"***, Civil Engineering Monograph 93/1, University of Technology, Sydney (5th printing, 1st version 1986).

NSWG (New South Wales Government), 2005. ***"Floodplain Development Manual"***

NSW SES (NSW State Emergency Service), 2015. ***"Narrabri Shire Local Flood Plan"***

Patterson Consulting Pty. Ltd., 1995. ***"Wee Waa Flood Levee – Review of Levee Design"***

PW, (Public Works), 1992. ***"Audit of Flood Levees for NSW – Town of Wee Waa"***

PW, 2012. ***"Wee Waa Inspection Report"***

PW, 2013. ***"Visual Audit of Wee Waa Levee"***

URS, 2015. ***"Wee Waa Levee Flood Investigation"***

WRM, 2016. ***"Narrabri Flood Study – Namoi River, Mulgate Creek and Long Gully"***

ANNEXURE A

NAMOI RIVER AT MOLLEE
STREAM GAUGE DATA (GS 419039)

TABLE A1
RECORDED PEAK HEIGHT AND DISCHARGE DATA IN DATE ORDER
NAMOI RIVER AT MOLLEE STREAM GAUGE

Year	Gauge Height(1) (m)	Discharge(2) (m^3/s)
1908	-	[2272]
1909	-	-(3)
1910	-	[4103]
1911	-	-(3)
1912	-	[143]
1913	-	[543]
1914	-	[188]
1915	-	[575]
1916	-	[1071]
1917	-	[806]
1918	-	[343]
1919	-	[153]
1920	-	[2984]
1921	-	[1713]
1922	-	[407]
1923	-	[300]
1924	-	[1040]
1925	-	[184]
1926	-	[224]
1927	-	[311]
1928	-	[579]
1929	-	[274]
1930	-	[336]
1931	-	[1523]
1932	-	[206]
1933	-	[541]
1934	-	[743]
1935	-	[446]
1936	-	[359]

Refer over for footnotes to table.

TABLE A1 (Cont'd)
RECORDED PEAK HEIGHT AND DISCHARGE DATA IN DATE ORDER
NAMOI RIVER AT MOLLEE STREAM GAUGE

Year	Gauge Height(1) (m)	Discharge(2) (m^3/s)
1937	-	[236]
1938	-	[282]
1939	-	[258]
1940	-	[292]
1941	-	[995]
1942	-	[1213]
1943	-	[342]
1944	-	[398]
1945	-	[366]
1946	-	[207]
1947	-	[440]
1948	-	[380]
1949	-	[788]
1950	-	[1490]
1951	-	[321]
1952	-	[1109]
1953	-	[207]
1954	-	[420]
1955	8.94	4,183
1956	-	[2119]
1957	-	[143]
1958	-	[342]
1959	-	[201]
1960	-	[403]
1961	-	[176]
1962	-	[883]
1963	-	[342]
1964	-	[1322]
1965	-	[154]

Refer over for footnotes to table.

TABLE A1 (Cont'd)
RECORDED PEAK HEIGHT AND DISCHARGE DATA IN DATE ORDER
NAMOI RIVER AT MOLLEE STREAM GAUGE

Year	Gauge Height[(1)] (m)	Discharge[(2)] (m^3/s)
1966	-	[180]
1967	-	[121]
1968	-	[496]
1969	-	[291]
1970	-	[304]
1971	8.43	2,898
1972	-	[152]
1973	2.97	123
1974	8.16	2,154
1975	3.53	160
1976	8.02	1,828
1977	7.32	872
1978	6.20	380
1979	3.13	134
1980	1.77	61
1981	3.79	180
1982	2.38	90
1983	4.31	218
1984	8.04	1,884
1985	4.39	225
1986	4.10	203
1987	5.01	275
1988	3.82	182
1989	6.87	551
1990	6.62	424
1991	6.40	398
1992	7.05	663
1993	4.34	221
1994	1.10	21

Refer over for footnotes to table.

TABLE A1 (Cont'd)
RECORDED PEAK HEIGHT AND DISCHARGE DATA IN DATE ORDER
NAMOI RIVER AT MOLLEE STREAM GAUGE

Year	Gauge Height(1) (m)	Discharge(2) (m^3/s)
1995	3.30	145
1996	5.34	303
1997	7.31	864
1998	8.01	1,807
1999	4.28	216
2000	7.97	1,736
2001	3.50	159
2002	2.10	76
2003	2.40	91
2004	7.67	1,220
2005	6.28	387
2006	1.56	51
2007	2.94	122
2008	6.22	382
2009	2.18	80
2010	7.27	825
2011	7.26	820
2012	7.94	1,666
2013	5.08	281
2014	5.63	328
2015	1.24	29
2016	6.43	401

1. With the exception of 1955 and 1971, gauge height records not available prior to 1973.
2. Numbers in [] represent peak discharge derived using a line of best fit analysis between Narrabri (sourced from WRM, 2016) and the Mollee stream gauge in order to estimate annual maximum discharges prior to the establishment of the Mollee stream gauge.
3. Peak discharge at Narrabri not presented in WRM, 2016. Peak discharge assumed to be 100 m^3/s for the purposes of the flood frequency analysis undertaken as part of the present study.

APPENDIX D

FLOOD DAMAGES

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D1 INTRODUCTION AND SCOPE

D1.1 Introduction

Damages from flooding belong to two categories:

- **Tangible Damages**
- **Intangible Damages**

Tangible damages are defined as those to which monetary values may be assigned, and may be subdivided into direct and indirect damages. Direct damages are those caused by physical contact of floodwater with damageable property. They include damages to commercial/industrial and residential building structures and contents, as well as damages to infrastructure services such as electricity and water supply. Indirect damages result from the interruption of community activities, including traffic flows, trade, industrial production, costs to relief agencies, evacuation of people and contents and clean up after the flood.

Generally, tangible damages are estimated in dollar values using survey procedures, interpretation of data from actual floods and research of government files.

The various factors included in the **intangible damage** category may be significant. However, these effects are difficult to quantify due to lack of data and the absence of an accepted method. Such factors may include:

- inconvenience
- isolation
- disruption of family and social activities
- anxiety, pain and suffering, trauma
- physical ill-health
- psychological ill-health.

D1.2 Scope of Investigation

In the following sections, tangible damages to residential, commercial / industrial and public properties have been estimated resulting from flooding at Wee Waa. Intangible damages have not been quantified. The threshold floods at which damages may commence to infrastructure and community assets have also been estimated, mainly from site inspection and interpretation of flood level data. However, there is no data available to allow a quantitative assessment of damages to be made to this category.

D1.3 Terminology

Definitions of the terms used in this Appendix are presented in **Chapter D8** which also summarises the value of Tangible Flood Damages.

D2 DESCRIPTION OF APPROACH

The damage caused by a flood to a particular property is a function of the depth of inundation above floor level and the value of the property and its contents. The warning time available for residents to take action to lift property above floor level also influences damages actually experienced. A spreadsheet model which has been developed by OEH for estimating residential damages and an in house spreadsheet model which has been developed for previous investigations of this nature for estimating commercial, industrial and public building damages were used to estimate damages on a property by property basis according to the type of development, the location of the property and the depth of inundation.

Using the results of the hydraulic model, a peak flood elevation for each event was interpolated at each property. The interpolated property flood levels were input to the spreadsheet models which also contained property characteristics and depth-damage relationships. The depth of above-floor inundation was computed as the difference between the interpolated flood level and the floor elevation at each property. The elevations of building floors were assessed by adding the height of floor above a representative natural surface within the allotment (as estimated by visual inspection) to the natural surface elevation determined from LiDAR survey data. The type of structure and potential for property damage were also assessed during the visual inspection.

The depth-damage curves for residential damages were determined using procedures described in *Guideline No. 4*. Damage curves for other categories of development (commercial and industrial, public buildings) were derived from previous floodplain management investigations.

Damages to the non-residential sector depend on the nature of the enterprise, the depth of inundation over the floor area and the time available for owners to take action to mitigate losses to contents. A spreadsheet model was used which was similar to the residential model in terms of both surveyed and estimated floor level and estimation of depths of inundation, but used typical unit damage data which had been adopted in similar studies in NSW in recent years.

It should be understood that this approach is not intended to identify individual properties liable to flood damages and the value of damages in individual properties, even though it appears to be capable of doing so. The reason for this caveat lies in the various assumptions used in the procedure, the main ones being:

- the assumption that computed water levels and topographic data used to define flood extents are exact and without any error;
- the assumption that the water levels as computed by the hydraulic model are not subject to localised influences;
- the estimation of property floor levels by visual inspection rather than by formal field survey;
- the use of "average" stage-damage relationships, rather than a unique relationship for each property;
- the uncertainties associated with assessing appropriate factors to convert *potential damages* to *actual flood damages* experienced for each property after residents have taken action to mitigate damages to contents.

The consequence of these assumptions is that some individual properties may be inappropriately classified as flood liable, while others may be excluded. Nevertheless, when applied over a broad area these effects would tend to cancel, and the resulting estimates of overall damages, would be expected to be reasonably accurate.

For the above reasons, the information contained in the spreadsheets used to prepare the estimates of flood damages for the catchments should not be used to provide information on the depths of above-floor inundation of individual properties.

D3 SOURCES OF DATA

D3.1 General

To estimate A*verage Annual Flood Damages* for a specific area it is necessary to estimate the damages for several floods of different magnitudes, i.e. of different frequencies, and then to integrate the area beneath the damage – frequency curve computed over the whole range of frequencies up to the PMF. To do this, it is necessary to have data on the damages sustained by all types of property over the likely range of inundation. There are several ways of doing this:

- The ideal way would be to conduct specific damage surveys in the aftermath of a range of floods, preferably immediately after each. An example approaching this ideal is the case of Nyngan where surveys were conducted in May 1990 following the disastrous flood of a month earlier (DWR, 1990). This approach would not be practicable at Wee Waa, as the damaging flooding in the town only occurred prior to the construction of the Town Levee in 1978.
- The second best way is for experienced loss adjusters to conduct a survey to estimate likely losses that would arise due to various depths of inundation. This approach is used from time to time, but it can add significantly to the cost of a floodplain management study (LMJ, 1985). It was not used for the present investigation.
- The third way is to use generalised data such as that published by CRES (Centre for Resource & Economic Studies, Canberra) and used in the Floodplain Management Study for Forbes (SKM, 1994). These kinds of data are considered to be suitable for generalised studies, such as broad regional studies. They are not considered to be suitable for use in specific areas, unless none of the other approaches can be satisfactorily applied.
- The fourth way is to adapt or transpose data from other flood liable areas. This was the approach used for the present study. As mentioned, the *Guideline No 4* procedure was adopted for the assessment of residential damages. The approach was based on data collected following major flooding in Katherine in 1998, with adjustments to account for changes in values due to inflation, and after taking into account the nature of development and flooding patterns in the study area. The data collected during site inspection in the flood liable areas assisted in providing the necessary adjustments. Commercial and industrial damages were assessed via reference to recent floodplain management investigations undertaken by Lyall and Associates of a similar nature to the present study.

D3.2 Property Data

The properties were divided into three categories: residential, commercial/industrial and public buildings.

For residential properties, the data used in the damages estimation included:

- the location/address of each property
- an assessment of the type of structure
- natural surface level
- floor level

For commercial/industrial and public properties, the required data included:

- the location of each property
- the nature of each enterprise
- an estimation of the floor area
- natural surface level
- floor level

The property information was used to classify the commercial and public developments into categories (i.e. high, medium or low value properties) which relate to the magnitude of likely flood damages.

Properties lying along the Major Overland Flow paths were included in the database. The total number of residential, commercial, industrial and public properties is shown in **Table D3.1**.

TABLE D3.1
NUMBER OF PROPERTIES INCLUDED IN DAMAGES DATABASE

Development Type	Number of Properties
Residential	707
Commercial / Industrial	135
Public	42
Total	884

D3.3 Flood Levels Used in the Analysis

Damages were computed for the design flood levels determined from the hydraulic model that was set up as part of the present investigation (refer **Appendix B** for details). Damages resulting from both local stormwater runoff and riverine flooding were computed for Wee Waa.

In the case of the damages arising from local stormwater runoff, the following three scenarios were assessed:

- No river flooding and gravity drainage of the protected area via the fourteen (14) penstock gated stormwater drainage pipes that control ponding levels behind the Town Levee (**Damage Scenario 1**).
- Pumping of stormwater runoff to the river side of the Town Levee via the six (6) permeant pumps and assuming the fourteen (14) penstock gates are in their closed position and it is not overtopped (**Damage Scenario 2**).
- Failure of the six (6) permanent pumps to operate during a storm event and assuming the fourteen (14) penstock gates are in their closed position and the Town Levee is not overtopped (**Damage Scenario 3**).

In the case of the damages arising from riverine flooding, the following two scenarios were assessed:

- No coincident rainfall over Wee Waa during river flooding (**Damage Scenario 4**).
- No coincident rainfall over Wee Waa during river flooding that causes a partial failure of the Town Levee (**Damage Scenario 5**).

For the purposes of assessing damages, the 10% AEP was adopted as the "threshold" flood at which damages commence in Wee Waa. While not modelled, a Namoi River flood with a 0.1% AEP was assumed to represent the threshold for overtopping of the Town Levee. Flood damages for this event were computed assuming floodwater would pond to the height of the low point in the Town Levee which has an elevation of about RL 192.4 m AHD.

D4 RESIDENTIAL DAMAGES

D4.1 Damage Functions

The procedures identified in *Guideline No 4* allow for the preparation of a depth versus damage relationship which incorporates structural damage to the building, damage to internals and contents, external damages and clean-up costs. In addition, there is the facility for including allowance for accommodation costs and loss of rent. Separate curves are computed for three residential categories:

- Single storey slab on ground construction
- Single storey elevated floor
- Two storey residence

The level of flood awareness and available warning time are taken into account by factors which are used to reduce "potential" damages to contents to "actual" damages. "Potential" damages represent losses likely to be experienced if no action were taken by residents to mitigate impacts. A reduction in the potential damages to "actual" damages is usually made to allow for property evacuation and raising valuables above floor level, which would reduce the damages actually experienced. The ability of residents to take action to reduce flood losses is mainly limited to reductions in damages to contents, as damages to the structure and clean-up costs are not usually capable of significant mitigation.

The reduction in damages to contents is site specific, being dependent on a number of factors related to the time of rise of floodwaters, the recent flood history and flood awareness of residents and emergency planning by the various Government Agencies (BoM and NSW SES).

While there is a well developed and tested flood warning system for the Namoi River operated by BoM, as well as detailed response procedures incorporated in the *Narrabri Local Flood Plan, 2015* developed by NSW SES which are implemented during flood alerts, actions taken by residents and business owners are unlikely to significantly reduce flood damages resulting from an overtopping event (i.e. because depths of inundation would be too great and they are unlikely to relocate contents to another town or remote evacuation centre during a flood event).

Flooding due to local stormwater runoff is "flash flooding" in nature with a time of rise generally limited to less than one hour. While the duration of peak flooding would be similarly short in the absence of riverine flooding, stormwater could be forced to pond for an extended period of time if river levels are elevated and the pumps are in operation. While Council maintains several truck mounted pumps which are used to reduce depths of ponding in several problem areas, these measures are only implemented after a heavy rainfall event. Consequently, there would be very limited time in advance of a storm event in which to warn residents and for them to take action to mitigate flood losses.

Table D4.1 over sets out the parameters and resulting factors that were adopted for converting potential to actual damages after taking into account the differences between the rate of rise and duration of inundation of local stormwater runoff and riverine flooding.

TABLE D4.1
DAMAGE ADJUSTMENT FACTORS/PARAMETERS FOR RESIDENTIAL DEVELOPMENT SUBJECT TO RIVERINE FLOODING AND LOCAL STORMWATER RUNOFF

Property Damage	Parameter/Factor	Local Stormwater Runoff	Riverine Flooding
Building	Typical Duration of Immersion (hours)	36	168
	Building Damage Repair Limitation Factor	1.0	1.0
	Total Building Adjustment Factor	2.02	3.04
Contents	Contents Damage Repair Limitation Factor	0.9	0.9
	Level of Flood Awareness	Low	High
	Effective Warning Time	0	24[(1)]
	Typical Table/Bench Height (TTBH) (m)	0.9	0.9
	Total Contents Adjustment Factor (Above-Floor Depth <= TTBH)	1.58	0.7
	Total Contents Adjustment Factor (Above-Floor Depth > TTBH)	1.58	1.58

1. Maximum value permitted in damages spreadsheet.

Table D4.2 shows total flood damages estimated for the three classes of residential property using the procedures identified in *Guideline No. 4*, for typical depths of above-floor inundation of 0.3 m and 1.0 m. A typical ground floor area of 240 m^2 was adopted for the assessment. The values in **Table D4.2** allow for damages to buildings and contents, as well as external damages and provision for alternative accommodation.

TABLE D4.2
DAMAGES TO RESIDENTIAL PROPERTIES

Type of Residential Construction	0.3 m Depth of Inundation Above Floor Level		1.0 m Depth of Inundation Above Floor Level	
	Local Stormwater Runoff	Riverine Flooding	Local Stormwater Runoff	Riverine Flooding
Single Storey Slab on Ground	$87,868	$71,294	$108,451	$126,702
Single Storey High Set	$79,374	$106,916	$120,605	$144,932
Double Storey	$55,562	$49,906	$75,915	$88,691

Note: These values allow for damages to buildings and contents, as well as external damages and provision for alternative accommodation.

D4.2 Total Residential Damages

Tables D4.3 and **D4.4** at the end of this Chapter summarise residential damages in Wee Waa resulting from local stormwater runoff and riverine flooding, respectively.

The occurrence of a 1% AEP storm event at Wee Waa in the absence of riverine flooding would result in one dwelling experiencing above-floor inundation (**Damage Scenario 1**). The number of dwellings that would experience above-floor inundation would increase to four should a 1% AEP storm event occur when the fourteen (14) penstock gates are closed due to elevated water levels in the river and the pumps are running at full capacity (**Damage Scenario 2**). The upper limit of potential above-floor inundation should all six permanent pumps not be operational during a 1% AEP storm event is limited to 15 dwellings (**Damage Scenario 3**).

The total residential flood damage at the 1% AEP level of flooding due to local stormwater runoff would generally be between about $0.45 Million (**Damage Scenario 1**) and $0.64 Million (**Damage Scenario 2**), but could be as high as about $1.48 Million (**Damage Scenario 3**) should the aforementioned pumps are not operational during the burst of flood producing rain.

During a riverine flood which just overtops the Town Levee and causes equalisation of water levels on both sides of the earthen embankment, a total of 594 dwellings would experience above-floor inundation, with the total residential damage in Wee Waa amounting to about $65 Million (**Damage Scenario 4**). A partial failure of the Town Levee during a 1% AEP riverine flood would also result in similar residential flood damages at Wee Waa (**Damage Scenario 5**).

An Extreme Flood on the Namoi River would result in all but seven out of a total of the 703 dwellings in Wee Waa experiencing above-floor inundation, with the upper limit of potential residential flood damage estimated to be about $94 million.

TABLE D4.3
RESIDENTIAL FLOOD DAMAGES – LOCAL STORMWATER RUNOFF ONLY

Design Flood Event (% AEP)	Damage Scenario 1			Damage Scenario 2			Damage Scenario 3		
	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)
	Flood Affected	Flood Damaged		Flood Affected	Flood Damaged		Flood Affected	Flood Damaged	
5	17	1	0.31	18	1	0.33	31	2	0.55
2	20	1	0.36	24	1	0.42	45	6	0.96
1	26	1	0.45	33	4	0.64	55	15	1.48
0.5	31	2	0.55	40	6	0.84	61	19	2.00
0.2	50	6	1.00	60	14	1.52	73	25	2.39
PMF	215	119	11.72	221	137	13.77	221	137	13.77

TABLE D4.4
RESIDENTIAL FLOOD DAMAGES - RIVERINE FLOODING ONLY

Design Flood Event (% AEP)	Damage Scenario 4			Damage Scenario 5		
	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)
	Flood Affected	Flood Damaged		Flood Affected	Flood Damaged	
5	0	0	0	674	560	59.31
2	0	0	0	678	585	62.65
1	0	0	0	681	595	64.08
0.5	0	0	0	681	596	64.18
0.2	0	0	0	682	601	64.89
0.1[1]	681	594	64.50	-	-	-
PMF	703	696	94.27	703	696	94.27

1. Approximate AEP when overtopping of the Town Levee first occurs.

D5 COMMERCIAL / INDUSTRIAL DAMAGES

D5.1 Direct Commercial / Industrial Damages

The method used to calculate damages requires each property to be categorised in terms of the following:

- damage category
- floor area
- floor elevation

The damage category assigned to each enterprise may vary between "low", "medium" or "high", depending on the nature of the enterprise and the likely effects of flooding. Damages also depend on the floor area.

It has recently been recognised following the 1998 flood in Katherine that previous investigations using stage-damage curves contained in proprietary software tends to seriously underestimate true damage costs. OEH are currently researching appropriate damage functions which could be adopted in the estimation of commercial and industrial categories as they have already done with residential damages. However, these data were not available for the present study.

On the basis of previous investigations, the following typical damage rates are considered appropriate for potential external and internal damages and clean-up costs for both commercial and industrial properties. They are indexed to a depth of inundation of 2 metres. At floor level and 1.2 m inundation, zero and 70% of these values respectively were assumed to occur:

Low value enterprise	\$280/m^2	(e.g. Commercial: small shops, cafes, joinery, public halls. Industrial: auto workshop with concrete floor and minimal goods at floor level, Council or Government Depots, storage areas.)
Medium value enterprise	\$420/m^2	(e.g. Commercial: food shops, hardware, banks, professional offices, retail enterprises, with furniture/fixtures at floor level which would suffer damage if inundated. Industrial: warehouses, equipment hire.)
High value enterprise	\$650/m^2	(e.g. Commercial: electrical shops, clothing stores, bookshops, newsagents, restaurants, schools, showrooms and retailers with goods and furniture, or other high value items at ground or lower floor level. Industrial: service stations, vehicle showrooms, smash repairs.)

The factor for converting potential to actual damages depends on a range of variables such as the available warning time, flood awareness and the depth of inundation. Given sufficient warning time, a well prepared business will be able to temporarily lift property above floor level. However, unless property is actually moved to flood free areas, floods which result in a large depth of inundation, will cause considerable damage to stock and contents.

For the present study, the above-floor potential damages were converted to actual damages using a multiplier which ranged between 0.5 and 0.8 depending on the depth of inundation above the floor. The multiplier of 0.5 was adopted to convert potential to actual damages for depths of inundation up to 1.2 m, increasing to 0.8 for greater depths.

D5.2 Indirect Commercial and Industrial Damages

Indirect commercial and industrial damages comprise costs of removal of goods and storage, loss of trading profit and loss of business confidence.

Disruption to trade takes the following forms:

- The loss through isolation at the time of the flood when water is in the business premises or separating clients and customers. The total loss of trade is influenced by the opportunity for trade to divert to an alternative source. There may be significant local loss but due to the trade transfer this may be considerably reduced at the regional or state level.
- In the case of major flooding, a downturn in business can occur within the flood affected region due to the cancellation of contracts and loss of business confidence. This is in addition to the actual loss of trading caused by closure of the business by flooding.

Loss of trading profit is a difficult value to assess and the magnitude of damages can vary depending on whether the assessment is made at the local, regional or national level. Differences between regional and national economic effects arise because of transfers between the sectors, such as taxes, and subsidies such as flood relief returned to the region.

Some investigations have lumped this loss with indirect damages and have adopted total damage as a percentage of the direct damage. In other cases, loss of profit has been related to the gross margin of the business, i.e. turnover less average wages. The former approach has been adopted in this present study. Indirect damages have been taken as 50% of direct actual damages. A clean-up cost of $15/metre^2 of floor area of each flooded property was also included.

D5.3 Total Commercial and Industrial Damages

Tables D5.1 and **D5.2** at the end of this Chapter summarise commercial damages in Wee Waa resulting from local stormwater runoff and riverine flooding, respectively.

The occurrence of a 1% AEP storm event at Wee Waa in the absence of riverine flooding would result in one commercial/industrial building experiencing above-floor inundation (**Damage Scenario 1**). The number of buildings that would experience above-floor inundation would increase to three should a 1% AEP storm event occur when the fourteen (14) penstock gates are closed due to elevated water levels in the river and the pumps are running at full capacity (**Damage Scenario 2**). The upper limit of potential above-floor inundation should all six (6) permanent pumps not be operational during a 1% AEP storm event is limited to 15 commercial/industrial buildings (**Damage Scenario 3**).

The total commercial/industrial flood damage at the 1% AEP level of flooding due to local stormwater runoff would generally be between about $0.1 Million (**Damage Scenario 1**) and $0.23 Million (**Damage Scenario 2**), but could be as high as about $0.92 Million (**Damage**

Scenario 3) should the aforementioned pumps are not operational during the burst of flood producing rain.

During a riverine flood which just overtops the Town Levee and causes equalisation of water levels on both sides of the earthen embankment, a total of 126 buildings would experience above-floor inundation, with the total commercial/industrial damage in Wee Waa amounting to about $51 Million (**Damage Scenario 4**). A partial failure of the Town Levee during a 1% AEP riverine flood would also result in similar commercial/industrial flood damages at Wee Waa (**Damage Scenario 5**).

An Extreme Flood on the Namoi River would result in all but three out of a total of the 135 buildings in Wee Waa experiencing above-floor inundation, with the upper limit of potential commercial/ industrial flood damage estimated to be about $64 million.

TABLE D5.1
COMMERCIAL/INDUSTRIAL FLOOD DAMAGES – LOCAL STORMWATER RUNOFF ONLY

Design Flood Event (% AEP)	Damage Scenario 1			Damage Scenario 2			Damage Scenario 3		
	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)
	Flood Affected	Flood Damaged		Flood Affected	Flood Damaged		Flood Affected	Flood Damaged	
5	3	0	0.05	3	0	0.05	14	3	0.31
2	4	0	0.06	5	2	0.12	18	9	0.54
1	6	1	0.10	10	3	0.23	23	15	0.92
0.5	8	2	0.18	20	7	0.47	28	17	1.91
0.2	20	7	0.47	25	14	0.94	34	21	4.11
PMF	54	46	10.11	54	48	11.76	54	48	11.76

TABLE D5.2
COMMERCIAL/INDUSTRIAL FLOOD DAMAGES - RIVERINE FLOODING ONLY

Design Flood Event (% AEP)	Damage Scenario 4			Damage Scenario 5		
	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)
	Flood Affected	Flood Damaged		Flood Affected	Flood Damaged	
5	0	0	0	133	123	48.51
2	0	0	0	135	126	49.62
1	0	0	0	135	126	50.08
0.5	0	0	0	135	126	50.24
0.2	0	0	0	135	129	50.79
0.1(1)	129	126	50.84	-	-	-
PMF	135	135	63.63	135	135	63.63

1. Approximate AEP when overtopping of the Town Levee first occurs.

D6 DAMAGES TO PUBLIC BUILDINGS

D6.1 Direct Damages – Public Buildings

Included under this heading are government buildings, churches, swimming pools and parks. Damages were estimated individually on an area basis according to the perceived value of the property. Potential internal damages were indexed to a depth of above-floor inundation of 2 metres as shown below. At floor level and 1.2 metres depth of inundation, zero and 70% of these values respectively were assumed to occur.

Low value	$280/m^2$	
Medium value	$420/m^2$	(e.g. council buildings, NSW SES HQ, fire station)
High value	$650/m^2$	(e.g. schools)

These values were obtained from the Nyngan Study (DWR, 1990), as well as commercial data presented in the Forbes Water Studies report (WS, 1992). External and structural damages were taken as 4 and 10% of internal damages respectively.

D6.2 Indirect Damages – Public Buildings

A value of $15/metre^2$ was adopted for the clean-up of each property. This value is based on results presented in the Nyngan Study and adjusted for inflation. Total "welfare and disaster" relief costs were assessed as 50% of the actual direct costs.

D6.3 Total Damages – Public Buildings

Tables D6.1 and **D6.2** at the end of this Chapter summarise public damages in Wee Waa resulting from local stormwater runoff and riverine flooding, respectively.

The occurrence of a 1% AEP storm event at Wee Waa would not result in any public buildings experiencing above-floor inundation, even if all six (6) permanent pumps were to be inoperable during the storm event.

The total damage to public buildings at the 1% AEP level of flooding due to local stormwater runoff is only about $0.03 Million and is a function of the limited clean-up costs.

During a riverine flood which just overtops the Town Levee and causes equalisation of water levels on both sides of the earthen embankment, a total of 33 buildings would experience above-floor inundation, with the total public damage in Wee Waa amounting to about $2.43 Million (**Damage Scenario 4**). By comparison, a partial failure of the Town Levee during a 1% AEP riverine flood would result in slightly less public flood damages at Wee Waa (**Damage Scenario 5**).

An Extreme Flood on the Namoi River would result in all 42 public buildings in Wee Waa experiencing above-floor inundation, with the upper limit of potential flood damage estimated to be about $5.38 million.

TABLE D6.1
PUBLIC FLOOD DAMAGES – LOCAL STORMWATER RUNOFF ONLY

Design Flood Event (% AEP)	Damage Scenario 1			Damage Scenario 2			Damage Scenario 3		
	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)
	Flood Affected	Flood Damaged		Flood Affected	Flood Damaged		Flood Affected	Flood Damaged	
5	2	0	0.03	2	0	0.03	2	0	0.03
2	2	0	0.03	2	0	0.03	2	0	0.03
1	5	0	0.03	4	0	0.03	5	0	0.03
0.5	5	0	0.03	5	0	0.05	5	0	0.03
0.2	5	0	0.05	5	0	0.05	5	0	0.05
PMF	19	10	0.46	20	13	0.61	20	13	0.61

TABLE D6.2
PUBLIC FLOOD DAMAGES - RIVERINE FLOODING ONLY

Design Flood Event (% AEP)	Damage Scenario 4			Damage Scenario 5		
	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)
	Flood Affected	Flood Damaged		Flood Affected	Flood Damaged	
5	0	0	0	36	29	2.12
2	0	0	0	37	30	2.28
1	0	0	0	37	32	2.38
0.5	0	0	0	37	32	2.39
0.2	0	0	0	38	33	2.42
0.1[(1)]	42	33	2.43	-	-	-
PMF	42	42	5.38	42	42	5.38

1. Approximate AEP when overtopping of the Town Levee first occurs.

D7 DAMAGES TO INFRASTUCTURE AND COMMUNITY ASSETS

No data were available regarding damage of community infrastructure during historic flood events. However, a qualitative matrix of the effects of flooding on important assets in Wee Waa is presented in **Table D7.1**.

TABLE D7.1
QUALITATIVE EFFECTS OF FLOODING ON
INFRASTRUCTURE AND COMMUNITY ASSETS(1)

Damage Sector	Design Flood Event (% AEP)					
	5	2	1	0.5	0.2	Extreme
Electricity	O	O	O	O	O	X
Telephone	X	X	X	X	X	X
Roads	X	X	X	X	X	X
Bridges	X	X	X	X	X	X
Sewerage	X	X	X	X	X	X
Water Supply	O	O	O	X	X	X
Parks and Gardens	X	X	X	X	X	X

1. Riverine flooding only

Notes: O = No significant damages likely to be incurred.
X = Some damages likely to be incurred.

D8 SUMMARY OF TANGIBLE DAMAGES

D8.1 Tangible Damages

From **Tables D8.1** and **D8.2** at the end of this chapter, considerable flood damages would only be expected in Wee Waa during very rare and extreme riverine floods, or due to a partial failure of the Town Levee. The relatively large flood damages is due to the rapid inundation of Wee Waa during an overtopping or partial failure event, whereby existing buildings would generally be inundated to depths exceeding 1.5 m.

D8.2 Definition of Terms

Average Annual Damages (also termed "expected damages") are determined by integrating the area under the damage-frequency curve. They represent the time stream of annual damages, which would be expected to occur on a year by year basis over a long duration.

Using an appropriate discount rate, average annual damages may be expressed as an equivalent "*Present Worth Value"* of damages and used in the economic analysis of potential flood management measures.

A flood management scheme which has a design 1% AEP level of protection, by definition, will eliminate damages up to this level of flooding. If the scheme has no mitigating effect on larger floods, then these damages represent the benefits of the scheme expressed on an average annual basis and converted to the *Present Worth Value* via the discount rate.

Under current NSW Treasury guidelines, economic analyses are carried out assuming a 50 year economic life for projects and discount rates of 7% pa. (best estimate) and 11% and 4% pa. (sensitivity analyses).

D8.3 Average Annual Damages

The *Average Annual Damages* in Wee Waa for all flood events up to the PMF in the case of local stormwater runoff and the Extreme Flood in the case of riverine flooding are shown in **Tables D8.3 and D8.4**, respectively. Note that values have been quoted to two decimal places to highlight the relatively small recurring damages in the town.

D8.4 Present Worth of Damages

The *Present Worth Value* of damages likely to be experienced in Wee Waa local stormwater runoff and riverine flooding for events up to the 1% AEP and PMF/Extreme Flood events, a 50 year economic life and discount rates of 4, 7 and 11 per cent are shown in **Tables D8.5** and **D8.6**.

For a discount rate of 7% pa and an economic life of 50 years, the *Present Worth Value* of damages for all storm events at Wee Waa up to 1% AEP in intensity is between about $0.8 Million and $1.1 Million. Therefore, one or more stormwater drainage upgrade schemes costing up to these amounts could be economically justified provided they eliminated damages in Wee Waa for all storms up to this level.

While the Town Levee is not overtopped during a 1% AEP Namoi River flood, its IFF level is below the level of a 5% AEP flood. The *Present Worth Value* of damages for all riverine floods between the IFF and the 1% AEP event assuming a partial failure of the Town Levee is about $100 Million. This is the amount that could be spent upgrading the Town Levee to ensure that it is geotechnically stable, free of defects and incorporates the required 1 m freeboard to the 1% AEP flood.

TABLE D8.1
TOTAL FLOOD DAMAGES – LOCAL STORMWATER RUNOFF ONLY - $ MILLION

Design Flood Event (%AEP)	Damage Scenario 1				Damage Scenario 2				Damage Scenario 3			
	Residential	Commercial	Public	Total	Residential	Commercial	Public	Total	Residential	Commercial	Public	Total
5	0.00	0.00	0.00	0.00	0.33	0.05	0.03	0.41	0.55	0.31	0.03	0.89
2	0.31	0.05	0.03	0.39	0.42	0.12	0.03	0.57	0.96	0.54	0.03	1.53
1	0.36	0.06	0.03	0.45	0.64	0.23	0.03	0.90	1.48	0.92	0.03	2.43
0.5	0.45	0.10	0.03	0.58	0.84	0.47	0.05	1.36	2.00	1.91	0.03	3.94
0.2	0.55	0.18	0.03	0.76	1.52	0.94	0.05	2.51	2.39	4.11	0.05	6.55
PMF	1.00	0.47	0.05	1.52	13.77	11.76	0.61	26.14	13.77	11.76	0.61	26.14

TABLE D8.2
TOTAL FLOOD DAMAGES - RIVERINE FLOODING ONLY - $ MILLION

Design Flood Event (%AEP)	Damage Scenario 4				Damage Scenario 5			
	Residential	Commercial	Public	Total	Residential	Commercial	Public	Total
5	0	0	0	0	59.31	48.51	2.12	109.94
2	0	0	0	0	62.65	49.62	2.28	114.55
1	0	0	0	0	64.08	50.08	2.38	116.54
0.5	0	0	0	0	64.18	50.24	2.39	116.81
0.2	0	0	0	0	64.89	50.79	2.42	118.10
0.1	64.5	50.84	2.43	117.77	-	-	-	-
Extreme Flood	94.27	63.63	5.38	163.28	94.27	63.63	5.38	163.28

1. Approximate AEP when overtopping of the Town Levee first occurs.

TABLE D8.3
AVERAGE ANNUAL DAMAGES – LOCAL STORMWATER RUNOFF ONLY - $ MILLION

Design Flood Event (%AEP)	Damage Scenario 1				Damage Scenario 2				Damage Scenario 3			
	Residential	Commercial	Public	Total	Residential	Commercial	Public	Total	Residential	Commercial	Public	Total
5	0.01	0	0	0.01	0.01	0	0	0.01	0.01	0.01	0	0.02
2	0.02	0	0	0.02	0.02	0	0	0.02	0.04	0.02	0	0.06
1	0.02	0	0	0.02	0.02	0.01	0	0.03	0.05	0.03	0	0.08
0.5	0.02	0	0	0.02	0.03	0.01	0	0.04	0.06	0.04	0	0.10
0.2	0.03	0.01	0	0.04	0.03	0.01	0	0.04	0.06	0.04	0	0.10
PMF	0.04	0.02	0	0.06	0.05	0.02	0	0.07	0.08	0.06	0	0.14

TABLE D8.4
AVERAGE ANNUAL DAMAGES - RIVERINE FLOODING ONLY - $ MILLION

Design Flood Event (%AEP)	Damage Scenario 4				Damage Scenario 5			
	Residential	Commercial	Public	Total	Residential	Commercial	Public	Total
5	0	0	0	0	1.48	1.21	0.05	2.74
2	0	0	0	0	3.31	2.68	0.12	6.11
1	0	0	0	0	3.95	3.18	0.14	7.27
0.5	0	0	0	0	4.27	3.43	0.15	7.85
0.2	0	0	0	0	4.46	3.59	0.16	8.21
0.1	0.03	0.03	0	0.06	-	-	-	-
Extreme Flood	0.10	0.08	0	0.18	4.63	3.70	0.17	8.50

1. Approximate AEP when overtopping of the Town Levee first occurs.

TABLE D8.5
PRESENT WORTH VALUE OF DAMAGES - LOCAL STORMWATER RUNOFF ONLY - $ MILLION

Discount Rate (%)	Damage Scenario 1		Damage Scenario 2		Damage Scenario 3	
	All Floods Up to 1% AEP	All Floods Up to PMF	All Floods Up to 1% AEP	All Floods Up to PMF	All Floods Up to 1% AEP	All Floods Up to PMF
4	0.4	1.3	0.6	1.5	1.7	3.0
7	0.3	0.8	0.4	1.0	1.1	1.9
11	0.2	0.5	0.3	0.6	0.7	1.3

TABLE D8.6
PRESENT WORTH VALUE OF DAMAGES - RIVERINE FLOODING ONLY - $ MILLION

Discount Rate (%)	Damage Scenario 4		Damage Scenario 5	
	All Floods Up to 1% AEP	All Floods Up to PMF	All Floods Up to 1% AEP	All Floods Up to PMF
4	0.0	3.9	156.3	182.1
7	0.0	2.5	100.3	116.9
11	0.0	1.6	65.4	76.2

D9 REFERENCES

DECC (Department of Environment and Climate Change, NSW), 2007. ***"Floodplain Management Guideline No 4. Residential Flood Damages"***.

DWR (Department of Water Resources, NSW), 1990. ***"Nyngan April 1990 Flood Investigation"***.

LMJ (Lyall, Macoun and Joy, Willing and Partners Pty Ltd), 1985. ***"Camden Floodplain Management Study"***.

SKM (Sinclair Knight Merz), 1994. ***"Forbes Floodplain Management Report and Draft Floodplain Management Plan, Volume 1"***.

WS (Water Studies), 1986. ***"The Sydney Floods of August 1986"***, Volume I Residential Flood Damage Survey, Report prepared for CRCE Water Studies Pty Ltd for the NSW PWD.

WS (Water Studies), 1992. ***"Forbes Flood Damage Survey, August 1990 Flood"***.

APPENDIX E

LEVEE FREEBOARD ANALYSIS

TABLE OF CONTENTS

FIGURES (BOUND IN VOLUME 2)

SYNOPSIS

This Appendix deals with the derivation of the freeboard allowance which has been incorporated into the design of the Wee Waa Town Levee. As there are presently no formal freeboard standards in Australia, the freeboard requirements for the Town Levee have been based on a joint probability analysis that consisted of an assessment of the possible increase in peak flood levels associated with a range of design variables and their associated probabilities of occurrence.

Design variables that have been incorporated in the derivation of the freeboard for the Wee Waa Town Levee comprised the following:

- increases in peak flood levels due to wind action;
- increases in peak flood levels due to wave action;
- increases in peak flood levels due to local water surge;
- uncertainties in the design flood level estimates due to inaccuracies in the LiDAR survey data and possible variations in key parameters such as hydraulic roughness;
- post-construction settlement of the levee;
- reduction in the crest level due to defects; and
- inaccuracies in peak flood levels as a result of future climate change.

The total freeboard allowance was assessed at four locations along the Town Levee as shown on **Figure E1.1**. **Table ES1** over gives a breakdown of the freeboard allowance which has been derived for each of the design variables and their associated probabilities of occurrence. Based on the findings of the assessment, a freeboard allowance of 1 m has been adopted in the design of the Town Levee.

TABLE ES1
FREEBOARD ALLOWANCE AT WEE WAA[1]

Design Variable	Probability of Occurrence (%)	Location A		Location B		Location C		Location D	
		Maximum Allowance (m)	Joint Probability Allowance (m)	Maximum Allowance (m)	Joint Probability Allowance (m)	Maximum Allowance (m)	Joint Probability Allowance (m)	Maximum Allowance (m)	Joint Probability Allowance (m)
Wave Action (Run-up)	50	0.48	0.24	0.41	0.21	0.38	0.19	0.47	0.23
Wave Action (Set-up)	50	0.30	0.15	0.10	0.05	0.07	0.04	0.09	0.04
Local Water Surge	50	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Uncertainties in Peak Flood Level Estimates	100	0.42	0.42	0.56	0.56	0.53	0.53	0.40	0.40
Levee Settlement	100	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Levee Defects	50	0.10	0.05	0.10	0.05	0.10	0.05	0.10	0.05
Future Climate Change	50	0.17	0.09	0.27	0.14	0.25	0.13	0.17	0.09
Total		**1.50**	**0.98**	**1.47**	**1.04**	**1.36**	**0.97**	**1.25**	**0.83**

1. Refer **Figure E1.1** for location where assessment relates.

E1. FREEBOARD COMPONENTS

E1.1 Wave Action

Where the levee face is exposed to a large expanse of flood water, windy conditions can generate significant waves. When superimposed on the design flood level, these waves may cause the levee to be overtopped.

There are two types of wave action to be considered when assessing this component of the freeboard allowance;

- *Wave Run-up* - When a wave generated over a certain fetch reaches an earth levee, it will run up the embankment based on its slope and surface roughness.
- *Wind Setup* – Wind blowing over a water surface exerts a horizontal shear force driving it in the direction of the wind, which results in a higher water level at the downwind end of the fetch.

The freeboard allowance for wave action is based on the Australian Wind Loading Standard – *AS/NSZ1170.2 (2002)* and guidelines for the estimation of wave run-up in *NSWPW (2010)* and *USDIBR (2012)*. The freeboard allowance for three locations with different approach winds and fetch length are shown below in **Table E1.1**.

TABLE E1.1
WAVE ACTION FREEBOARD ALLOWANCE

Location[(1)]	Effective Fetch Length (km)	Wind Direction	Design Wind Speed[(2)] (m/s)	Significant Wave Height (m)	Wave Run-up[(3)] (m)	Wind Setup (m)
A	3.19	North West	26	0.87	0.48	0.30
B	2.92	East	22	0.68	0.41	0.10
C	2.59	South East	22	0.64	0.38	0.07
D	2.96	West	27	0.87	0.47	0.09

1. Refer **Figure E1.1** for location where assessment relates.
2. Design wind speed taken from *AS/NZS1170.2, 2002*
3. Using embankment slope of 1V:2.5H assuming "rubble-mound slopes" (NSWPW, 2010)

E1.2 Local Water Surge

When the velocity and direction of flow changes abruptly, such as alongside a levee bank, local water levels can become elevated when compared to the broader water surface (commonly referred to as "water surge"). Flow velocities of between 0.2-0.5 m/s adjacent to the Town Levee were extracted from the TUFLOW model results and used to estimate local water surge. The local water surge at each location can be seen in **Table ES1**.

E1.3 Inaccuracies in Design Flood Level Estimates

Uncertainties in the determination of peak flood levels occur if there is doubt about any of the parameters used in the computation process. Confidence in the computed flood levels may be compromised by the following:

- *Model calibration* – A lack of historic flood data to enable the model to be calibrated for a flow which matches the design flood for the levee design (in this case the 1% AEP event). It is noted that the Flood Study TUFLOW model was originally calibrated to the February 1971, February 1984 and July 1998 flood events which had equivalent AEP's of between about 4 and 10 per cent, so estimates of peak flood levels reached by rarer events could be considered to have a greater error band.
- *Availability of detailed survey data* – LiDAR survey data was captured by LPI between February 2009 and June 2014 to a vertical accuracy of ±150 mm and horizontal accuracy of ±800 mm.
- *How accurately flood slope can be calculated given the available data* - The design flood levels were modelled in Namoi River TUFLOW using LiDAR levels sampled on a 40 m grid spacing along the alignment of the levee. The two-dimensional nature of the modelling coupled with the high level of detail used for the underlying topography means that the flood slope can be assessed with a high degree of certainty.
- *Degree of uncertainty in model parameters* – The model parameters adopted for design flood estimation may not reflect contemporaneous conditions at the time of an actual flood (e.g. rainfall losses and hydraulic roughness).

The above factors may result in the underestimation of either design flows or levels. Sensitivity analyses were undertaken to determine the increase in peak flood levels associated with a 20% increase in the 'best estimate' hydraulic roughness and a 30% increase in the peak 1% AEP flow. The computed vertical inaccuracies in the design flood level estimates based on the findings of the sensitivity analyses are given in **Table E1.2**, along with the stated vertical accuracy of the LiDAR survey data.

TABLE E1.2
INACCURACIES IN DESIGN FLOOD LEVEL ESTIMATES
1% AEP

Location[1]	Vertical Error in LiDAR (m)	Impact of 20% Increase in Hydraulic Roughness (m)	Impact of 30% Increase in Peak Flow Estimates (m)	Total (m)
A	0.15	0.10	0.17	0.42
B	0.15	0.14	0.27	0.56
C	0.15	0.13	0.25	0.53
D	0.15	0.08	0.17	0.40

1. Refer **Figure E1.1** for location where assessment relates.

E1.4 Levee Settlement

The existing earthen levee will be raised using material sourced from a local borrow pit, the location of which has yet to be determined. In most cases settlement of an earth embankment occurs post construction as a result of drying, shrinkage and cracking. As stated in the geotechnical report contained in **Appendix B**, a levee of up to 2.5 m height which is constructed of the clayey material sourced from the local borrow pit can be expected to have a maximum settlement of 20 mm.

E1.5 Defects in Levee

The structural integrity of a levee depends on its age, design, construction methodology, fill material and maintenance history. If any of these components are compromised then defects in the levee may cause it to fail. The following will mitigate the likelihood of defects occurring.

- *Design and Construction* – It is envisaged that the raised sections of levee will be designed with a 150 mm thick topsoil layer to allow vegetation to establish which reduces the risk of erosion by direct rainfall.
- *Maintenance* - A levee maintenance program will need to be developed and implemented by WSC in order to identify and repair any defects that may cause a progressive failure of the levee.

The risk of defects occurring in an earthen levee is reduced through the design and construction of a vegetated layer of topsoil and regular inspection and maintenance. Levees that are neglected should allow for an additional 500 mm freeboard to cater for defects. For the purpose of the freeboard assessment, it has been assumed that the Wee Waa Town Levee will be well maintained. Based on this assumption, a freeboard allowance for possible defects in the levee of only 100 mm has been adopted.

E1.6 Climate Change

OEH recommends that its guideline *Practical Considerations of Climate Change, 2007* be used as the basis for examining climate change induced increases in rainfall intensities in projects undertaken under the State Floodplain Management Program and the FDM. The guideline recommends that until more work is completed in relation to the climate change impacts on rainfall intensities, sensitivity analyses should be undertaken based on increases in rainfall intensities ranging between 10 and 30 per cent. On current projections the increase in rainfalls within the service life of developments or flood management measures is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit. Under present day climatic conditions, increasing the 1% AEP design rainfall intensities by 10 per cent would produce a 0.5% AEP flood; and increasing those rainfalls by 30 per cent would produce a 0.2% AEP event.

Along the alignment of the Town Levee, 1% AEP flood levels would be increased by up to 100 mm as a result of a 10 per cent increase in rainfall intensities and by up to 270 mm as a result of a 30 per cent increase in rainfall intensities. **Table ES1** shows the freeboard allowance which has been adopted for uncertainties in the peak flood level estimates due to potential increases in rainfall intensities linked with future climate change.

E2. FREEBOARD ALLOWANCE

E2.1 Joint Probability Analysis

The freeboard allowances set out in **Section E1** represent the maximum increases possible for each design variable. It is highly unlikely that these will compound along the Town Levee during a flood event, therefore each design variable is assigned a probability of occurrence in order to determine a factored freeboard allowance. As shown in **Table ES1**, the factored values are added together at each location to determine the total freeboard allowance along the Town Levee. The total freeboard allowance along the Town Levee ranges from 830 mm to 1040 mm. As such, a freeboard allowance of 1000 mm (or 1 m) has been adopted for the design of the Town Levee.

E3. REFERENCES

NSWG (New South Wales Government), 2005. "Floodplain Development Manual – The Management of Flood Liable Land"

U.S. Department of the Interior Bureau of Reclamation (USDIBR), Design Standard No. 13 – Embankment Dams, Chapter 6: Freeboard, 2012

Standards Australia, Australia/New Zealand standard 1170.2:2002, Structural design action, Part 2 Wind Actions, 2002

NSW Public Works (NSWPW), Wagga Wagga Levee Upgrade – Flood Freeboard, 2010

PJ Hawkes, Department of Environment, Food and Rural Affairs (UK), Use of Joint Probability Methods in Flood Management – A Guide to Best Practice, 2005

Chris Stanton, Stanton Associates, Flood Levee Design based on Progressive Failure Probability

NARRABRI SHIRE COUNCIL

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

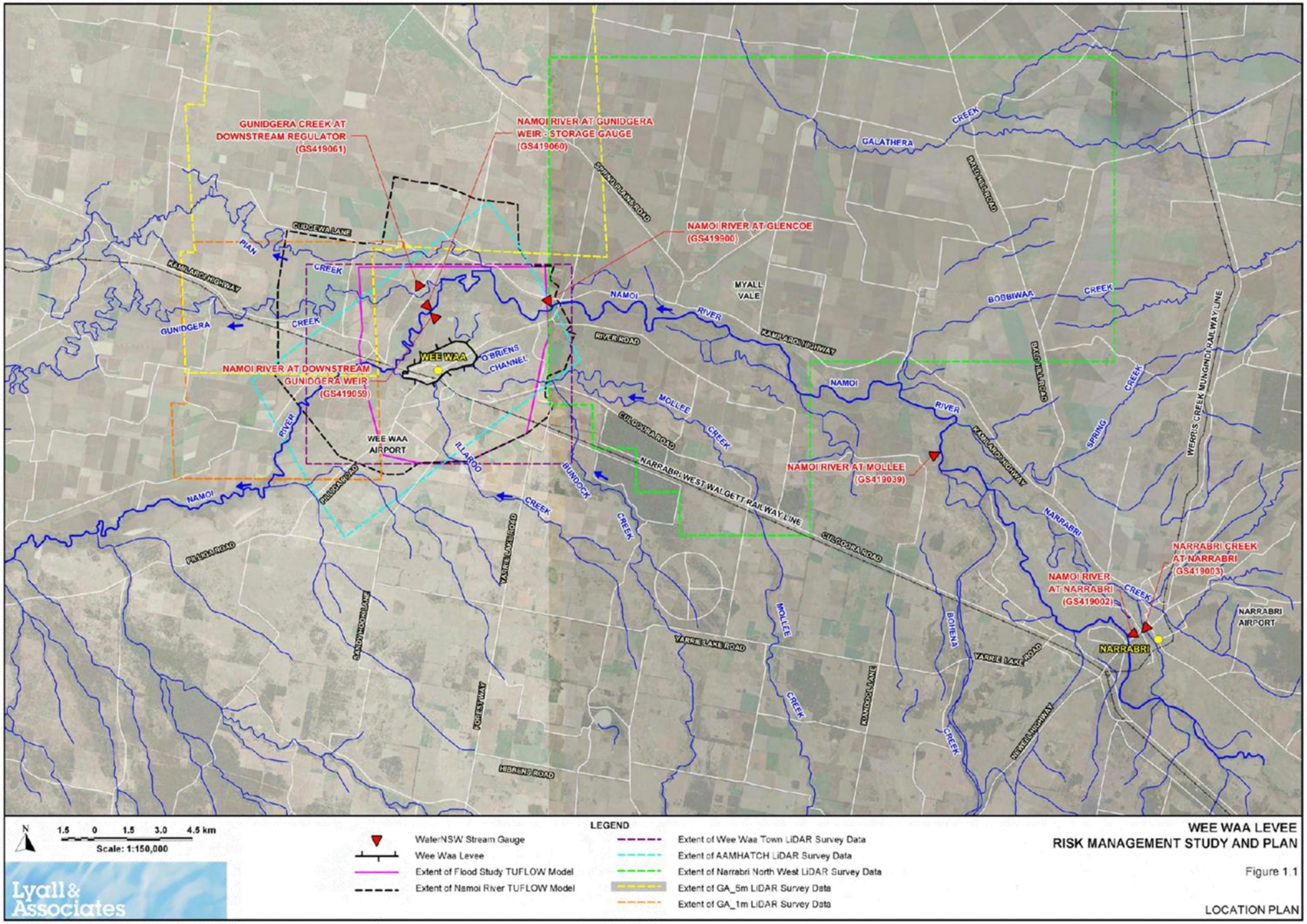
AUGUST 2019

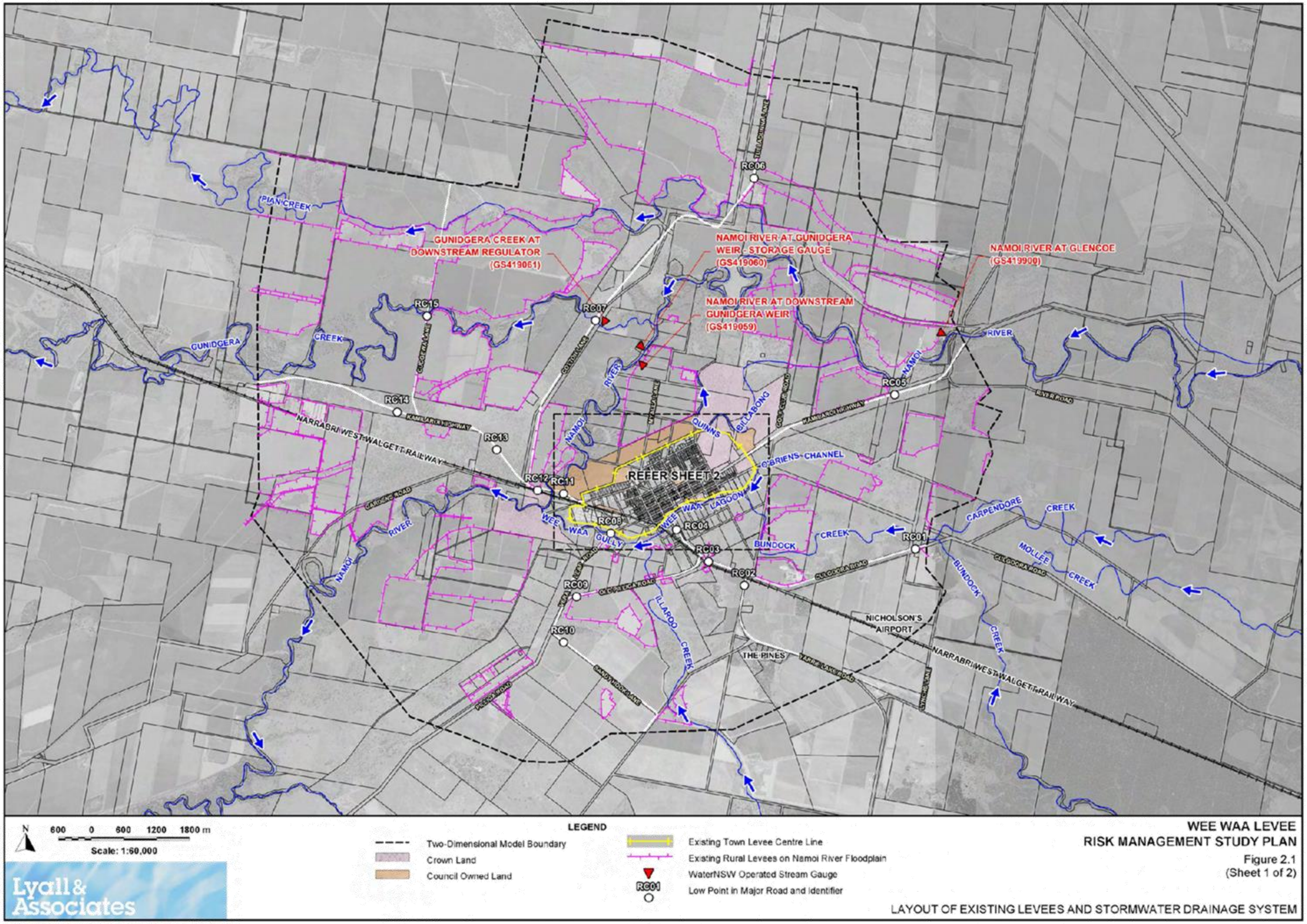
VOLUME 2 – FIGURES

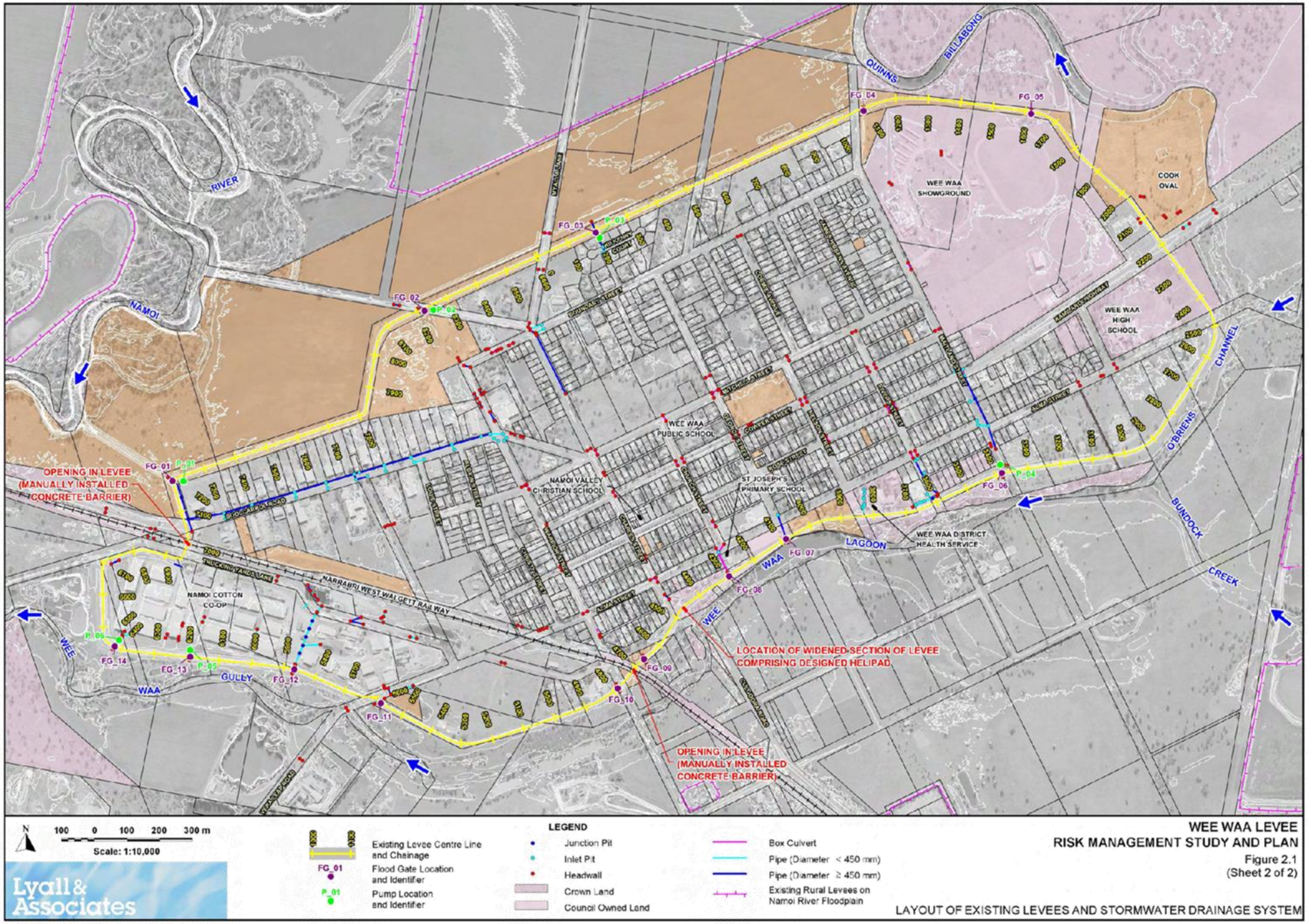
DRAFT REPORT FOR PUBLIC EXHIBITION

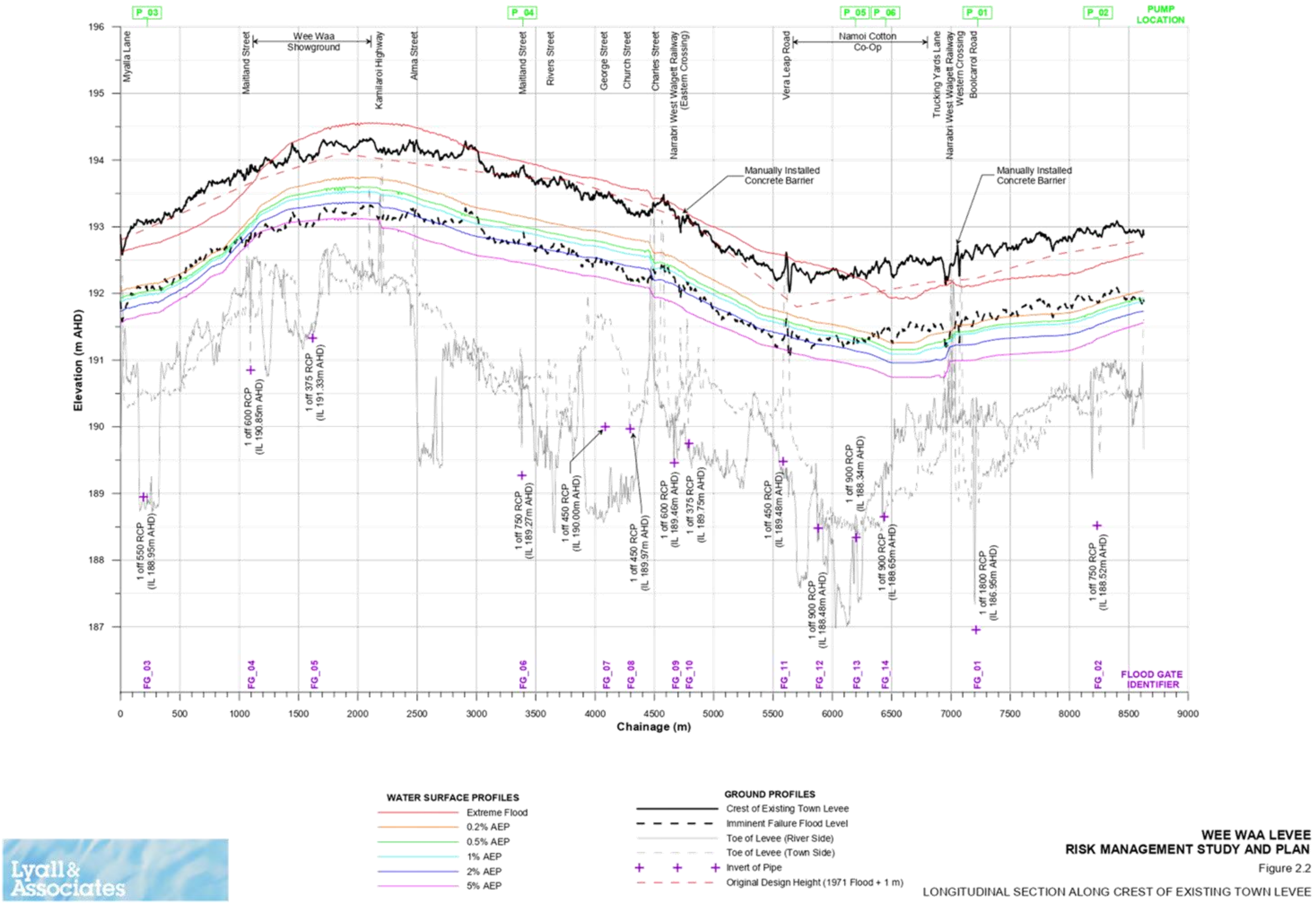
Job No: EE409 File: WWL_V2_Figures_[Rev 1.2].docx	Date: August 2019 Rev No: 1.2	Principal: SAB Authors: SAB/TDR

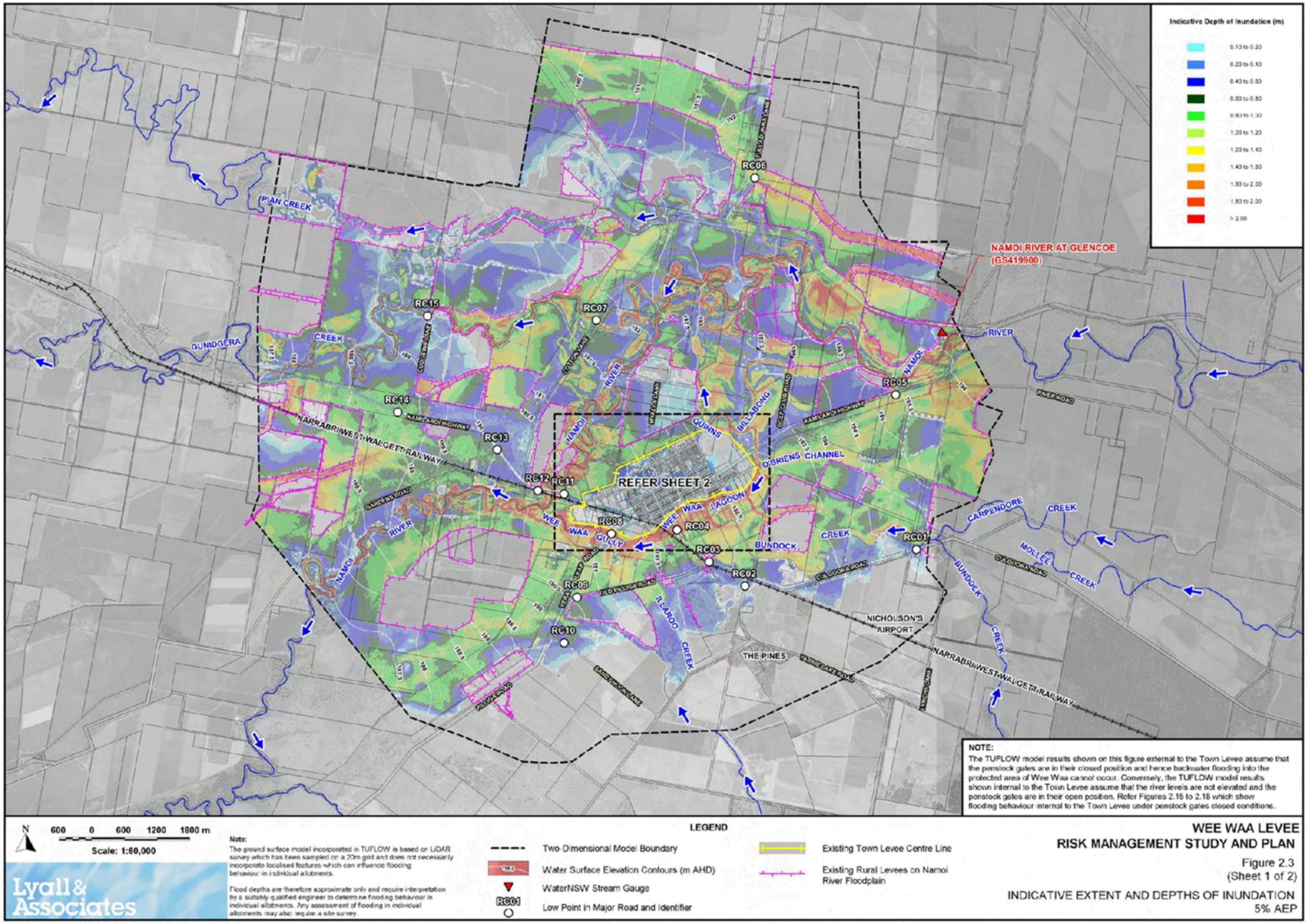
LIST OF FIGURES

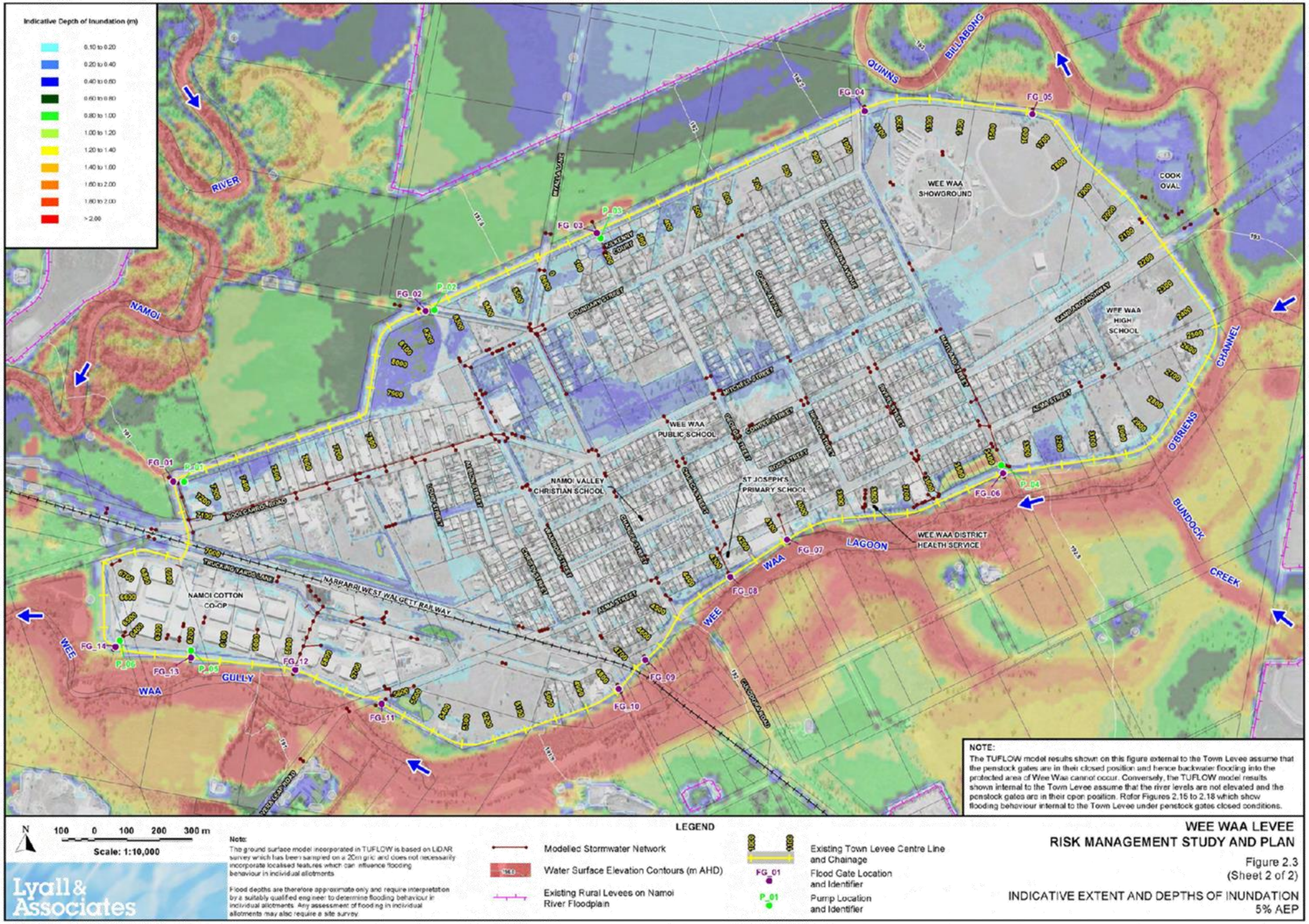

GUNIDGERA CREEK AT
DOWNSTREAM REGULATOR
(GS419061)
NAMOI RIVER AT GUNIDGERA
WEIR - STORAGE GAUGE
(GS419060)
NAMOI RIVER AT GLENCOE
(GS419900)
NAMOI RIVER AT DOWNSTREAM
GUNIDGERA WEIR
(GS419059)
NAMOI RIVER AT MOLLEE
(GS419039)
NAMOI RIVER
AT NARRABRI
(GS419002)
NARRABRI CREEK
AT NARRABRI
(GS419003)
WEE WAA
WEE WAA
AIRPORT
NARRABRI
NARRABRI
AIRPORT
MYALL
VALE
O'BRIENS
CHANNEL
KAMILAROI HIGHWAY
CUDGEWA LANE
SPRING PLAINS ROAD
RIVER ROAD
CULGOORA ROAD
NARRABRI WEST WALGETT RAILWAY LINE
WERRIS CREEK MUNGINDI RAILWAY LINE
YARRIE LAKE ROAD
PILLIGA ROAD
FOREST WAY
HIBBENS ROAD
NEWELL HIGHWAY
GALATHERA
CREEK
BOBBIWAA
SPRING
MOLLEE
BUNDOCK
BOHENA
NAMOI
RIVER
GUNIDGERA
PIAN
1.5 0 1.5 3.0 4.5 km
Scale: 1:150,000
LEGEND
WaterNSW Stream Gauge
Wee Waa Levee
Extent of Flood Study TUFLOW Model
Extent of Namoi River TUFLOW Model
Extent of Wee Waa Town LiDAR Survey Data
Extent of AAMHATCH LiDAR Survey Data
Extent of Narrabri North West LiDAR Survey Data
Extent of GA_5m LiDAR Survey Data
Extent of GA_1m LiDAR Survey Data
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 1.1
LOCATION PLAN

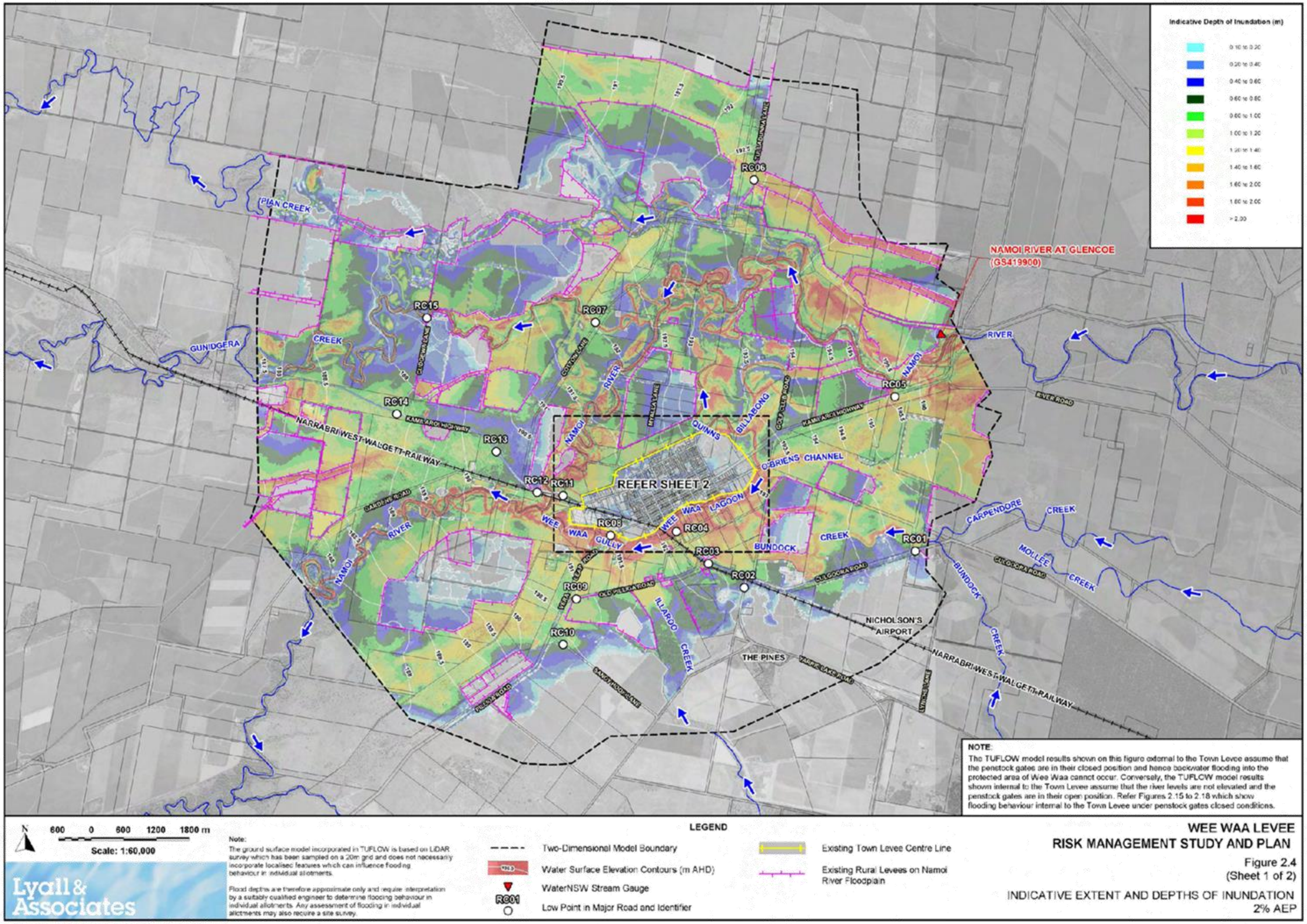

GUNIDGERA CREEK AT DOWNSTREAM REGULATOR (GS419061)
NAMOI RIVER AT GUNIDGERA WEIR - STORAGE GAUGE (GS419060)
NAMOI RIVER AT DOWNSTREAM GUNIDGERA WEIR (GS419059)
NAMOI RIVER AT GLENCOE (GS419900)
REFER SHEET 2
NARRABRI WEST-WALGETT RAILWAY
NICHOLSON'S AIRPORT
THE PINES
RC01 RC02 RC03 RC04 RC05 RC06 RC07 RC08 RC09 RC10 RC11 RC12 RC13 RC14 RC15
LEGEND
Two-Dimensional Model Boundary
Crown Land
Council Owned Land
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WaterNSW Operated Stream Gauge
Low Point in Major Road and Identifier
Scale: 1:60,000
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY PLAN
Figure 2.1
(Sheet 1 of 2)
LAYOUT OF EXISTING LEVEES AND STORMWATER DRAINAGE SYSTEM


OPENING IN LEVEE (MANUALLY INSTALLED CONCRETE BARRIER)
LOCATION OF WIDENED SECTION OF LEVEE COMPRISING DESIGNED HELIPAD
OPENING IN LEVEE (MANUALLY INSTALLED CONCRETE BARRIER)
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
NAMOI RIVER
QUINNS BILLABONG
O'BRIENS CHANNEL
BUNDOCK CREEK
WEE WAA LAGOON
WEE WAA GULLY
100 0 100 200 300 m
Scale: 1:10,000
LEGEND
Existing Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
Junction Pit
Inlet Pit
Headwall
Crown Land
Council Owned Land
Box Culvert
Pipe (Diameter < 450 mm)
Pipe (Diameter ≥ 450 mm)
Existing Rural Levees on Namoi River Floodplain
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.1
(Sheet 2 of 2)
LAYOUT OF EXISTING LEVEES AND STORMWATER DRAINAGE SYSTEM

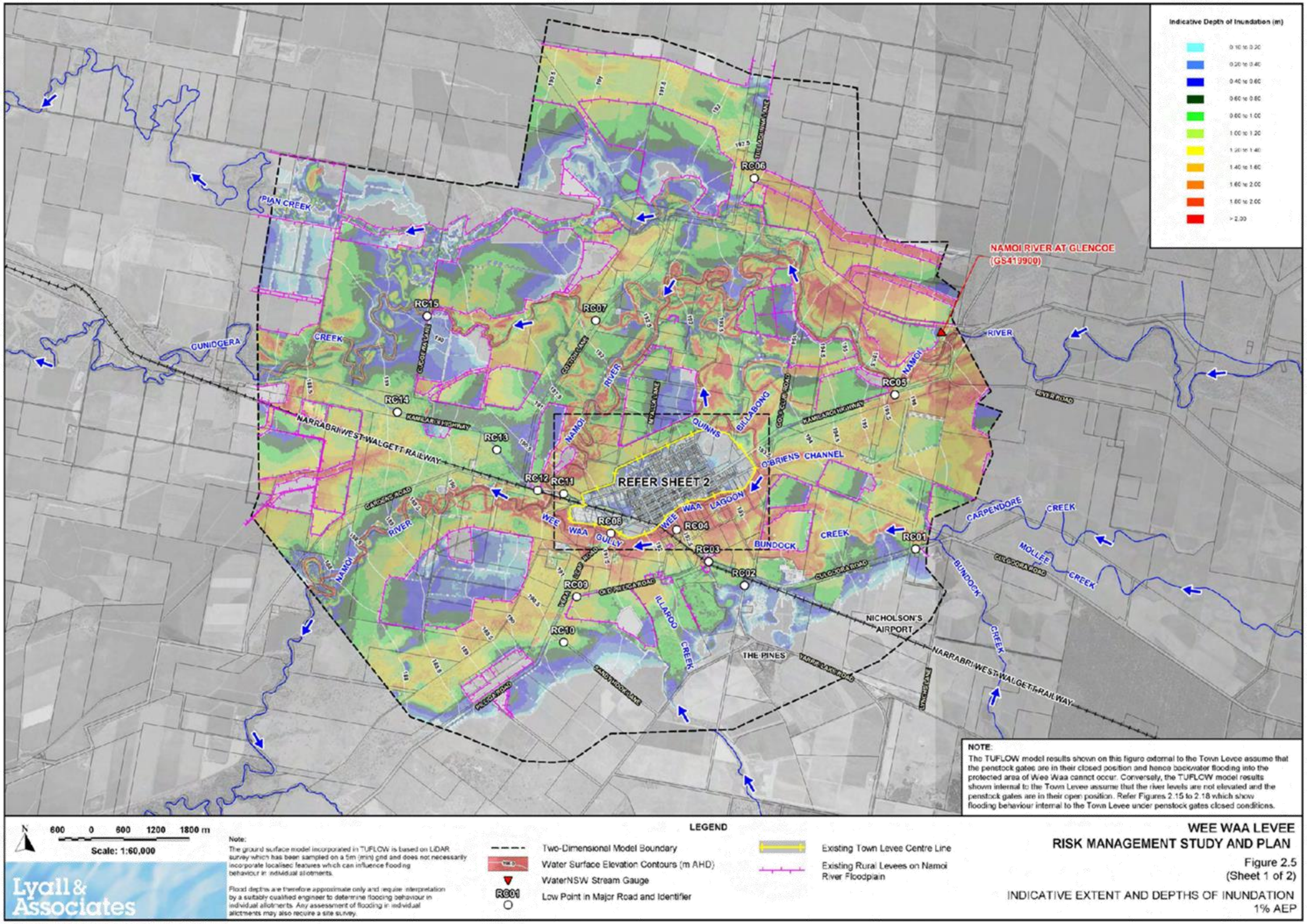

PUMP LOCATION
P_03
P_04
P_05
P_06
P_01
P_02
Myalla Lane
Maitland Street
Wee Waa Showground
Kamilaroi Highway
Alma Street
Maitland Street
Rivers Street
George Street
Church Street
Charles Street
Narrabri West Walgett Railway (Eastern Crossing)
Vera Leap Road
Namoi Cotton Co-Op
Trucking Yards Lane
Narrabri West Walgett Railway Western Crossing
Boolcarrol Road
Manually Installed Concrete Barrier
Manually Installed Concrete Barrier
Elevation (m AHD)
Chainage (m)
1 off 550 RCP (IL 188.95m AHD)
1 off 600 RCP (IL 190.85m AHD)
1 off 375 RCP (IL 191.33m AHD)
1 off 750 RCP (IL 189.27m AHD)
1 off 450 RCP (IL 190.00m AHD)
1 off 450 RCP (IL 189.97m AHD)
1 off 600 RCP (IL 189.46m AHD)
1 off 375 RCP (IL 189.75m AHD)
1 off 450 RCP (IL 189.48m AHD)
1 off 900 RCP (IL 188.48m AHD)
1 off 900 RCP (IL 188.34m AHD)
1 off 900 RCP (IL 188.65m AHD)
1 off 1800 RCP (IL 186.95m AHD)
1 off 750 RCP (IL 188.52m AHD)
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
FG_01
FG_02
FLOOD GATE IDENTIFIER
WATER SURFACE PROFILES
Extreme Flood
0.2% AEP
0.5% AEP
1% AEP
2% AEP
5% AEP
GROUND PROFILES
Crest of Existing Town Levee
Imminent Failure Flood Level
Toe of Levee (River Side)
Toe of Levee (Town Side)
Invert of Pipe
Original Design Height (1971 Flood + 1 m)
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.2
LONGITUDINAL SECTION ALONG CREST OF EXISTING TOWN LEVEE

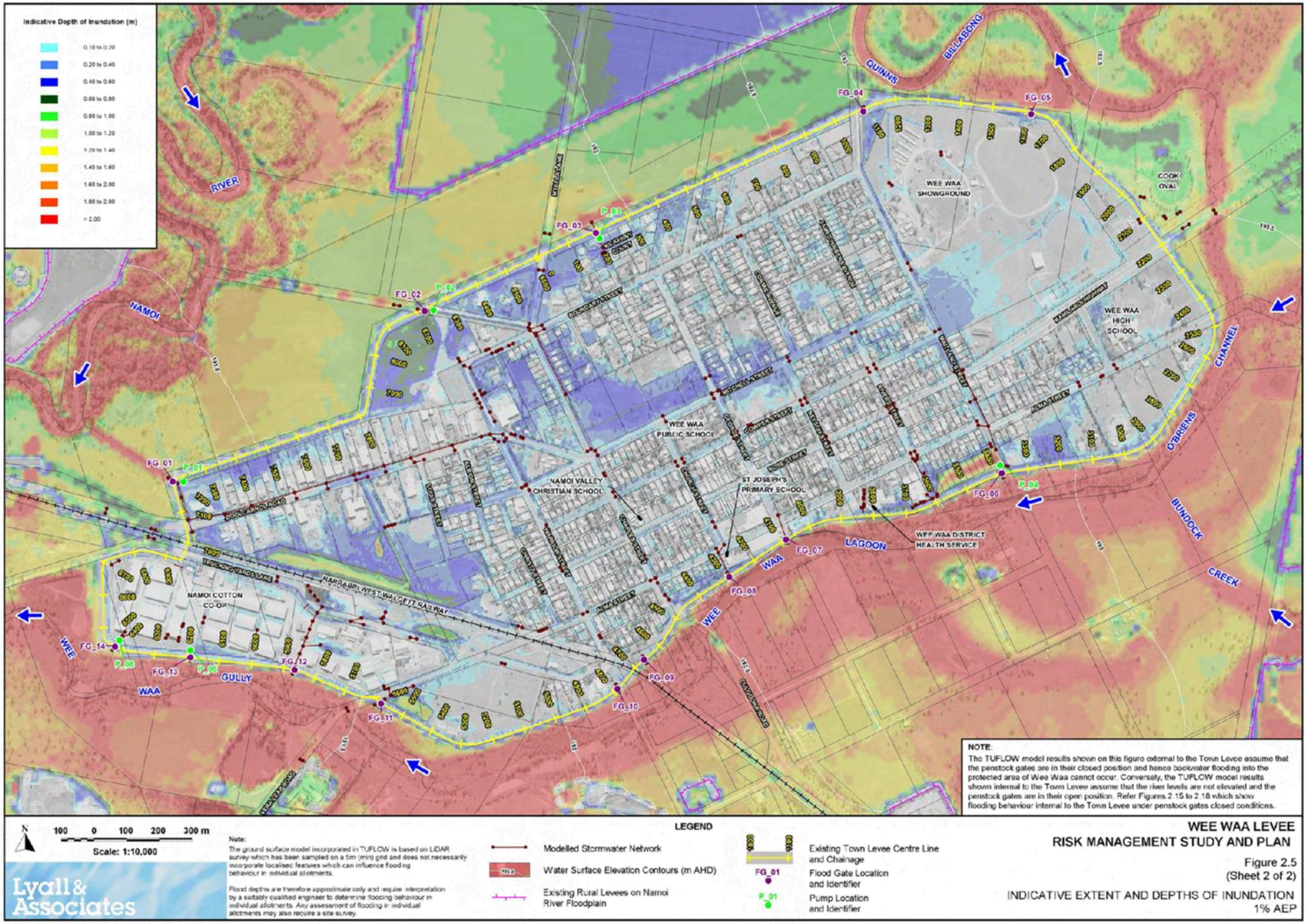

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 1.80
1.80 to 2.00
> 2.00
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
REFER SHEET 2
NARRABRI-WEST-WALGETT-RAILWAY
QUINNS BILLABONG
O'BRIENS CHANNEL
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
NICHOLSON'S AIRPORT
THE PINES
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
Water Surface Elevation Contours (m AHD)
WaterNSW Stream Gauge
RC01
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.3
(Sheet 1 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
5% AEP

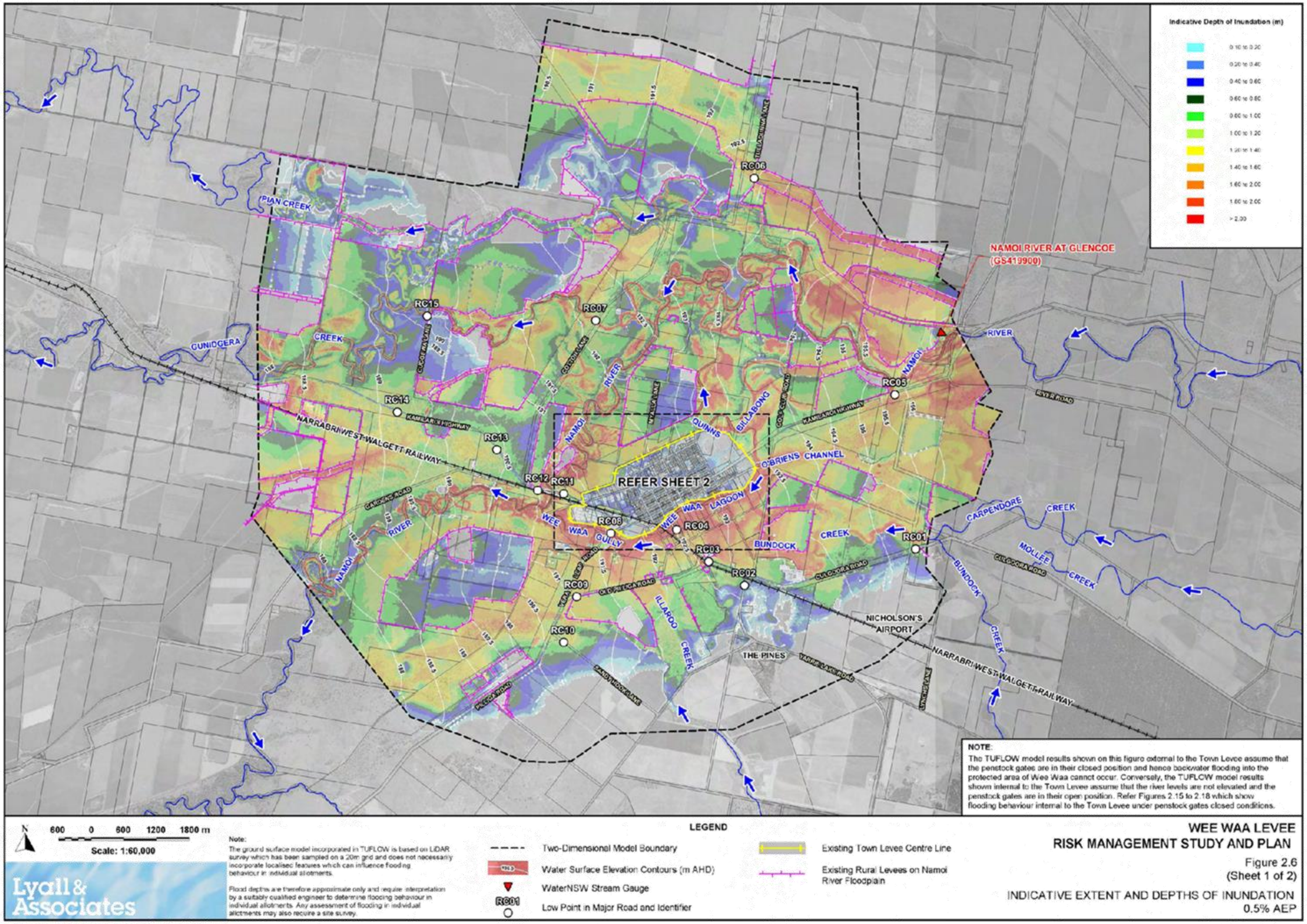

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI
RIVER
QUINNS
BILLABONG
COOK OVAL
WEE WAA SHOWGROUND
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
WEE WAA
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
WEE WAA GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Water Surface Elevation Contours (m AHD)
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.3
(Sheet 2 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
5% AEP

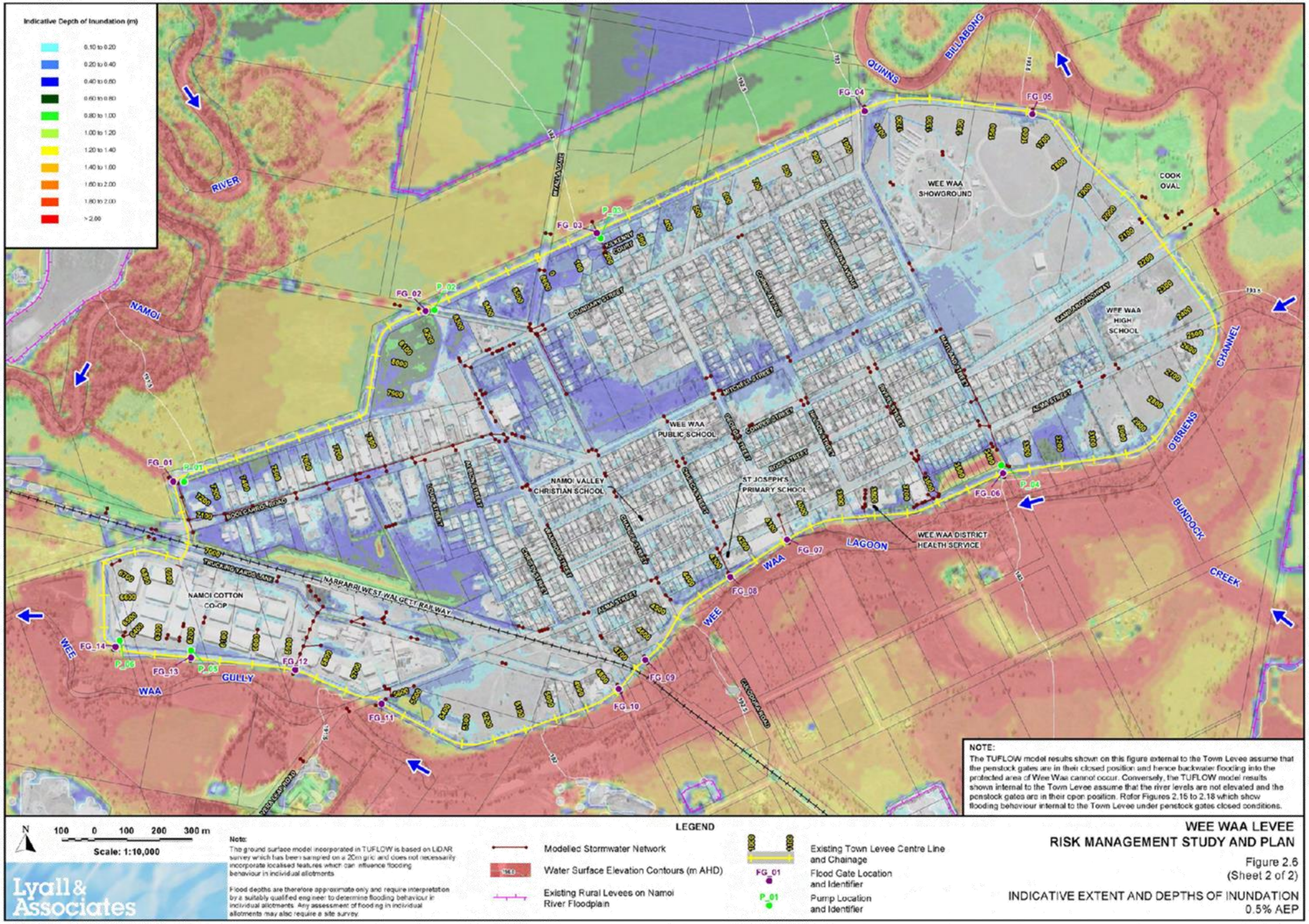

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
QUINNS BILLABONG
O'BRIENS CHANNEL
REFER SHEET 2
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
NARRABRI-WEST-WALGETT-RAILWAY
NICHOLSON'S AIRPORT
THE PINES
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
Water Surface Elevation Contours (m AHD)
WaterNSW Stream Gauge
RC01
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.4
(Sheet 1 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
2% AEP

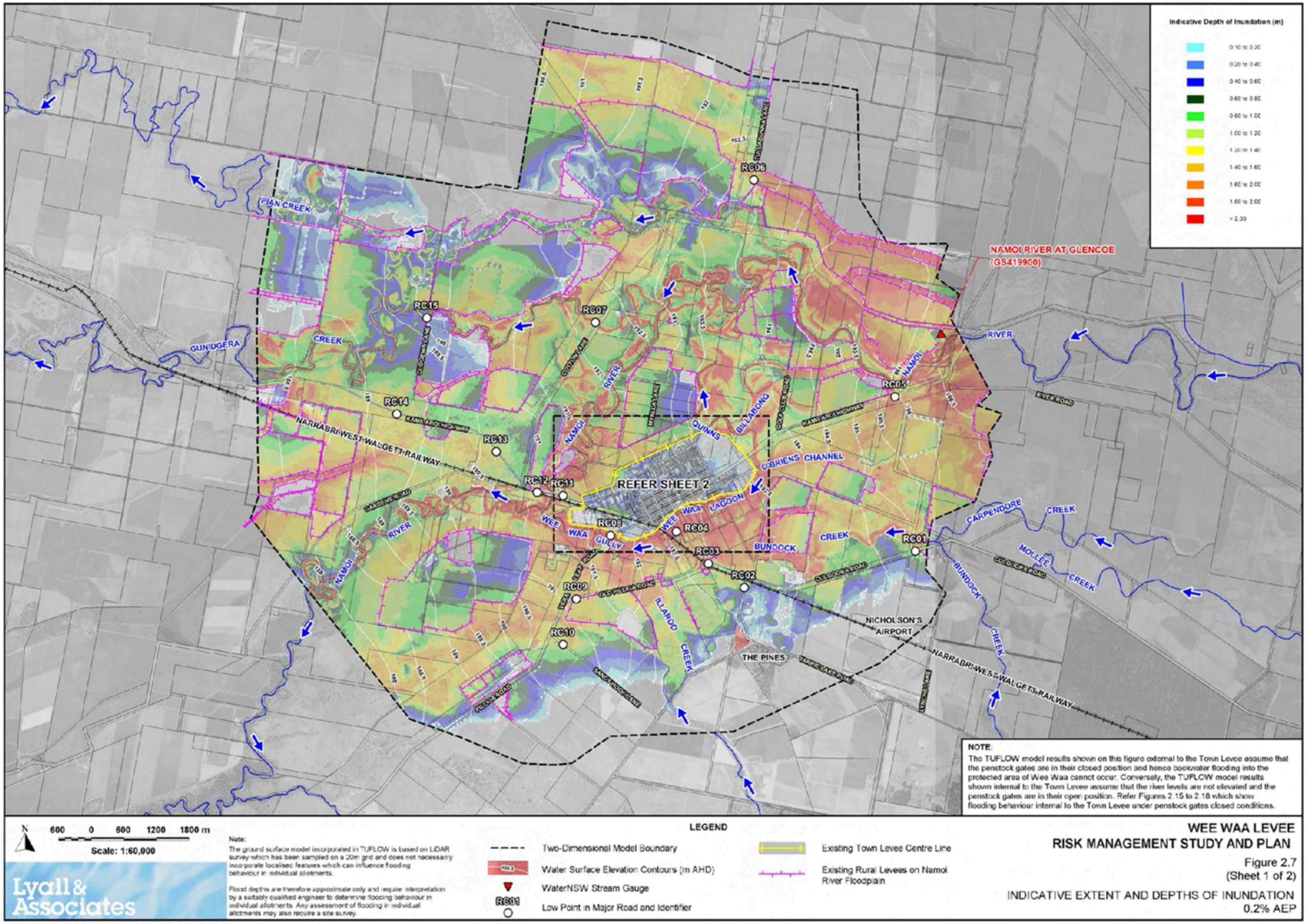

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI RIVER
QUINNS BILLABONG
O'BRIENS CHANNEL
BUNDOCK CREEK
WEE WAA LAGOON
WEE WAA GULLY
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
BOUNDARY STREET
MITCHELL STREET
KAMILAROI HIGHWAY
ALMA STREET
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Water Surface Elevation Contours (m AHD)
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.4
(Sheet 2 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
2% AEP

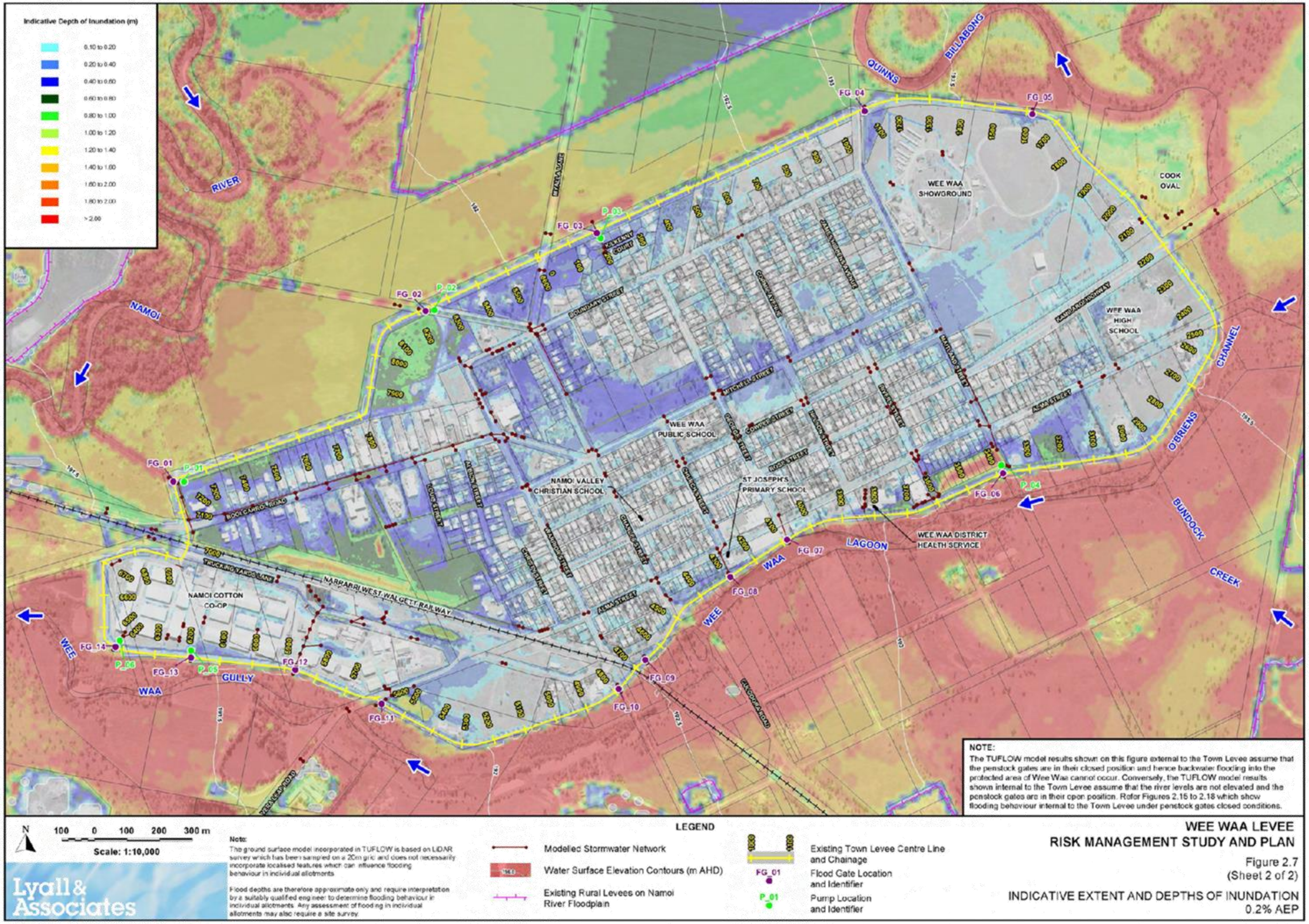

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
QUINNS BILLABONG
O'BRIENS CHANNEL
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
REFER SHEET 2
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
NARRABRI-WEST-WALGETT RAILWAY
KAMILAROI HIGHWAY
RIVER ROAD
CULGOORA ROAD
GARDENS ROAD
OLD PILLIGA ROAD
NICHOLSON'S AIRPORT
THE PINES
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
Water Surface Elevation Contours (m AHD)
WaterNSW Stream Gauge
RC01
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.5
(Sheet 1 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
1% AEP

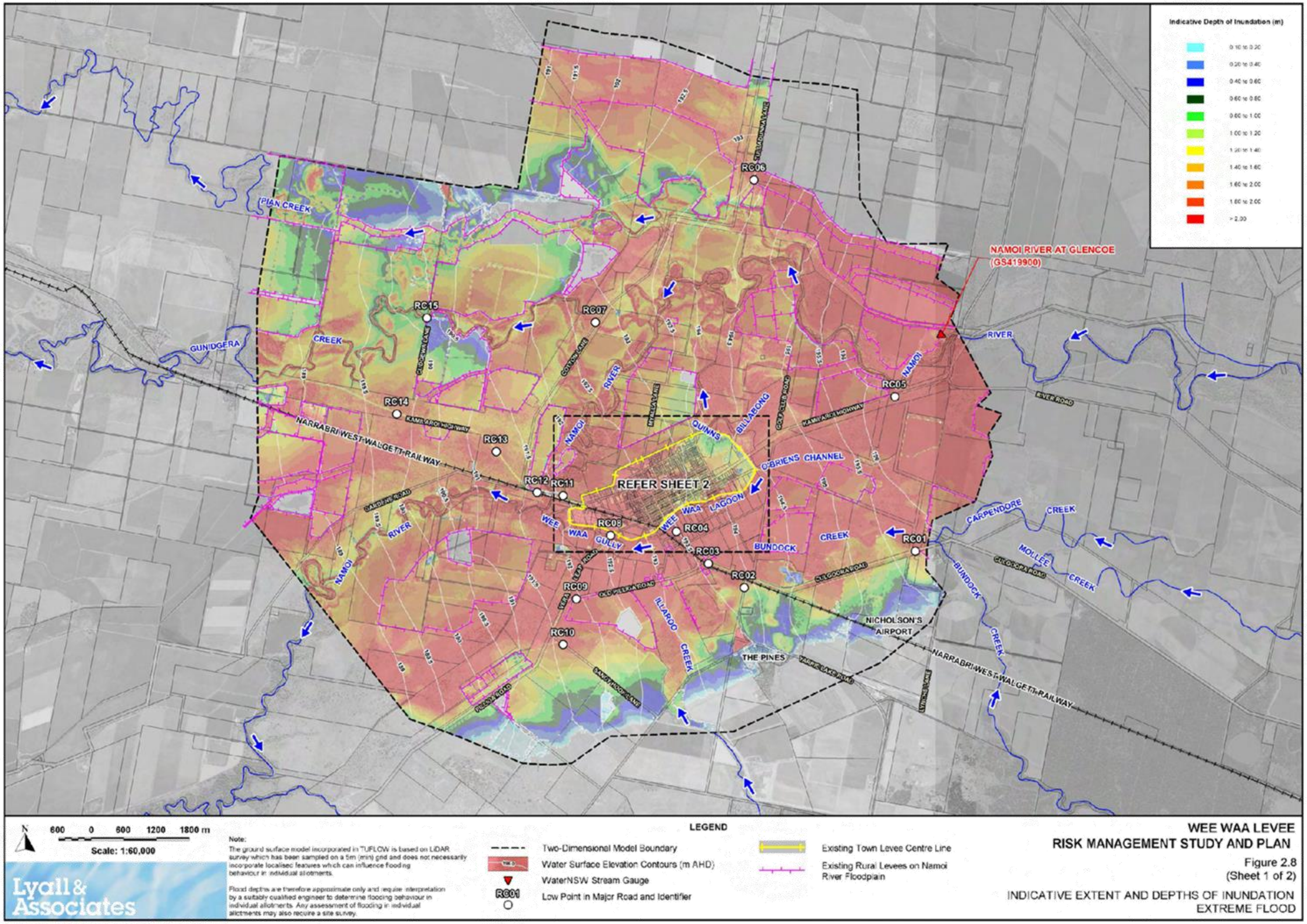

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI
RIVER
QUINNS
BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
NAMOI COTTON CO-OP
NARRABRI-WEST WALGETT RAILWAY
WEE
WAA
GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Water Surface Elevation Contours (m AHD)
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.5
(Sheet 2 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
1% AEP

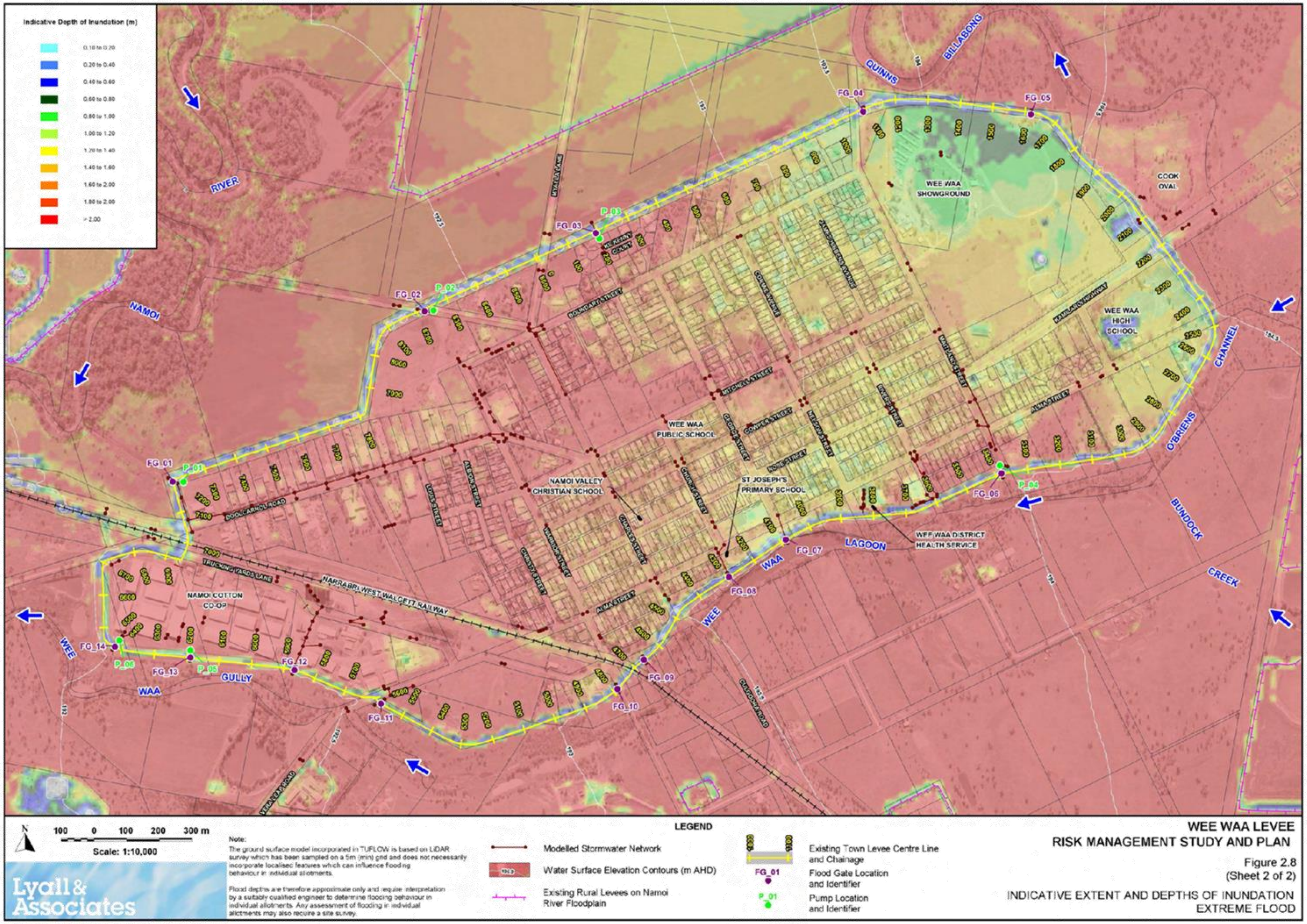

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
QUINNS BILLABONG
O'BRIENS CHANNEL
REFER SHEET 2
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
KAMILAROI HIGHWAY
NARRABRI-WEST-WALGETT RAILWAY
RIVER ROAD
CULGOORA ROAD
NICHOLSON'S AIRPORT
THE PINES
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
Water Surface Elevation Contours (m AHD)
WaterNSW Stream Gauge
RC01
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.6
(Sheet 1 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
0.5% AEP

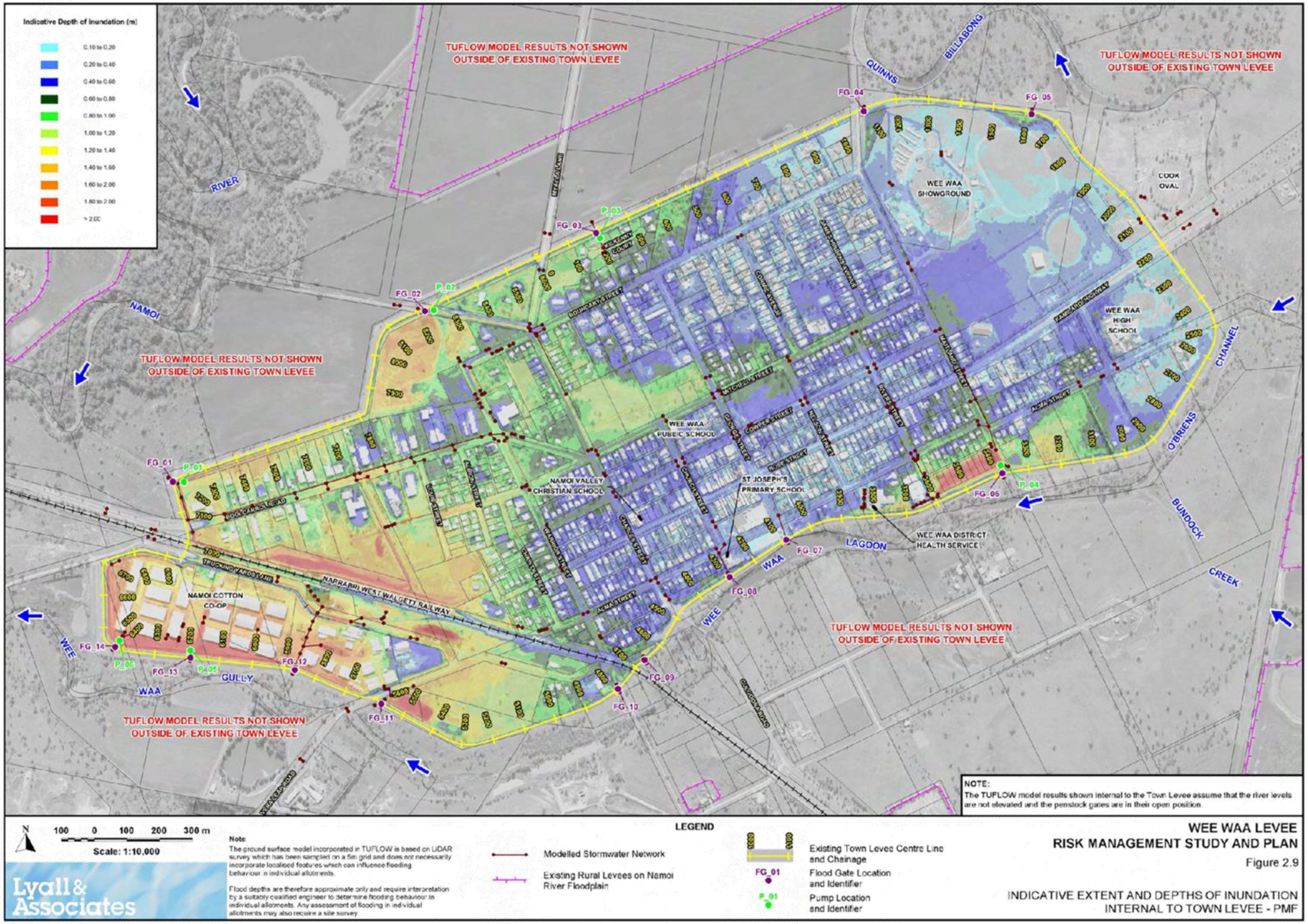

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI
RIVER
QUINNS
BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
LAGOON
WAA
WEE
GULLY
WAA
WEE
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Water Surface Elevation Contours (m AHD)
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.6
(Sheet 2 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
0.5% AEP

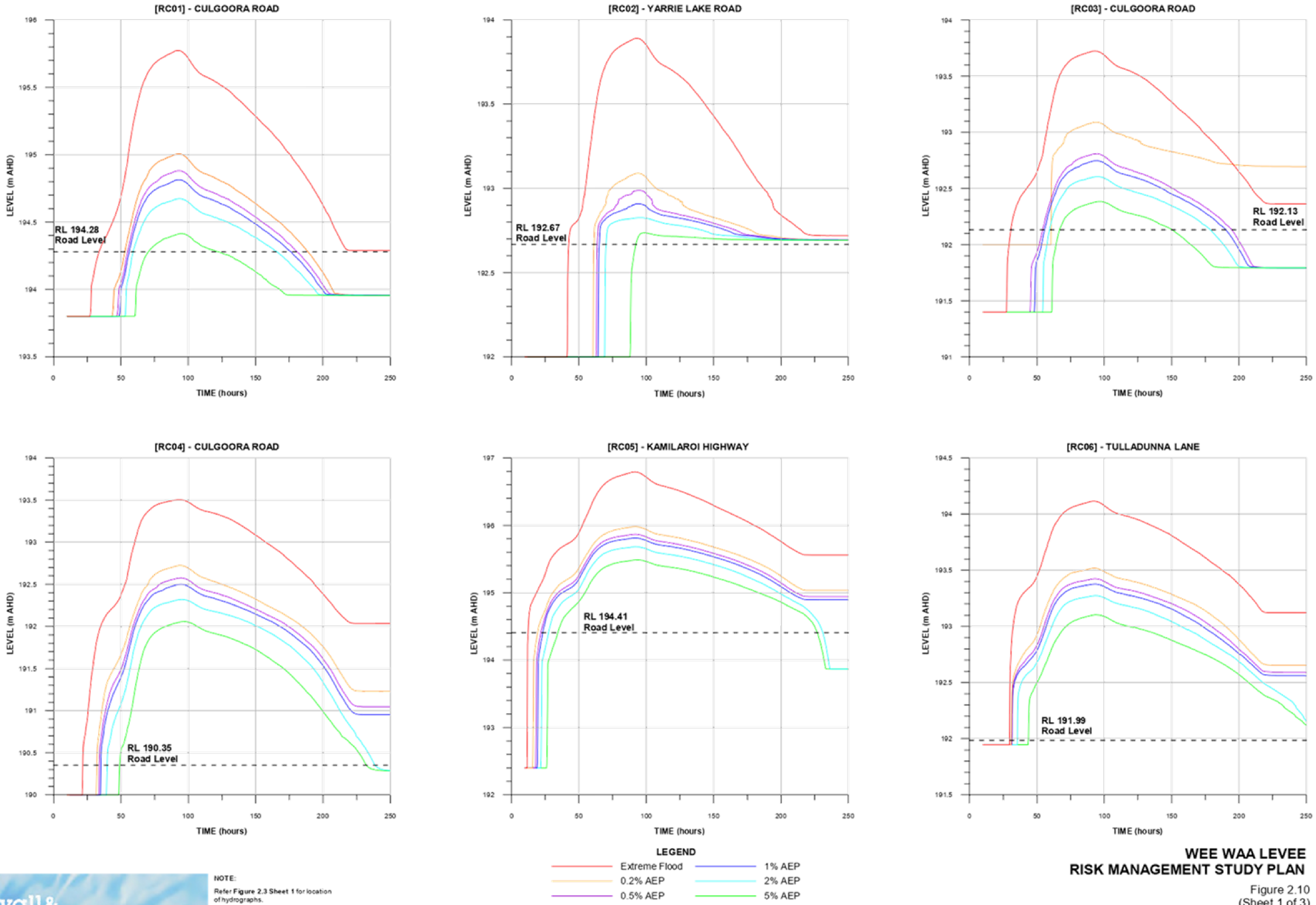

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
RIVER ROAD
KAMILAROI HIGHWAY
NARRABRI-WEST-WALGETT-RAILWAY
QUINNS BILLABONG
O'BRIENS CHANNEL
REFER SHEET 2
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
CULGOORA ROAD
ILLAROO CREEK
NICHOLSON'S AIRPORT
THE PINES
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
Water Surface Elevation Contours (m AHD)
WaterNSW Stream Gauge
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.7
(Sheet 1 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
0.2% AEP


Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI
RIVER
QUINNS
BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
WEE
WAA
GULLY
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Water Surface Elevation Contours (m AHD)
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.7
(Sheet 2 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
0.2% AEP


Indicative Depth of Inundation (m)
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
REFER SHEET 2
QUINNS BILLABONG
O'BRIENS CHANNEL
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
NARRABRI-WEST-WALGETT-RAILWAY
KAMILAROI HIGHWAY
NICHOLSON'S AIRPORT
THE PINES
RIVER ROAD
CULGOORA ROAD
OLD PILLIGA ROAD
LEGEND
600 0 600 1200 1800 m
Scale: 1:60,000
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
Lyall & Associates
Two-Dimensional Model Boundary
Water Surface Elevation Contours (m AHD)
WaterNSW Stream Gauge
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.8
(Sheet 1 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
EXTREME FLOOD


Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI
RIVER
QUINNS
BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
WEE
WAA
NAMOI COTTON CO-OP
TRUCKING YARDS LANE
NARRABRI WEST WALGETT RAILWAY
DOOLCARNOI ROAD
GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Water Surface Elevation Contours (m AHD)
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.8
(Sheet 2 of 2)
INDICATIVE EXTENT AND DEPTHS OF INUNDATION
EXTREME FLOOD

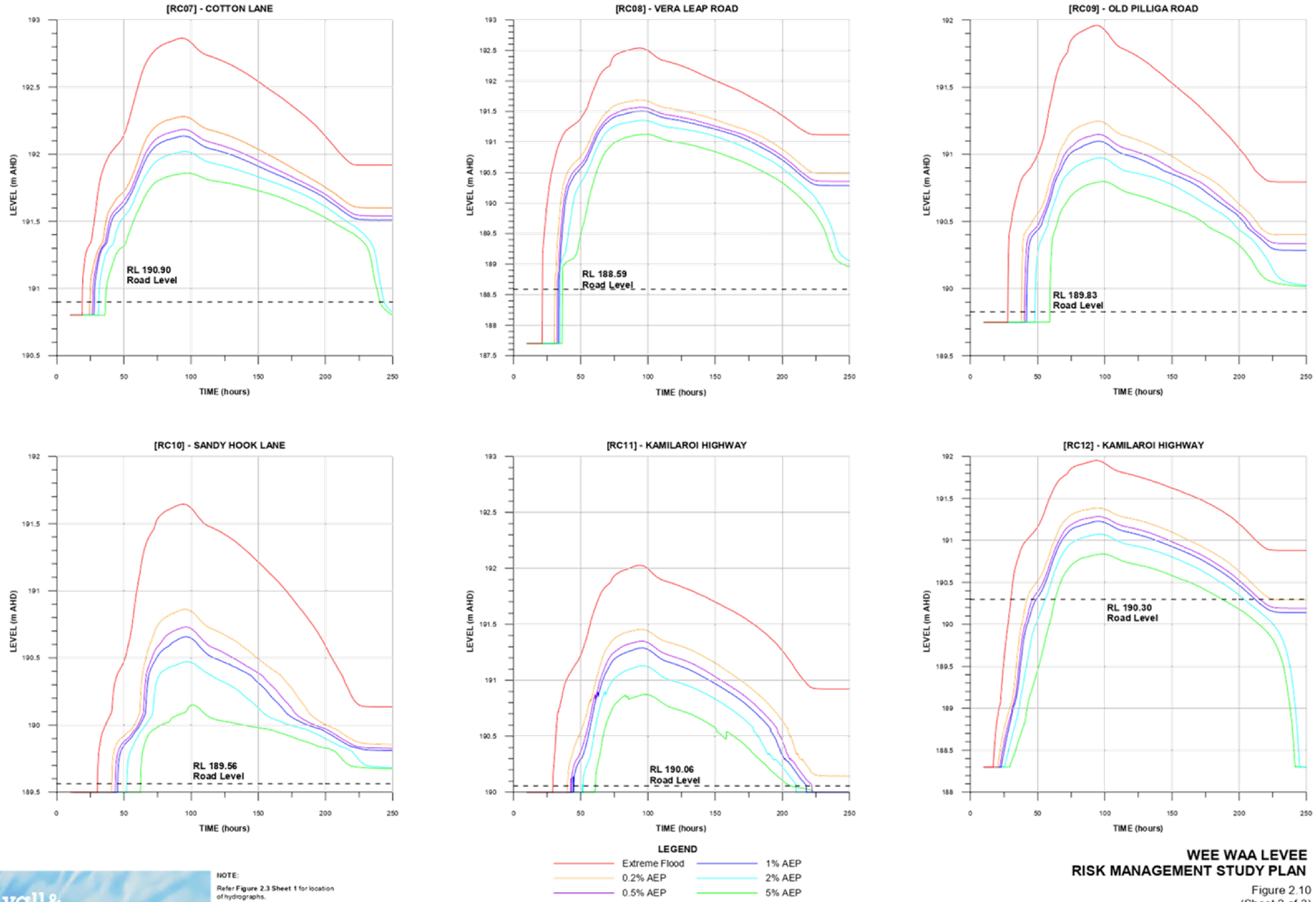

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
NAMOI RIVER
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
O'BRIENS CHANNEL
QUINNS BILLABONG
NOTE:
The TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position.
100 0 100 200 300 m
Scale: 1:10,000
Note
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
Lyall & Associates
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.9
INDICATIVE EXTENT AND DEPTHS OF INUNDATION INTERNAL TO TOWN LEVEE - PMF



NOTE:
Refer Figure 2.3 Sheet 1 for location of hydrographs.

WEE WAA LEVEE
RISK MANAGEMENT STUDY PLAN

Figure 2.10
(Sheet 1 of 3)
TIME OF RISE OF FLOODWATERS

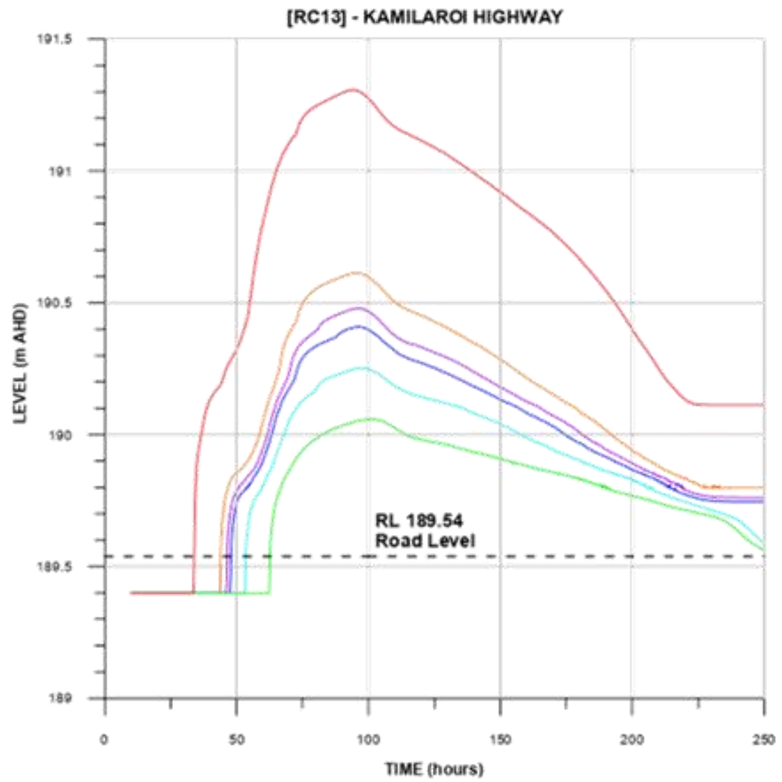


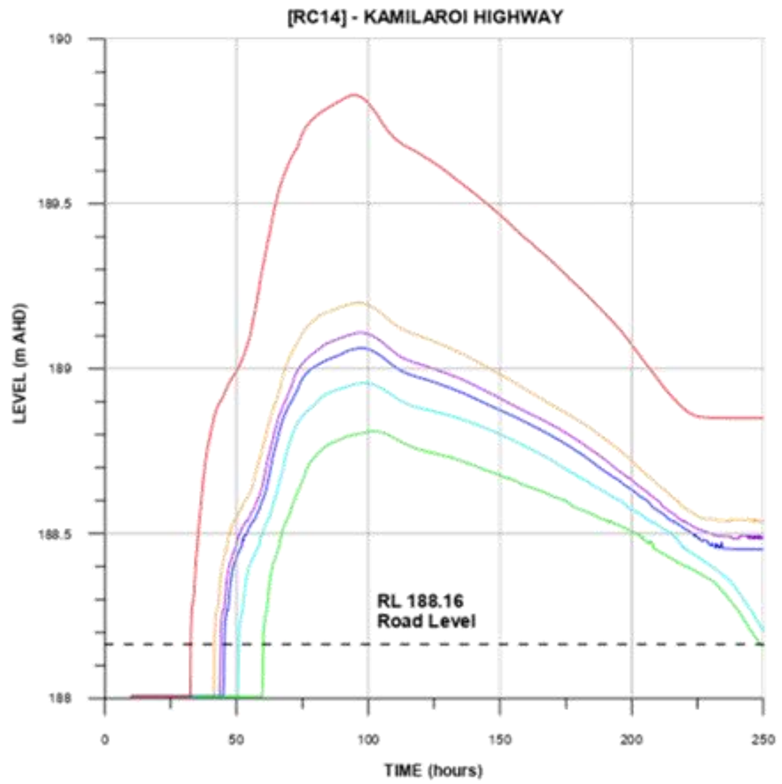
Lyall & Associates

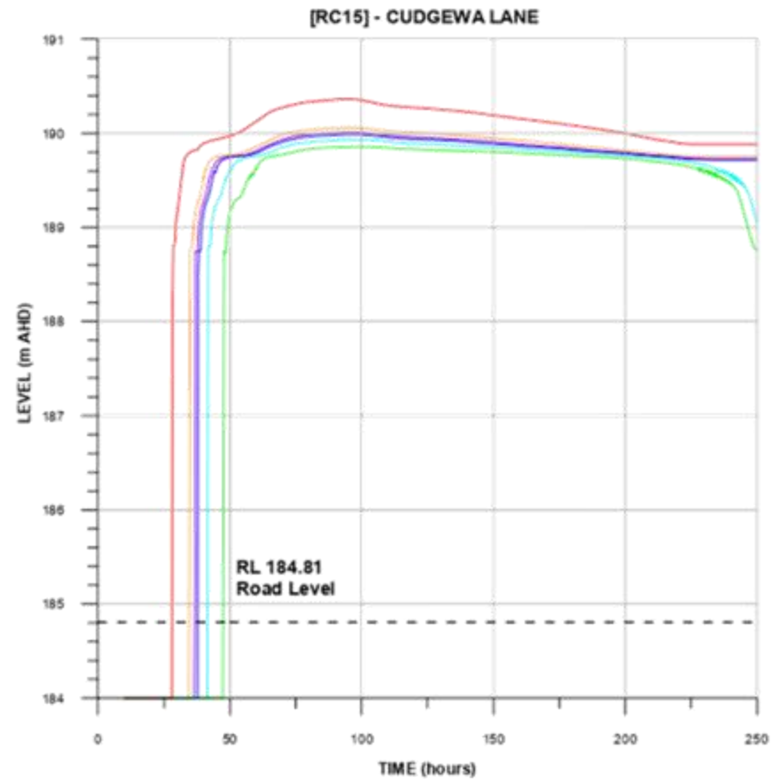
NOTE:
Refer Figure 2.3 Sheet 1 for location of hydrographs.

WEE WAA LEVEE
RISK MANAGEMENT STUDY PLAN

Figure 2.10
(Sheet 2 of 3)
TIME OF RISE OF FLOODWATERS







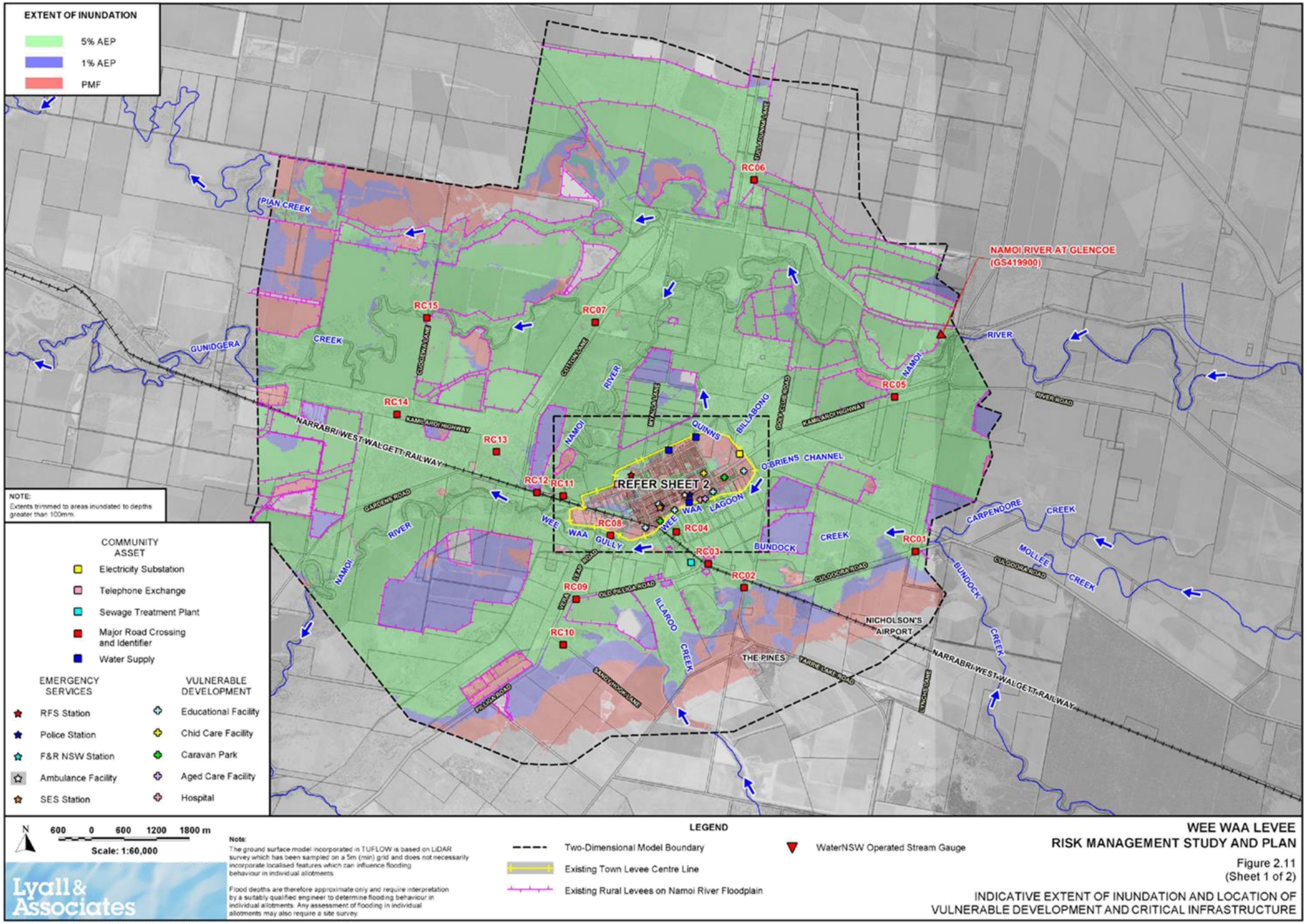
Lyall & Associates

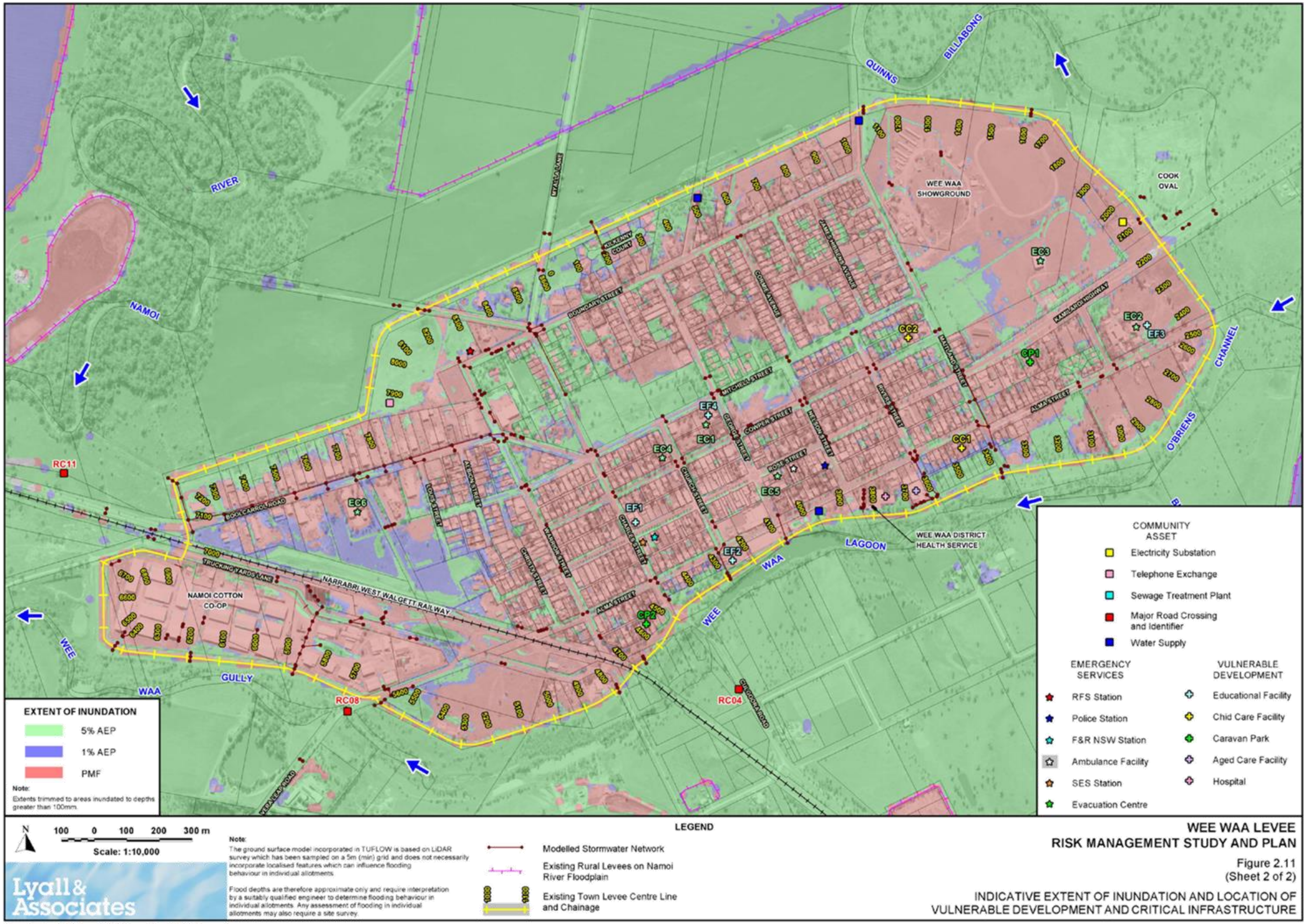
NOTE:
Refer Figure 2.3 Sheet 1 for location of hydrographs.

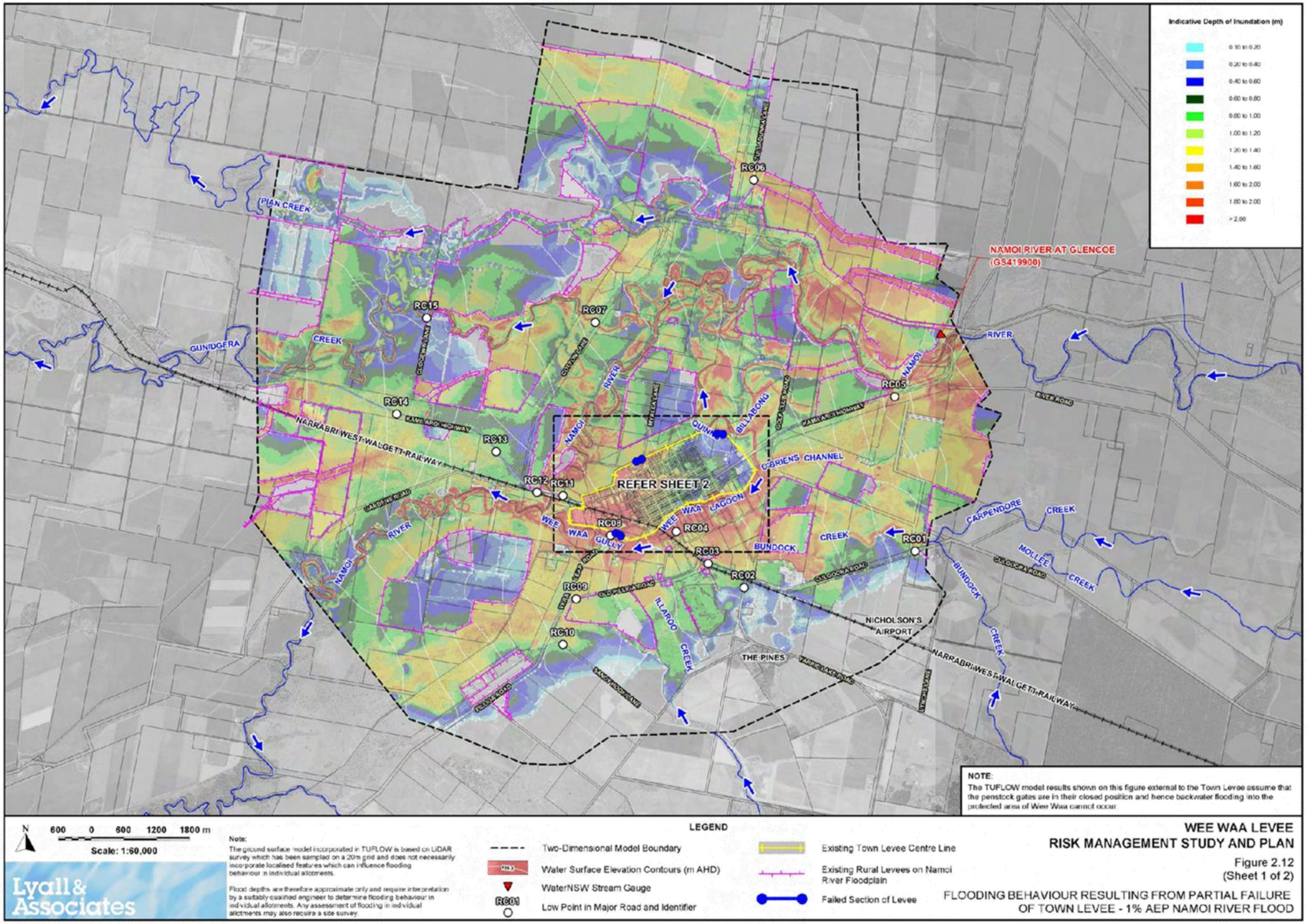
WEE WAA LEVEE
RISK MANAGEMENT STUDY PLAN

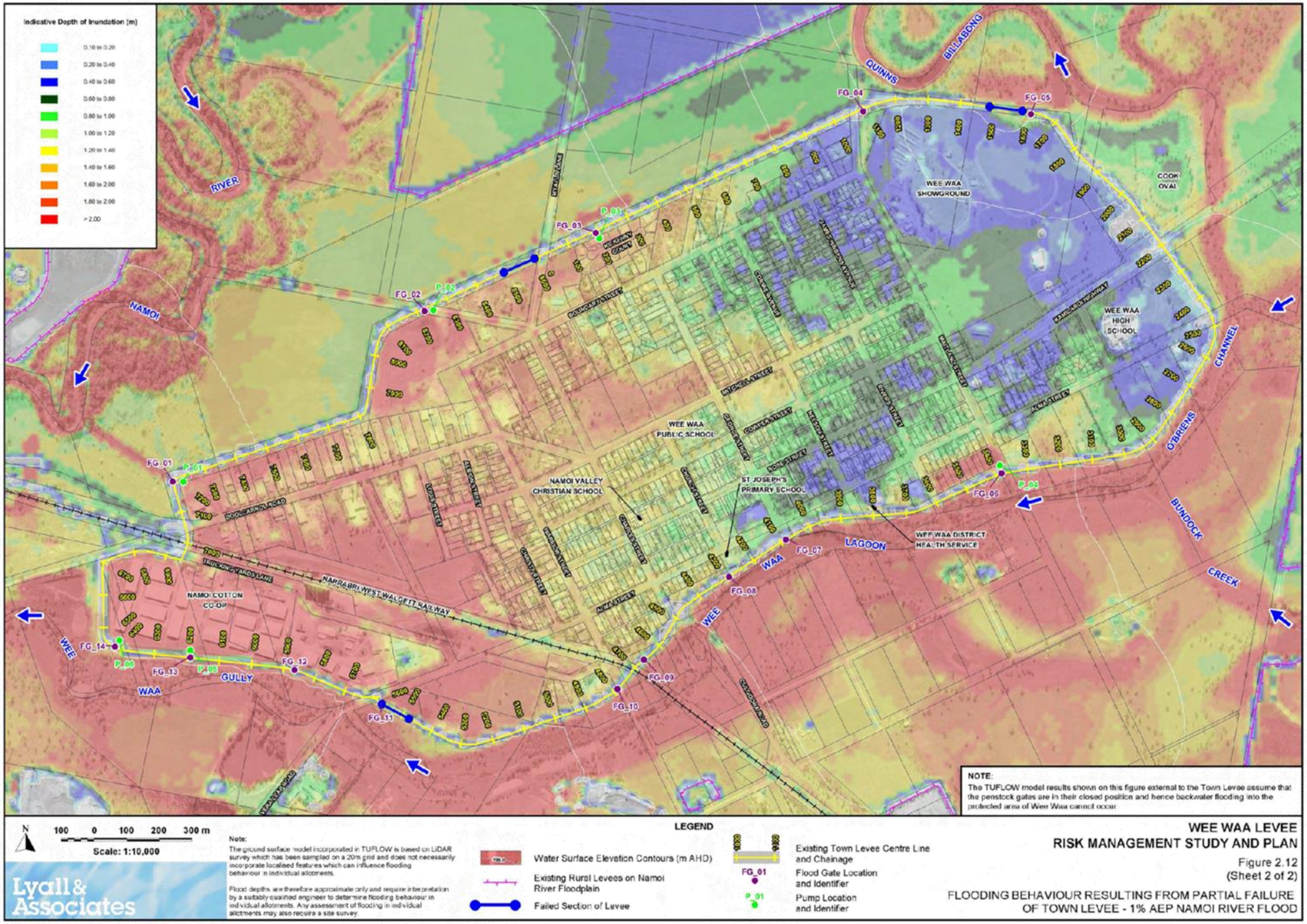
Figure 2.10
(Sheet 3 of 3)

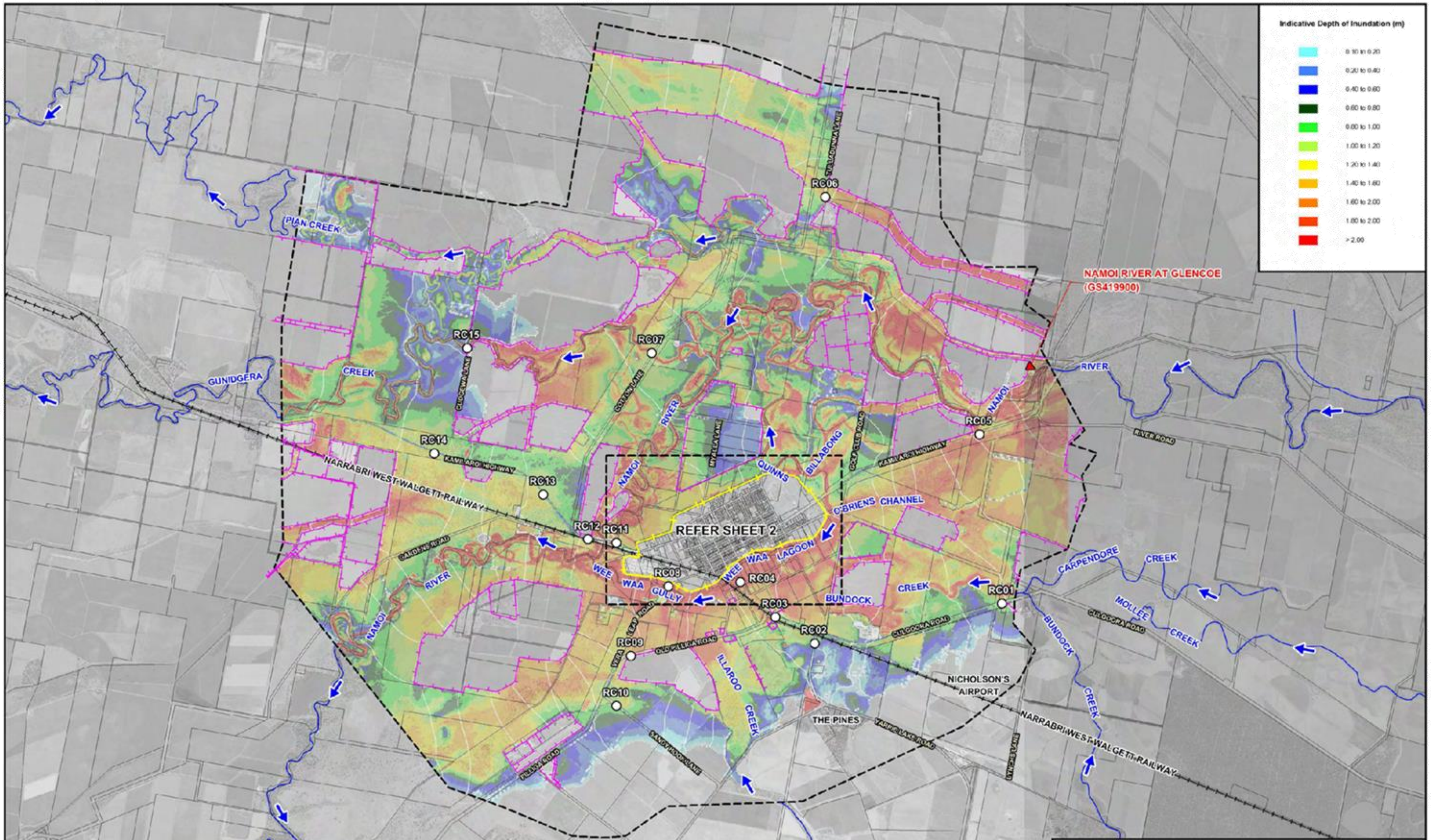
TIME OF RISE OF FLOODWATERS


EXTENT OF INUNDATION
5% AEP
1% AEP
PMF
NOTE:
Extents trimmed to areas inundated to depths greater than 100mm.
COMMUNITY ASSET
Electricity Substation
Telephone Exchange
Sewage Treatment Plant
Major Road Crossing and Identifier
Water Supply
EMERGENCY SERVICES
RFS Station
Police Station
F&R NSW Station
Ambulance Facility
SES Station
VULNERABLE DEVELOPMENT
Educational Facility
Chid Care Facility
Caravan Park
Aged Care Facility
Hospital
PIAN CREEK
GUNIDGERA
CREEK
NAMOI RIVER AT GLENCOE
(GS419900)
RIVER
NAMOI
RIVER ROAD
KAMILAROI HIGHWAY
NARRABRI WEST WALGETT RAILWAY
REFER SHEET 2
QUINNS
BILLABONG
O'BRIENS CHANNEL
LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
CULGOORA ROAD
NICHOLSON'S AIRPORT
THE PINES
ILLAROO CREEK
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WaterNSW Operated Stream Gauge
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.11
(Sheet 1 of 2)
INDICATIVE EXTENT OF INUNDATION AND LOCATION OF VULNERABLE DEVELOPMENT AND CRITICAL INFRASTRUCTURE


WEE WAA SHOWGROUND
COOK OVAL
NAMOI COTTON CO-OP
WEE WAA DISTRICT HEALTH SERVICE
NAMOI
RIVER
QUINNS
BILLABONG
CHANNEL
O'BRIENS
WEE WAA LAGOON
WEE WAA GULLY
NARRABRI WEST WALGETT RAILWAY
KAMILAROI HIGHWAY
BOUNDARY STREET
MITCHELL STREET
COWPER STREET
ROSE STREET
ALMA STREET
MAITLAND STREET
TRUCKING YARDS LANE
BOOLCARROL ROAD
EXTENT OF INUNDATION
5% AEP
1% AEP
PMF
Note:
Extents trimmed to areas inundated to depths greater than 100mm.
COMMUNITY ASSET
Electricity Substation
Telephone Exchange
Sewage Treatment Plant
Major Road Crossing and Identifier
Water Supply
EMERGENCY SERVICES
RFS Station
Police Station
F&R NSW Station
Ambulance Facility
SES Station
Evacuation Centre
VULNERABLE DEVELOPMENT
Educational Facility
Chid Care Facility
Caravan Park
Aged Care Facility
Hospital
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.11
(Sheet 2 of 2)
INDICATIVE EXTENT OF INUNDATION AND LOCATION OF VULNERABLE DEVELOPMENT AND CRITICAL INFRASTRUCTURE


Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
BILLABONG
O'BRIENS CHANNEL
REFER SHEET 2
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
NARRABRI-WEST-WALGETT-RAILWAY
NICHOLSON'S AIRPORT
THE PINES
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
Water Surface Elevation Contours (m AHD)
WaterNSW Stream Gauge
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
Failed Section of Levee
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.12
(Sheet 1 of 2)
FLOODING BEHAVIOUR RESULTING FROM PARTIAL FAILURE OF TOWN LEVEE - 1% AEP NAMOI RIVER FLOOD


Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI RIVER
QUINNS BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
WEE WAA LAGOON
WEE WAA GULLY
O'BRIENS CHANNEL
BUNDOCK CREEK
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur
100 0 100 200 300 m
Scale: 1:10,000
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
Lyall & Associates
LEGEND
Water Surface Elevation Contours (m AHD)
Existing Rural Levees on Namoi River Floodplain
Failed Section of Levee
Existing Town Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.12
(Sheet 2 of 2)
FLOODING BEHAVIOUR RESULTING FROM PARTIAL FAILURE OF TOWN LEVEE - 1% AEP NAMOI RIVER FLOOD



NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur.

N
600 0 600 1200 1800 m
Scale: 1:60,000

Lyall & Associates

Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

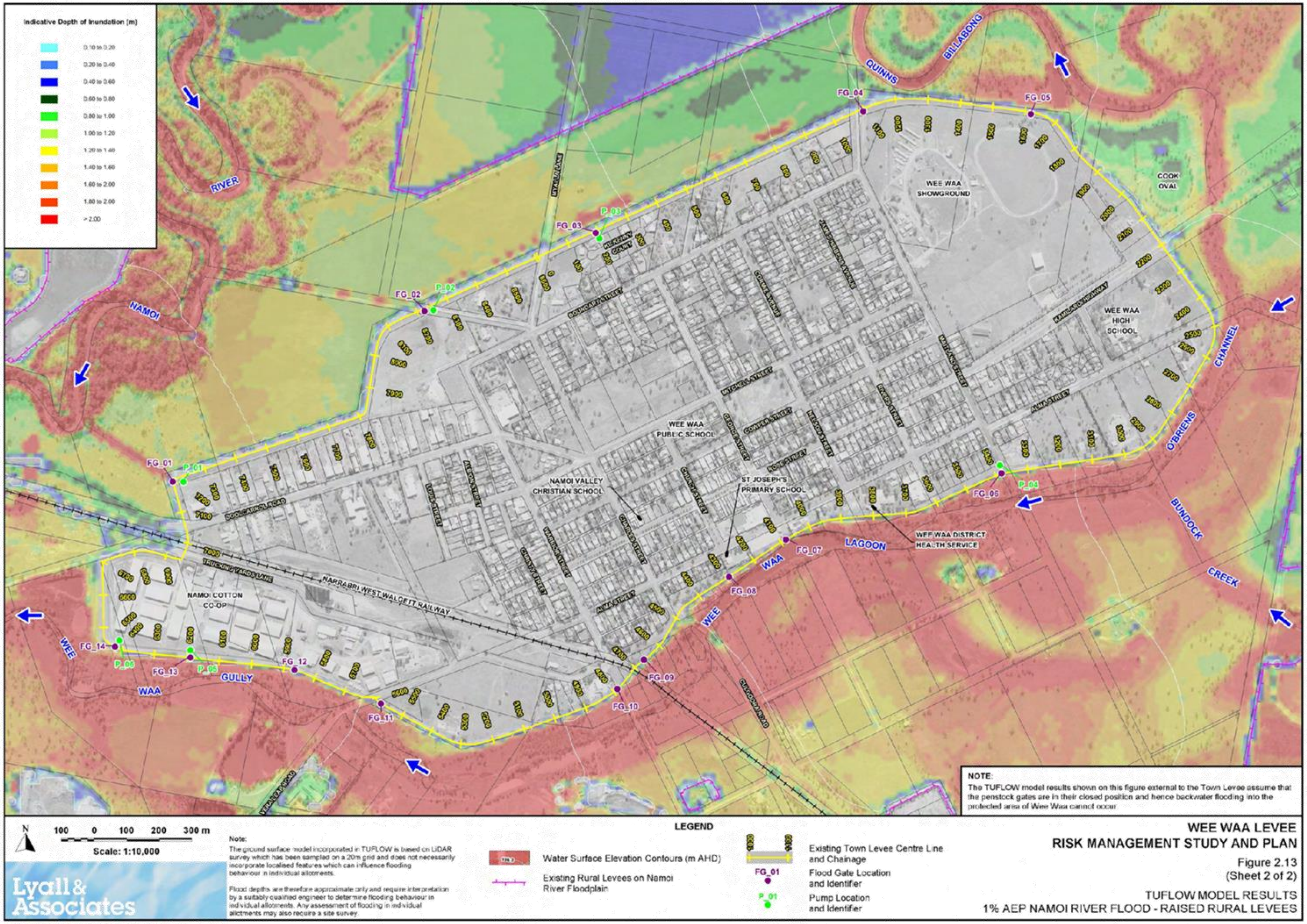
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

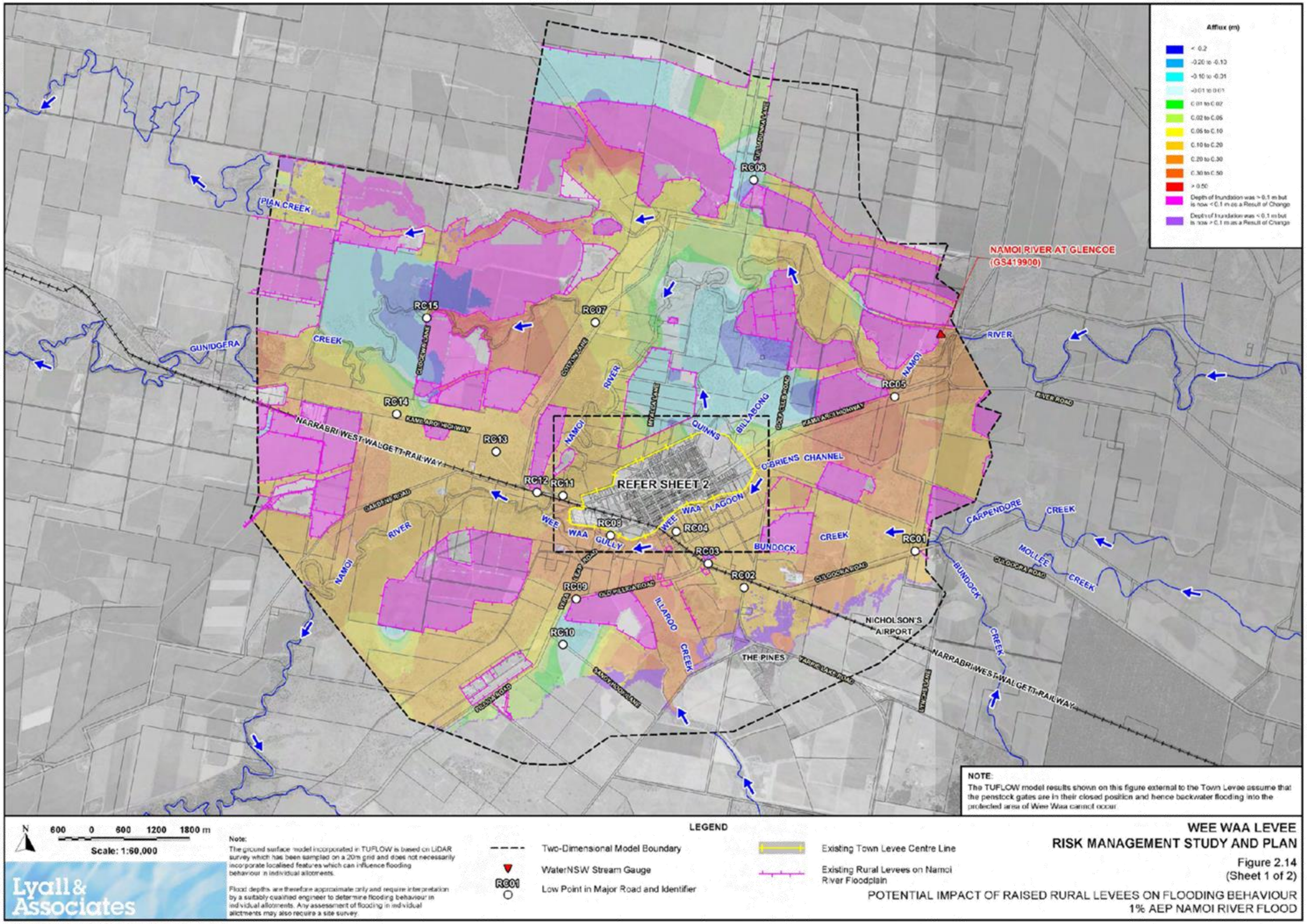
LEGEND
- Two-Dimensional Model Boundary
- Water Surface Elevation Contours (m AHD)
- WaterNSW Stream Gauge
- RC01 Low Point in Major Road and Identifier
- Existing Town Levee Centre Line
- Existing Rural Levees on Namoi River Floodplain

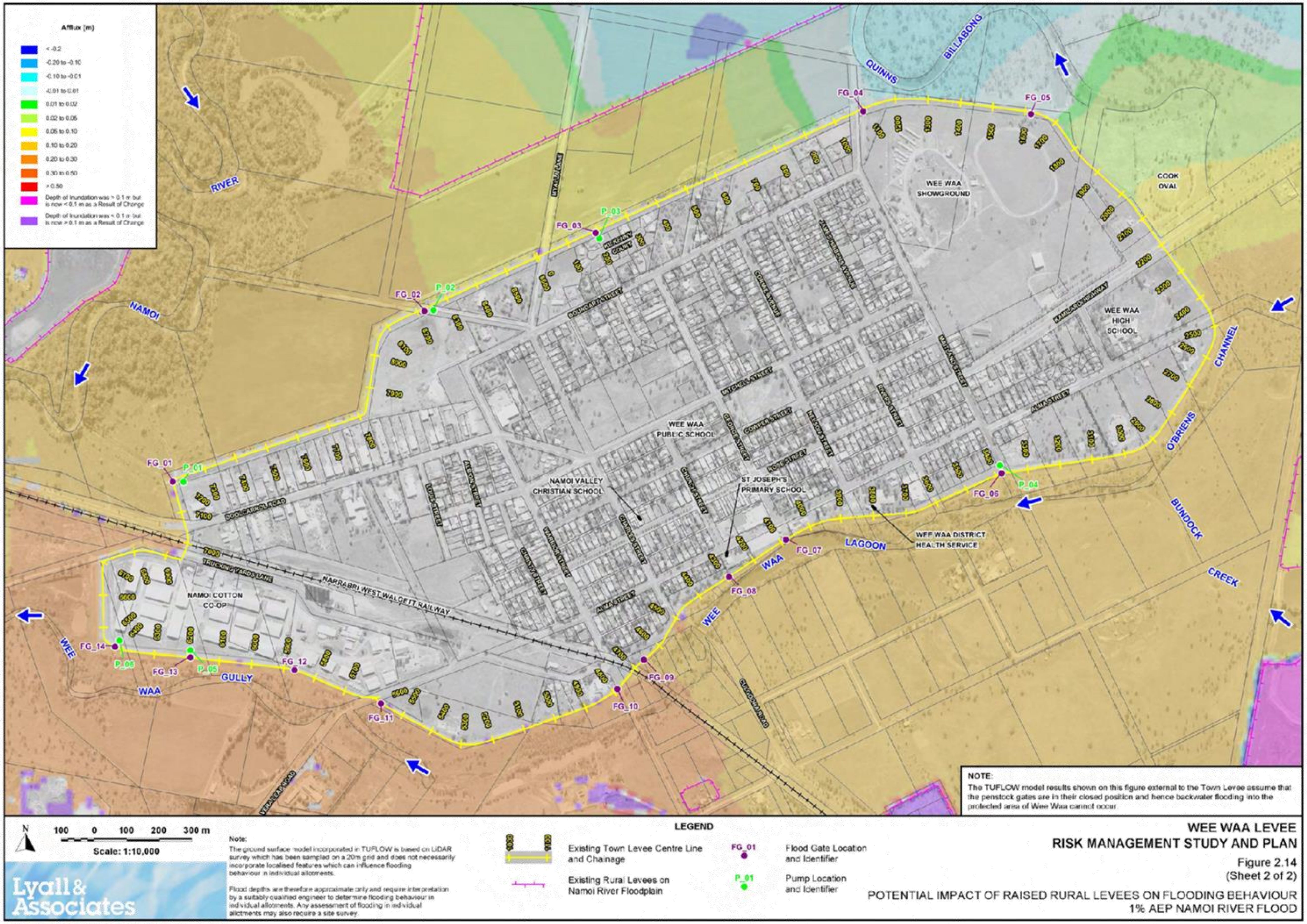
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

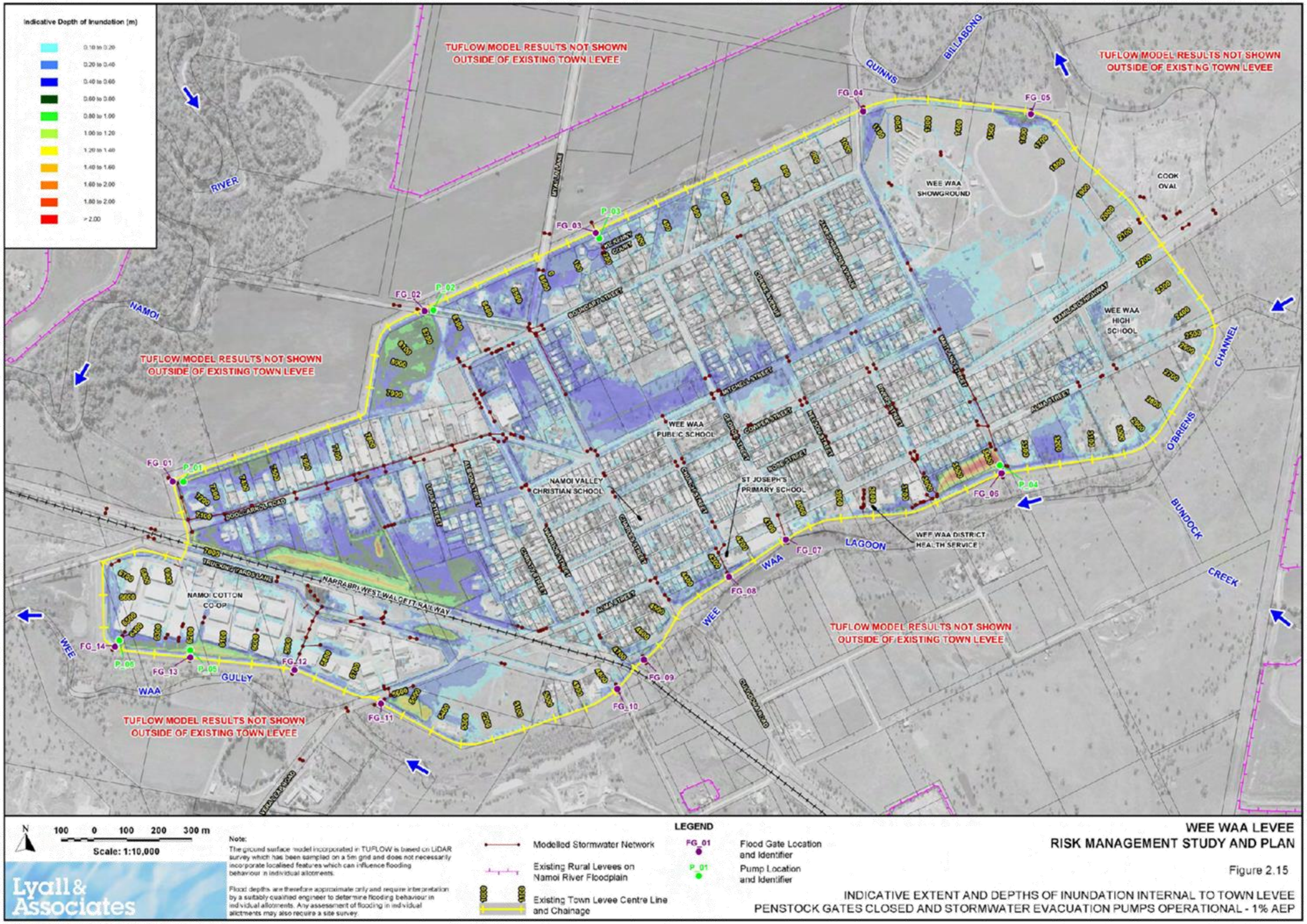
Figure 2.13
(Sheet 1 of 2)

TUFLOW MODEL RESULTS
1% AEP NAMOI RIVER FLOOD - RAISED RURAL LEVEES

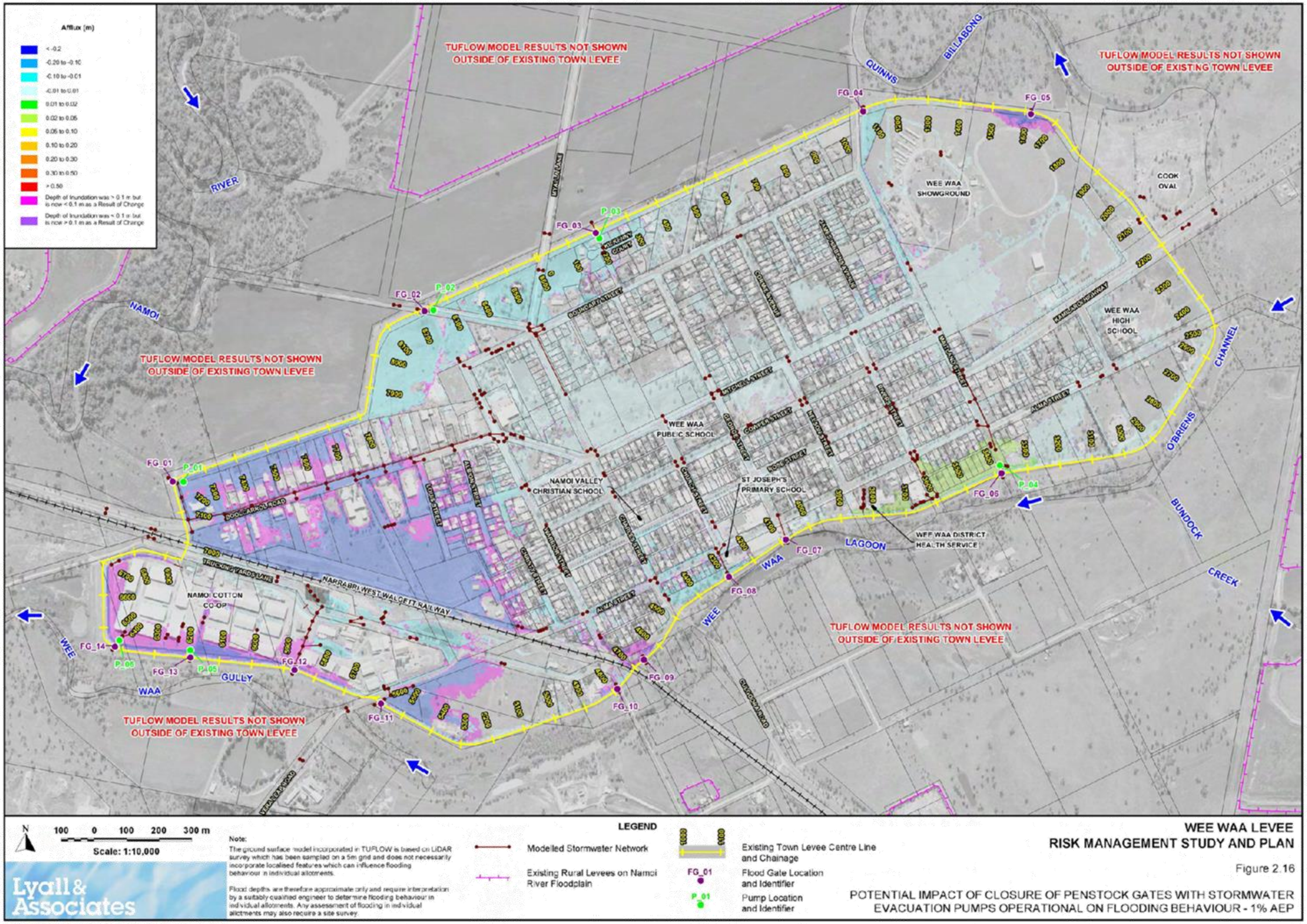

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
NAMOI RIVER
QUINNS BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
TRUCKING YARDS LANE
WEE WAA LAGOON
WEE WAA GULLY
O'BRIENS CHANNEL
BUNDOCK CREEK
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Water Surface Elevation Contours (m AHD)
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.13
(Sheet 2 of 2)
TUFLOW MODEL RESULTS
1% AEP NAMOI RIVER FLOOD - RAISED RURAL LEVEES

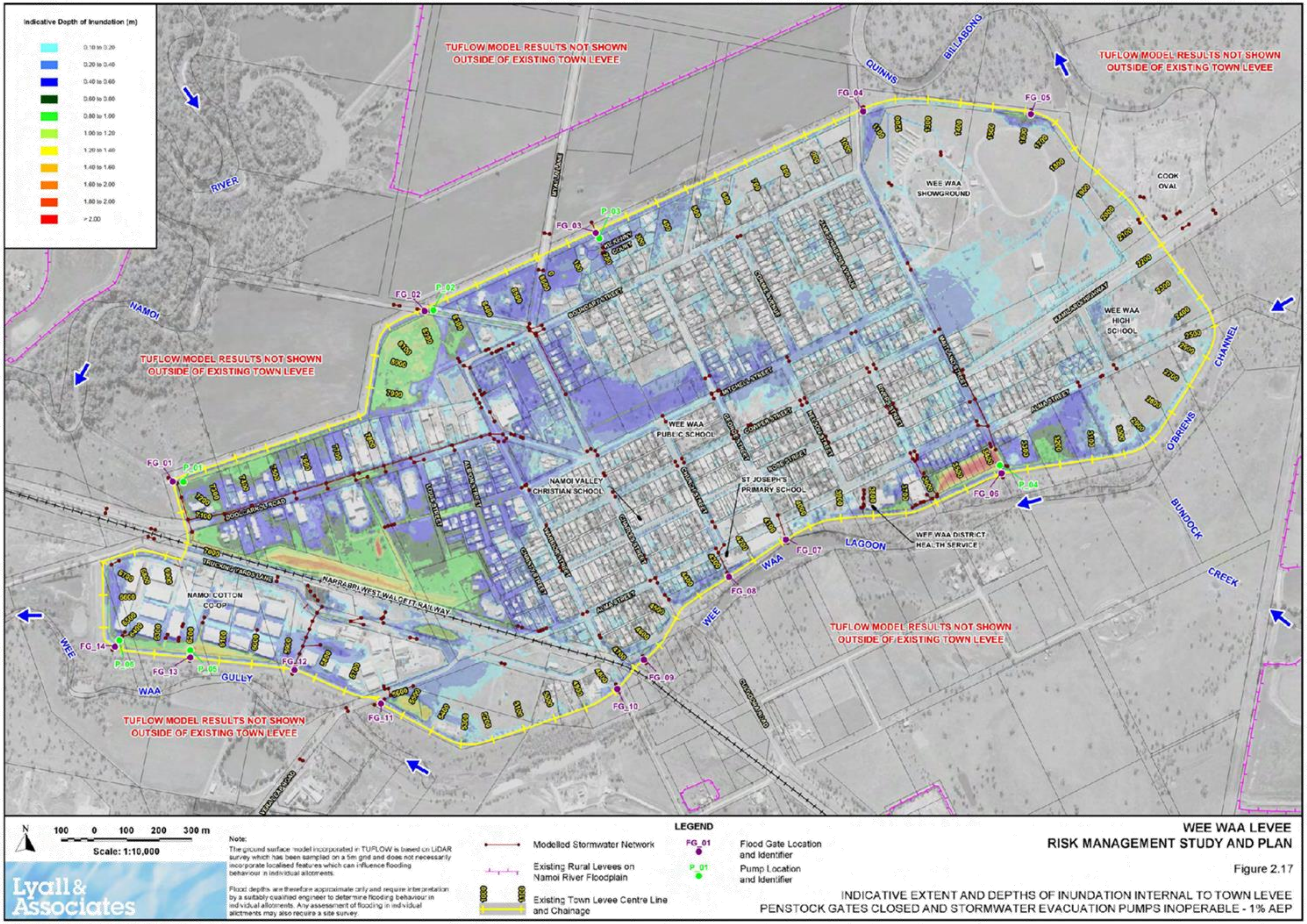

Afflux (m)
< 0.2
-0.20 to -0.10
-0.10 to -0.01
C.02 to C.05
C.05 to C.10
C.10 to C.20
C.20 to C.30
C.30 to C.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
NAMOI RIVER AT GLENCOE (GS419900)
REFER SHEET 2
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
NARRABRI-WEST-WALGETT-RAILWAY
QUINNS BILLABONG
O'BRIENS CHANNEL
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
NICHOLSON'S AIRPORT
THE PINES
KAMILAROI HIGHWAY
RIVER ROAD
CULGOORA ROAD
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
WaterNSW Stream Gauge
RC01
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.14
(Sheet 1 of 2)
POTENTIAL IMPACT OF RAISED RURAL LEVEES ON FLOODING BEHAVIOUR
1% AEP NAMOI RIVER FLOOD

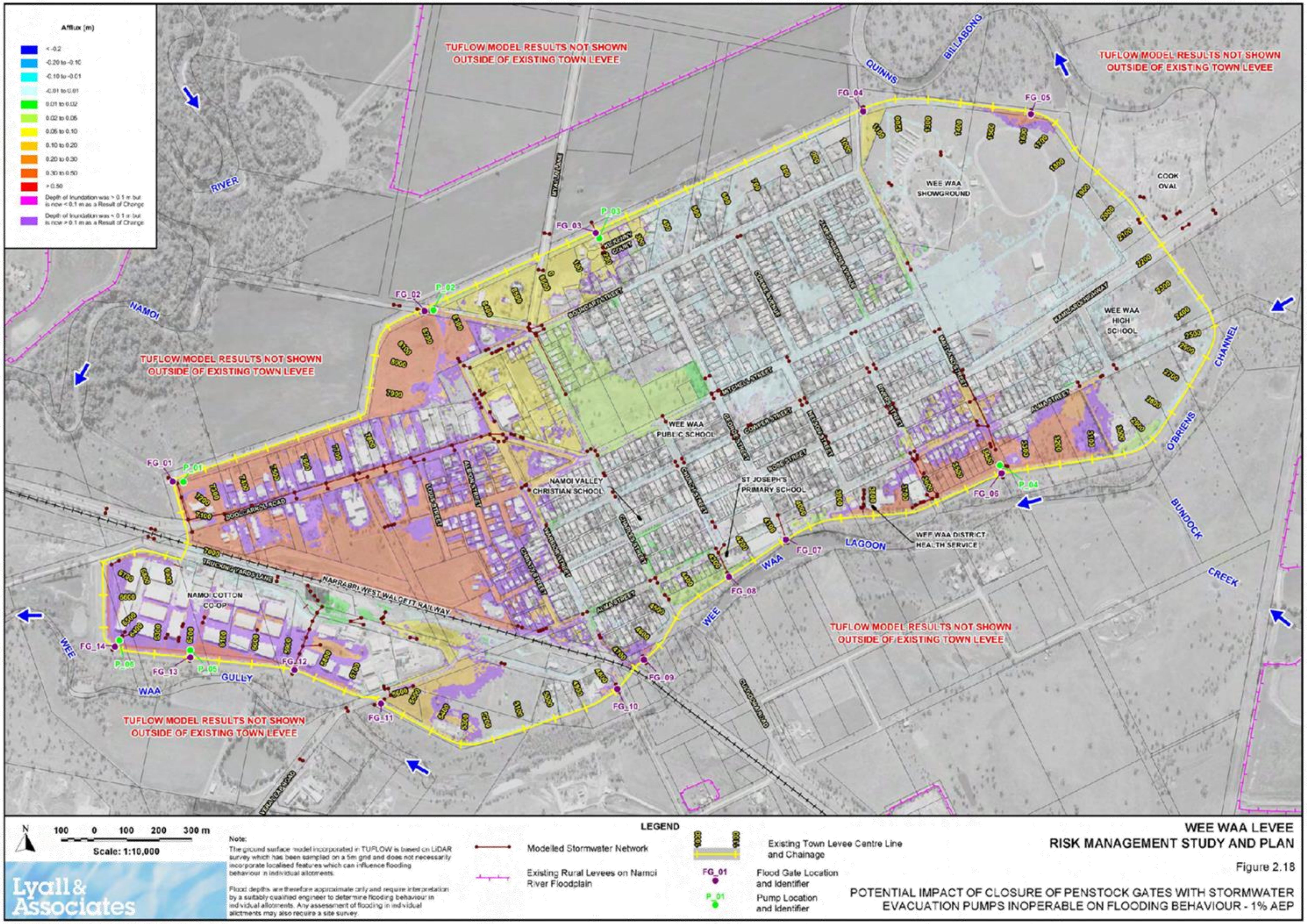

Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
QUINNS BILLABONG
NAMOI RIVER
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
WEE WAA LAGOON
O'BRIENS CHANNEL
BUNDOCK CREEK
WEE WAA GULLY
FG_01 FG_02 FG_03 FG_04 FG_05 FG_06 FG_07 FG_08 FG_09 FG_10 FG_11 FG_12 FG_13 FG_14
P_01 P_02 P_03 P_04 P_05 P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Existing Town Levee Centre Line and Chainage
Existing Rural Levees on Namoi River Floodplain
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.14
(Sheet 2 of 2)
POTENTIAL IMPACT OF RAISED RURAL LEVEES ON FLOODING BEHAVIOUR
1% AEP NAMOI RIVER FLOOD

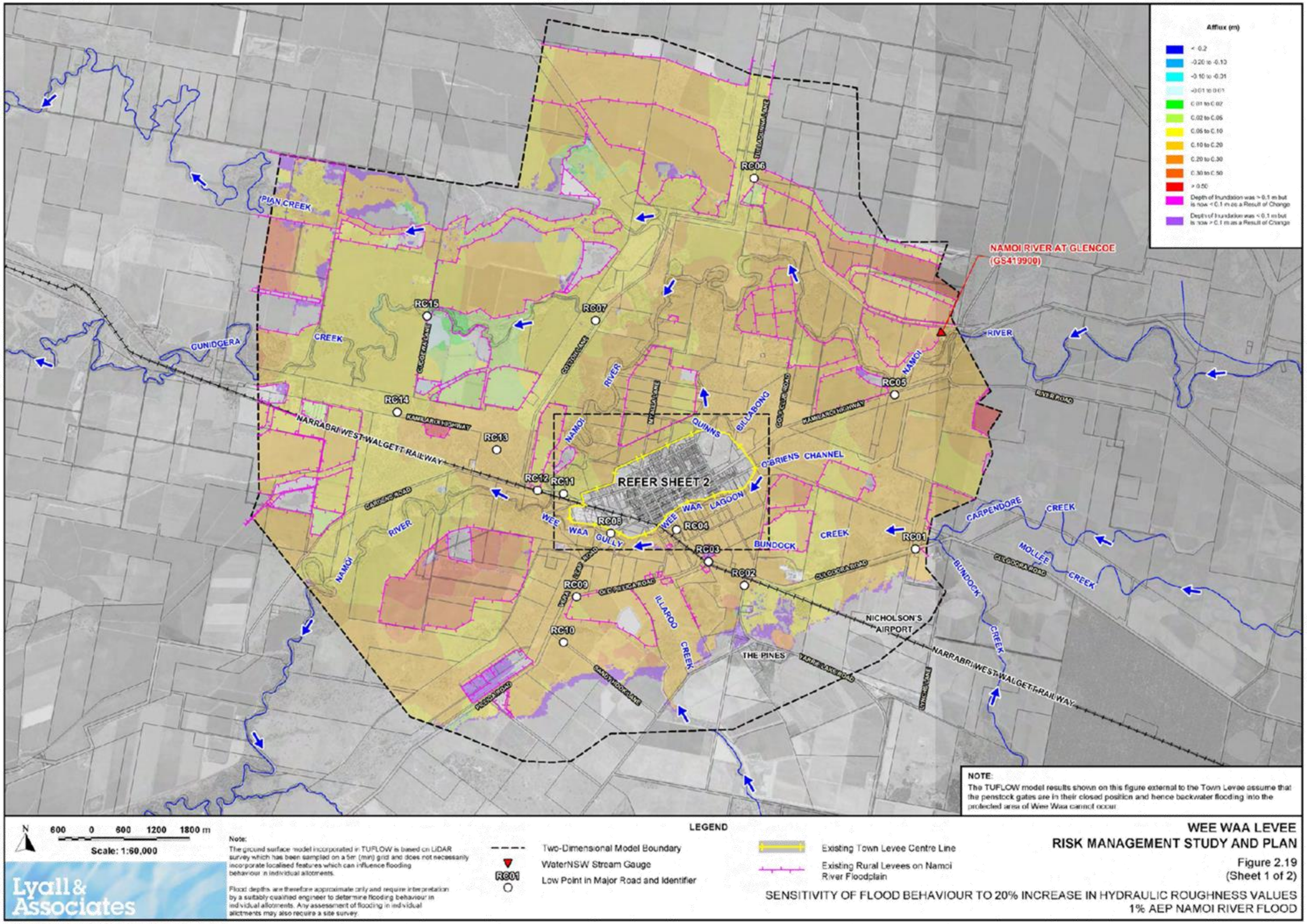


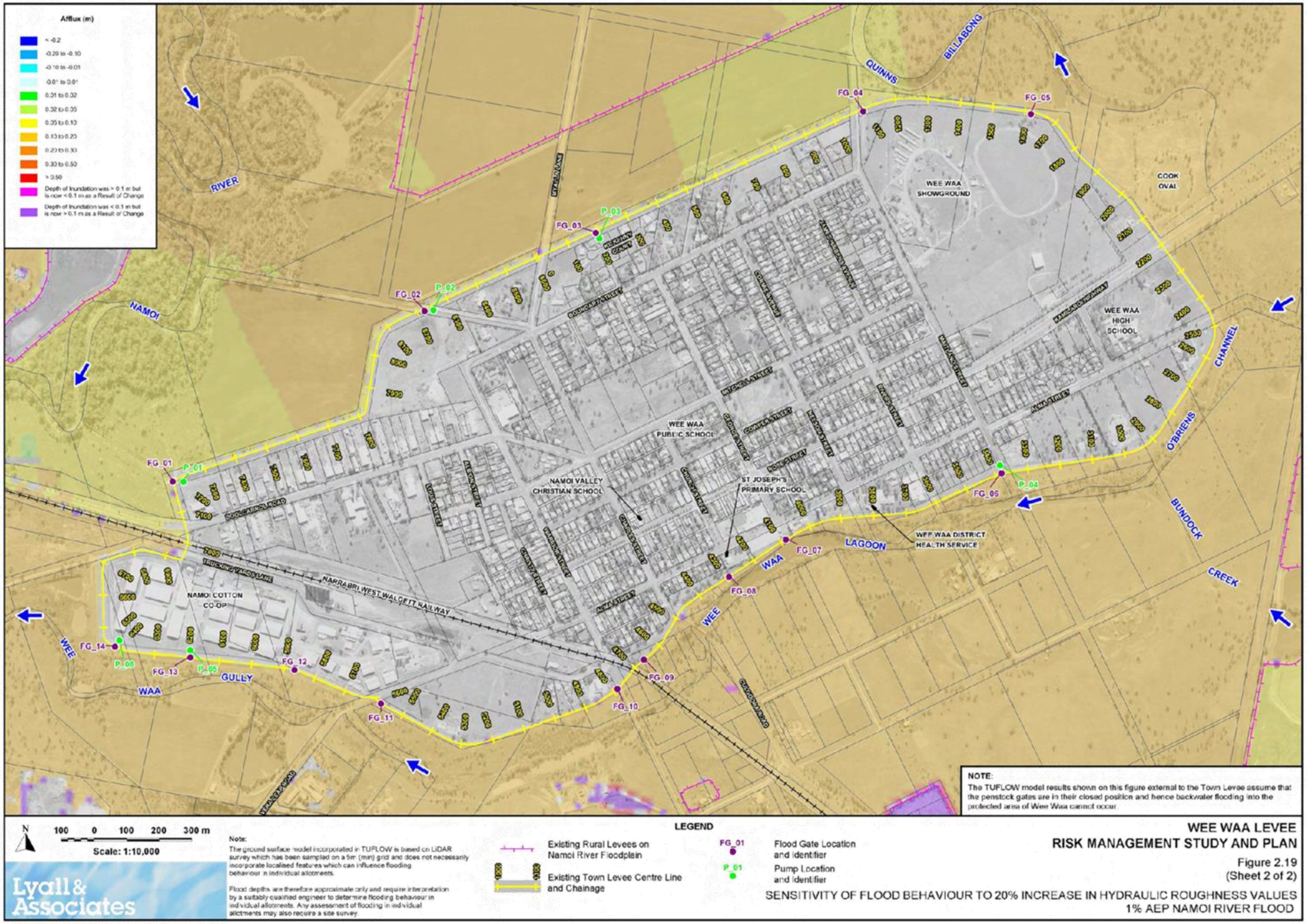
Indicative Depth of Inundation (m)
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
NAMOI RIVER
BILLABONG
QUINNS
O'BRIENS CHANNEL
BUNDOCK CREEK
WEE WAA LAGOON
WEE WAA GULLY
Scale: 1:10,000
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.15
INDICATIVE EXTENT AND DEPTHS OF INUNDATION INTERNAL TO TOWN LEVEE
PENSTOCK GATES CLOSED AND STORMWATER EVACUATION PUMPS OPERATIONAL - 1% AEP

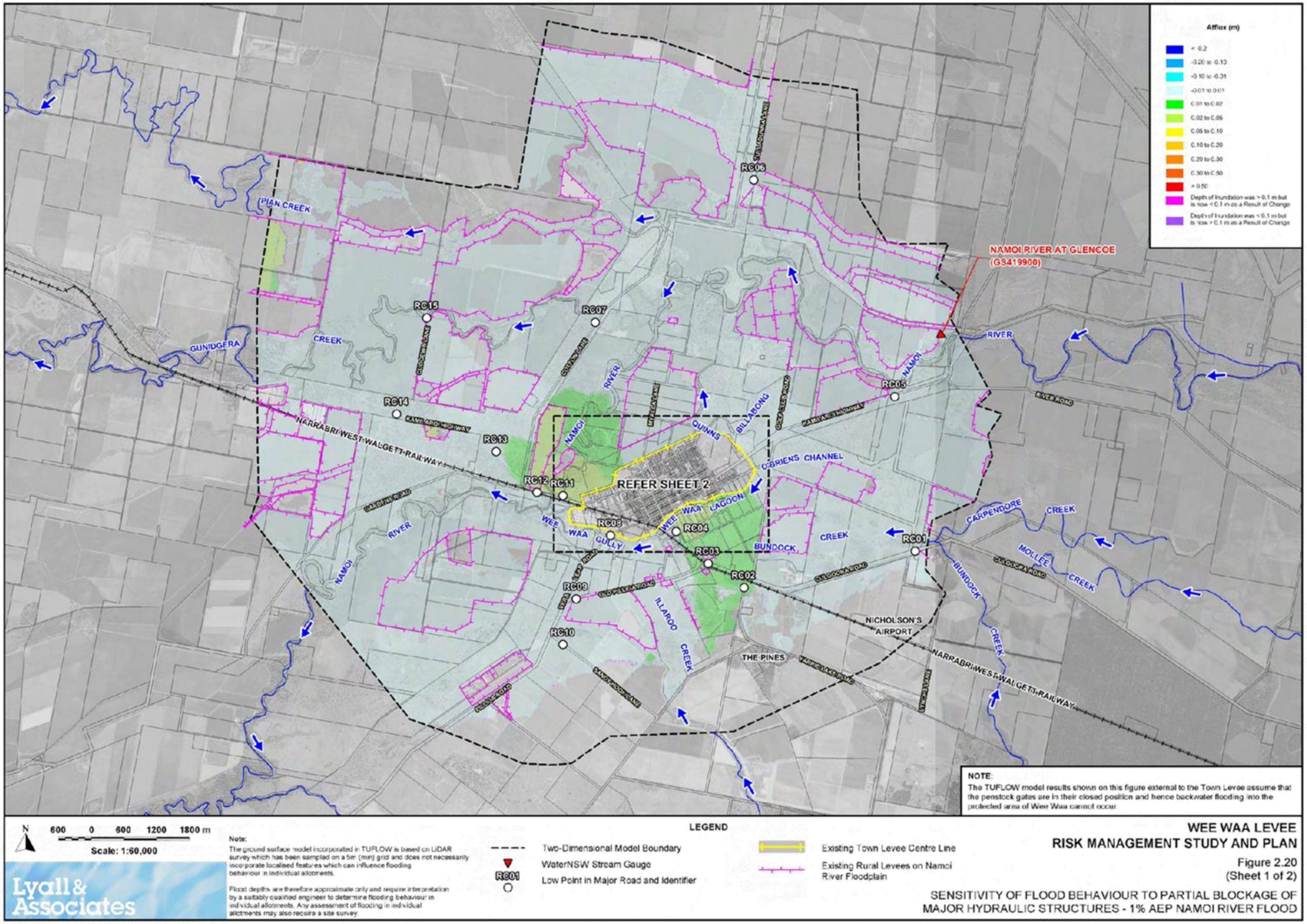

Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
NAMOI RIVER
QUINNS BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI-WEST WALGETT RAILWAY
WEE WAA LAGOON
WEE WAA GULLY
O'BRIENS CHANNEL
BUNDOCK CREEK
FG_01 FG_02 FG_03 FG_04 FG_05 FG_06 FG_07 FG_08 FG_09 FG_10 FG_11 FG_12 FG_13 FG_14
P_01 P_02 P_03 P_04 P_05 P_06
100 0 100 200 300 m
Scale: 1:10,000
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
Lyall & Associates
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.16
POTENTIAL IMPACT OF CLOSURE OF PENSTOCK GATES WITH STORMWATER EVACUATION PUMPS OPERATIONAL ON FLOODING BEHAVIOUR - 1% AEP

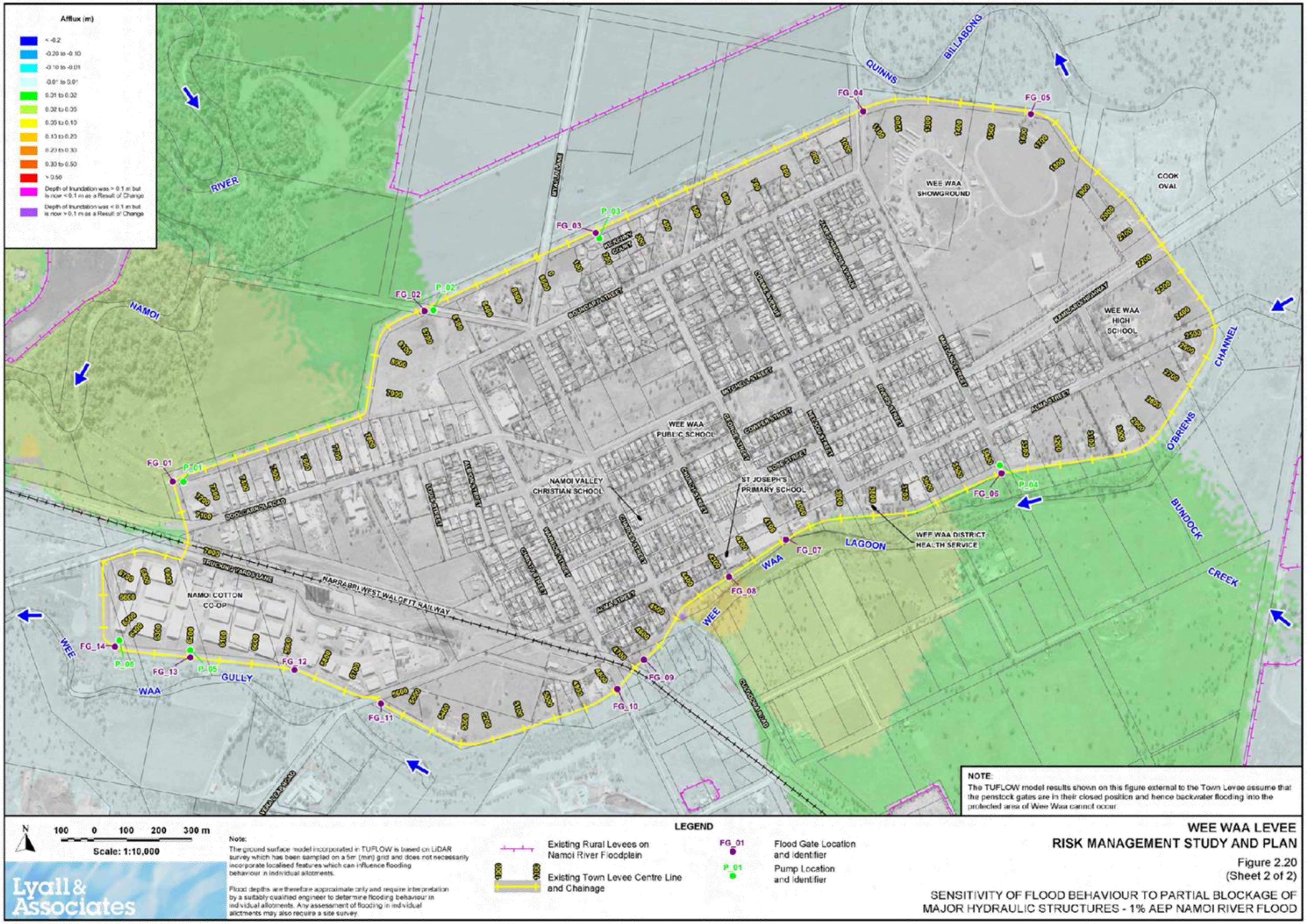

Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.20
1.20 to 1.40
1.40 to 1.60
1.60 to 2.00
1.80 to 2.00
> 2.00
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
NAMOI RIVER
QUINNS BILLABONG
O'BRIENS CHANNEL
BUNDOCK CREEK
WEE WAA LAGOON
WEE WAA GULLY
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
TRUCKING YARDS LANE
DOOLGARKOL ROAD
FG_01 FG_02 FG_03 FG_04 FG_05 FG_06 FG_07 FG_08 FG_09 FG_10 FG_11 FG_12 FG_13 FG_14
P_01 P_02 P_03 P_04 P_05 P_06
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.17
INDICATIVE EXTENT AND DEPTHS OF INUNDATION INTERNAL TO TOWN LEVEE
PENSTOCK GATES CLOSED AND STORMWATER EVACUATION PUMPS INOPERABLE - 1% AEP

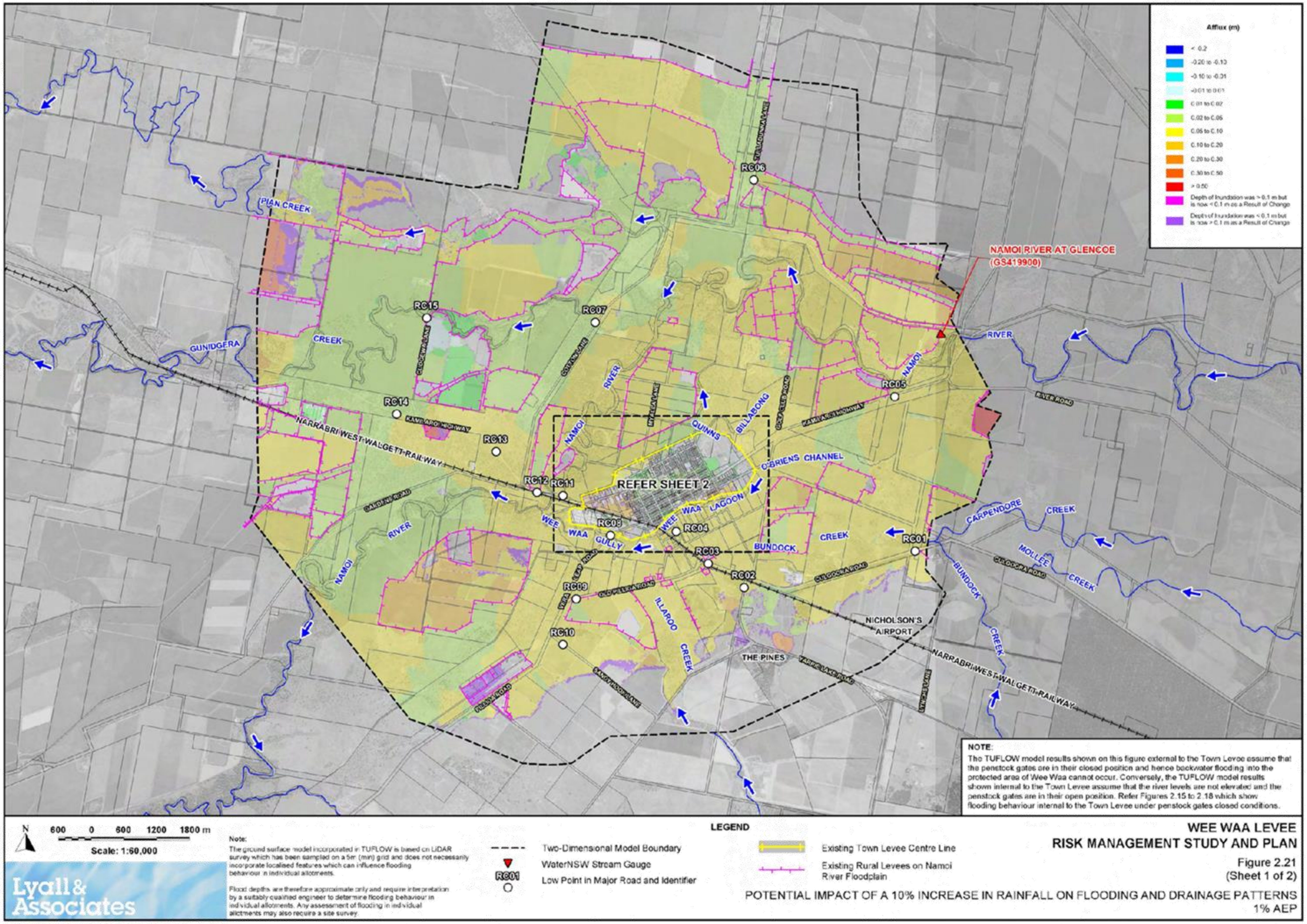

Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
NAMOI
RIVER
QUINNS
BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
WEE WAA
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
WEE WAA GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.18
POTENTIAL IMPACT OF CLOSURE OF PENSTOCK GATES WITH STORMWATER EVACUATION PUMPS INOPERABLE ON FLOODING BEHAVIOUR - 1% AEP

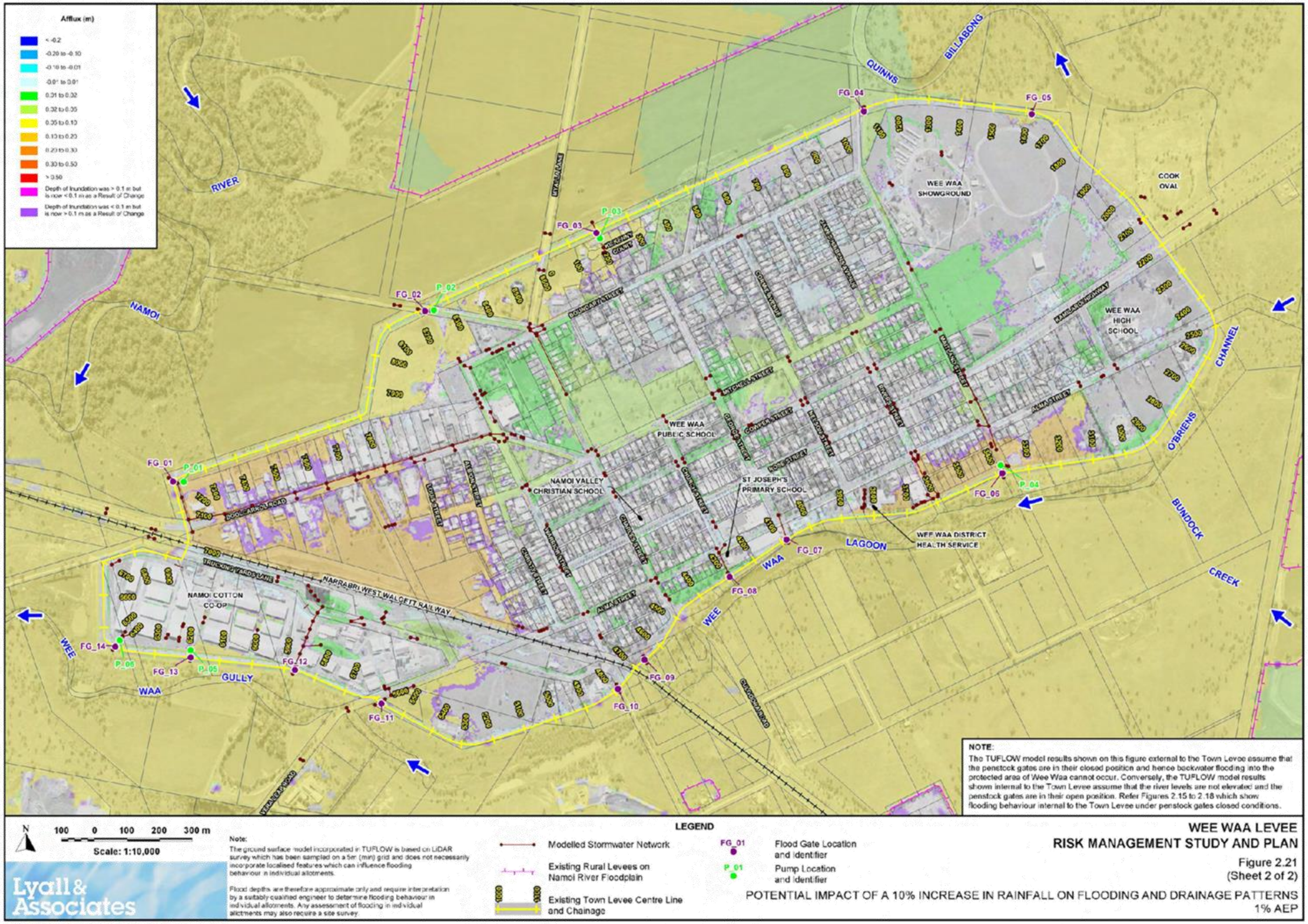

Afflux (m)
< 0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
RC06
RC07
RC15
RC14
RC13
RC12
RC11
RC05
RC04
RC03
RC02
RC01
RC09
RC10
RC08
NAMOI RIVER
QUINNS BILLABONG
O'BRIENS CHANNEL
REFER SHEET 2
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
KAMILAROI HIGHWAY
NARRABRI WEST-WALGETT RAILWAY
NICHOLSON'S AIRPORT
THE PINES
RIVER ROAD
CULGOORA ROAD
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
WaterNSW Stream Gauge
RC01
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.19
(Sheet 1 of 2)
SENSITIVITY OF FLOOD BEHAVIOUR TO 20% INCREASE IN HYDRAULIC ROUGHNESS VALUES
1% AEP NAMOI RIVER FLOOD


Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
NAMOI RIVER
QUINNS BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK CREEK
WEE WAA LAGOON
WEE WAA DISTRICT HEALTH SERVICE
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
WEE WAA GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.19
(Sheet 2 of 2)
SENSITIVITY OF FLOOD BEHAVIOUR TO 20% INCREASE IN HYDRAULIC ROUGHNESS VALUES
1% AEP NAMOI RIVER FLOOD

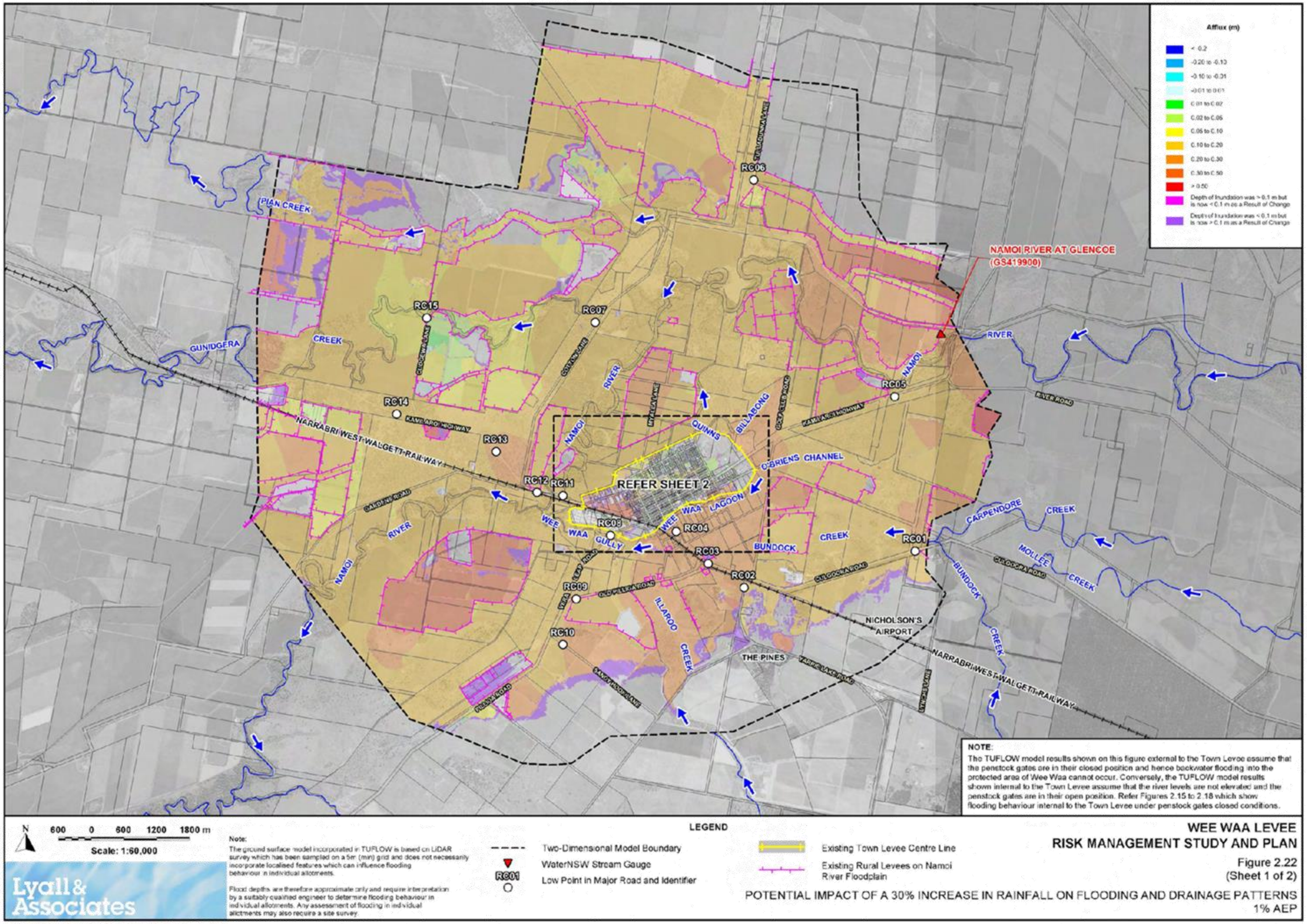

Afflux (m)
< 0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA
CREEK
RC06
RC07
RC15
RC14
RC13
RC12
RC11
RC08
RC04
RC03
RC02
RC01
RC05
RC09
RC10
NAMOI
RIVER
NAMOI
RIVER
NAMOI
RIVER
REFER SHEET 2
QUINNS
BILLABONG
O'BRIENS CHANNEL
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
BUNDOCK CREEK
ILLAROO CREEK
NARRABRI-WEST-WALGETT-RAILWAY
NARRABRI-WEST-WALGETT-RAILWAY
KAMILAROI HIGHWAY
RIVER ROAD
CULGOORA ROAD
NICHOLSON'S AIRPORT
THE PINES
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
WaterNSW Stream Gauge
RC01
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.20
(Sheet 1 of 2)
SENSITIVITY OF FLOOD BEHAVIOUR TO PARTIAL BLOCKAGE OF MAJOR HYDRAULIC STRUCTURES - 1% AEP NAMOI RIVER FLOOD

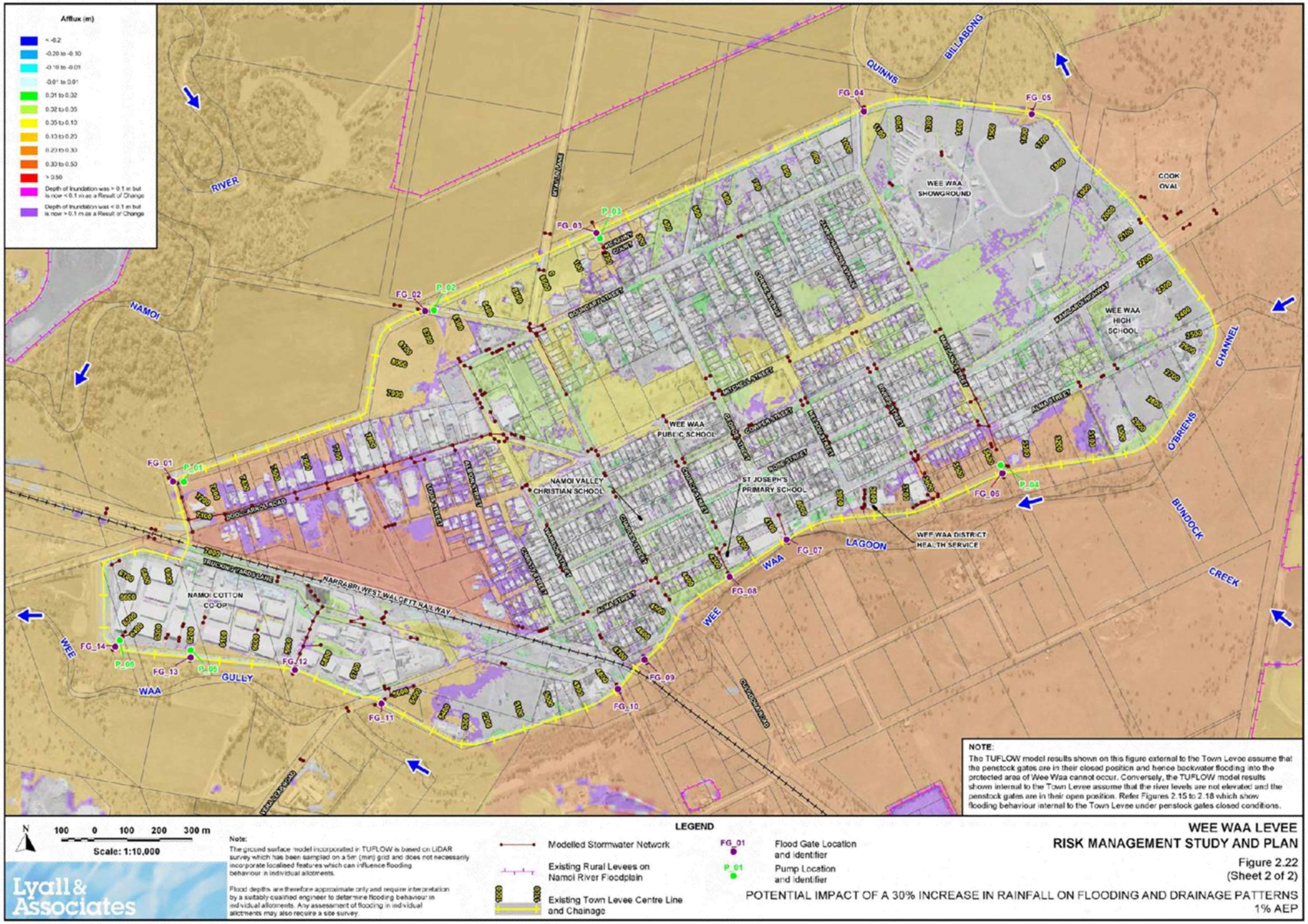

Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
QUINNS
BILLABONG
NAMOI
RIVER
FG_01
P_01
FG_02
P_02
FG_03
P_03
FG_04
FG_05
FG_06
P_04
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
P_05
FG_14
P_06
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
WEE
WAA
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
TRUCKING YARDS LANE
WEE
WAA
GULLY
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.20
(Sheet 2 of 2)
SENSITIVITY OF FLOOD BEHAVIOUR TO PARTIAL BLOCKAGE OF MAJOR HYDRAULIC STRUCTURES - 1% AEP NAMOI RIVER FLOOD

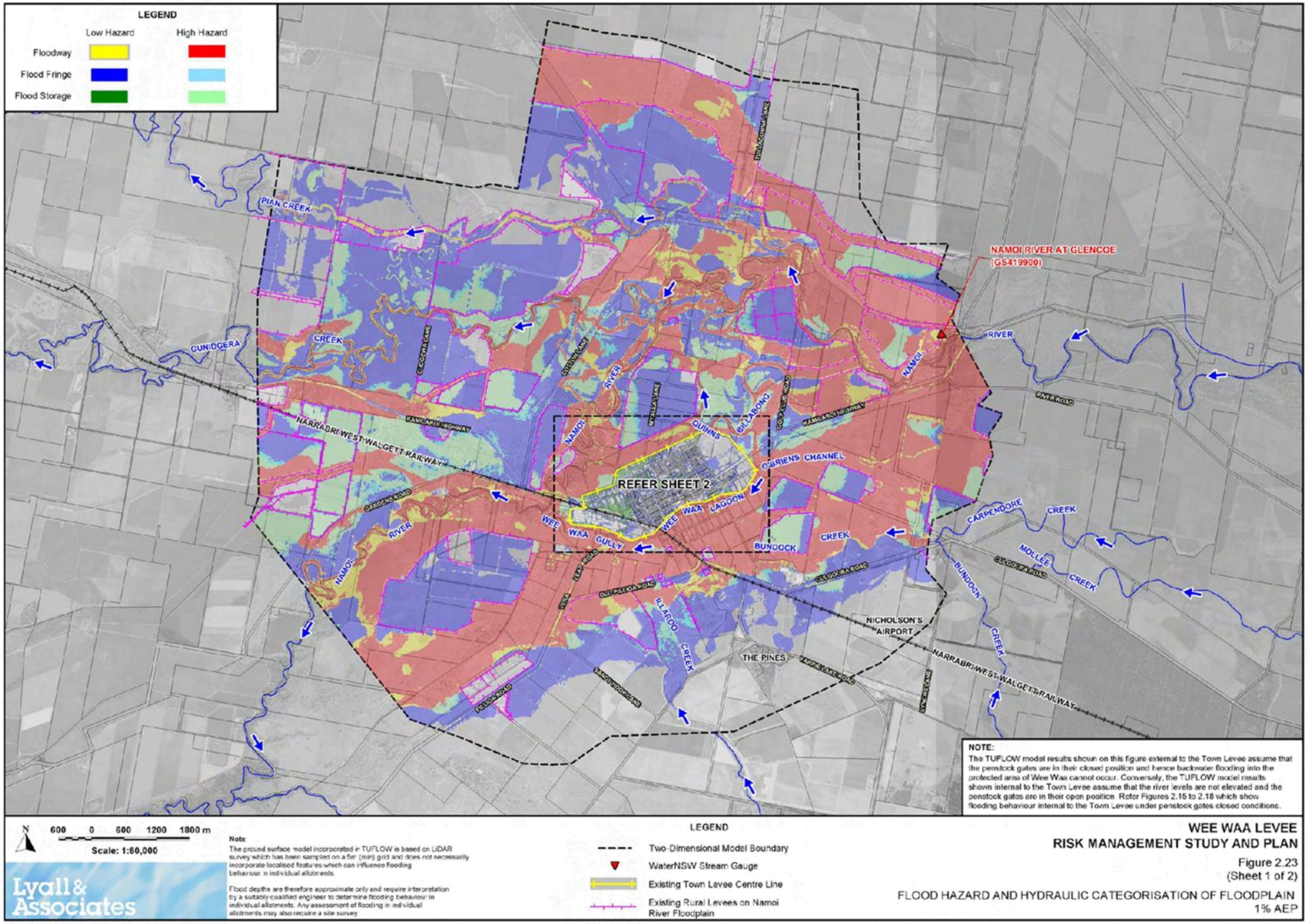

Afflux (m)
< 0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
REFER SHEET 2
QUINNS BILLABONG
O'BRIENS CHANNEL
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
NARRABRI-WEST-WALGETT-RAILWAY
NICHOLSON'S AIRPORT
THE PINES
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
WaterNSW Stream Gauge
RC01 Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.21
(Sheet 1 of 2)
POTENTIAL IMPACT OF A 10% INCREASE IN RAINFALL ON FLOODING AND DRAINAGE PATTERNS
1% AEP

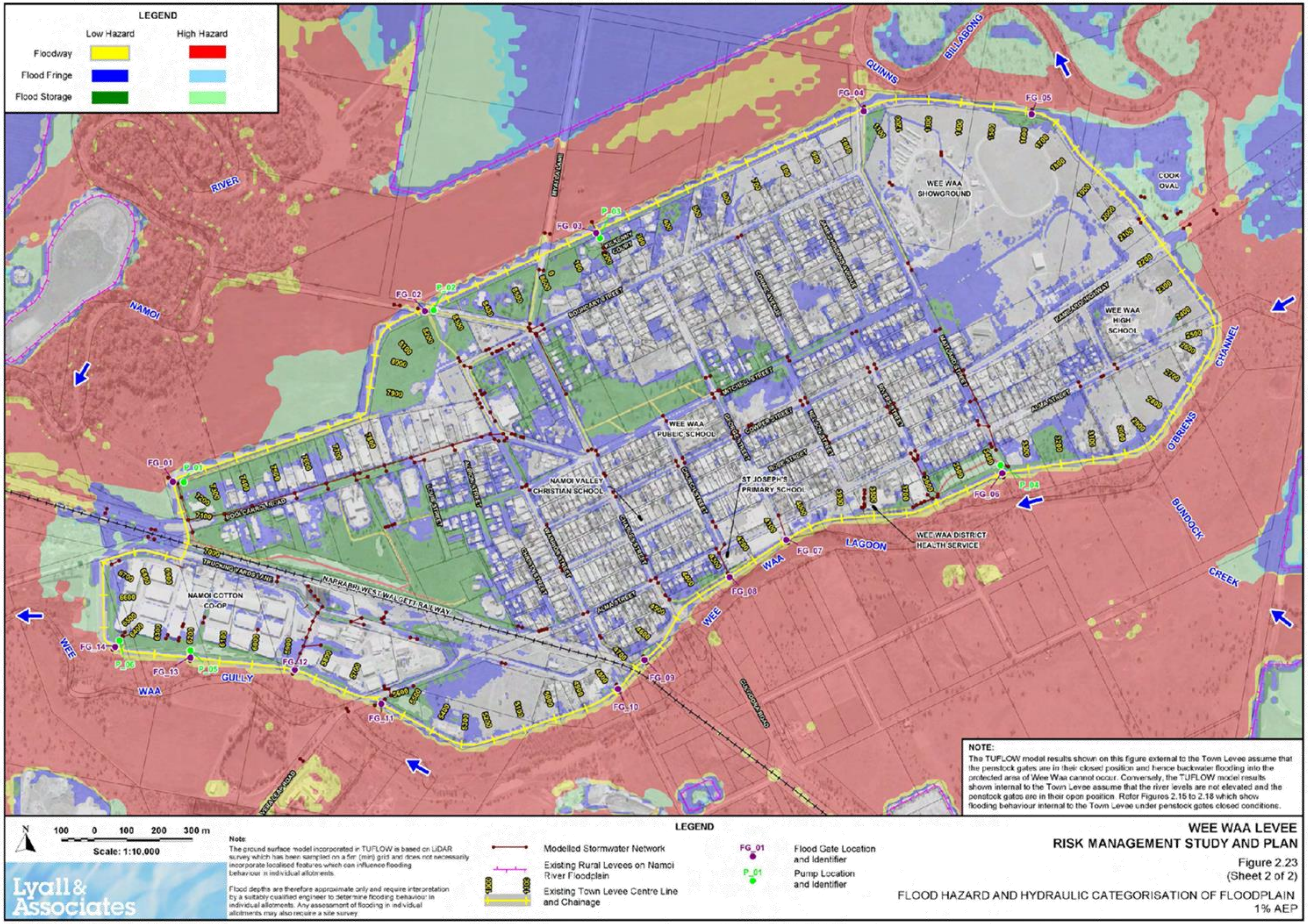


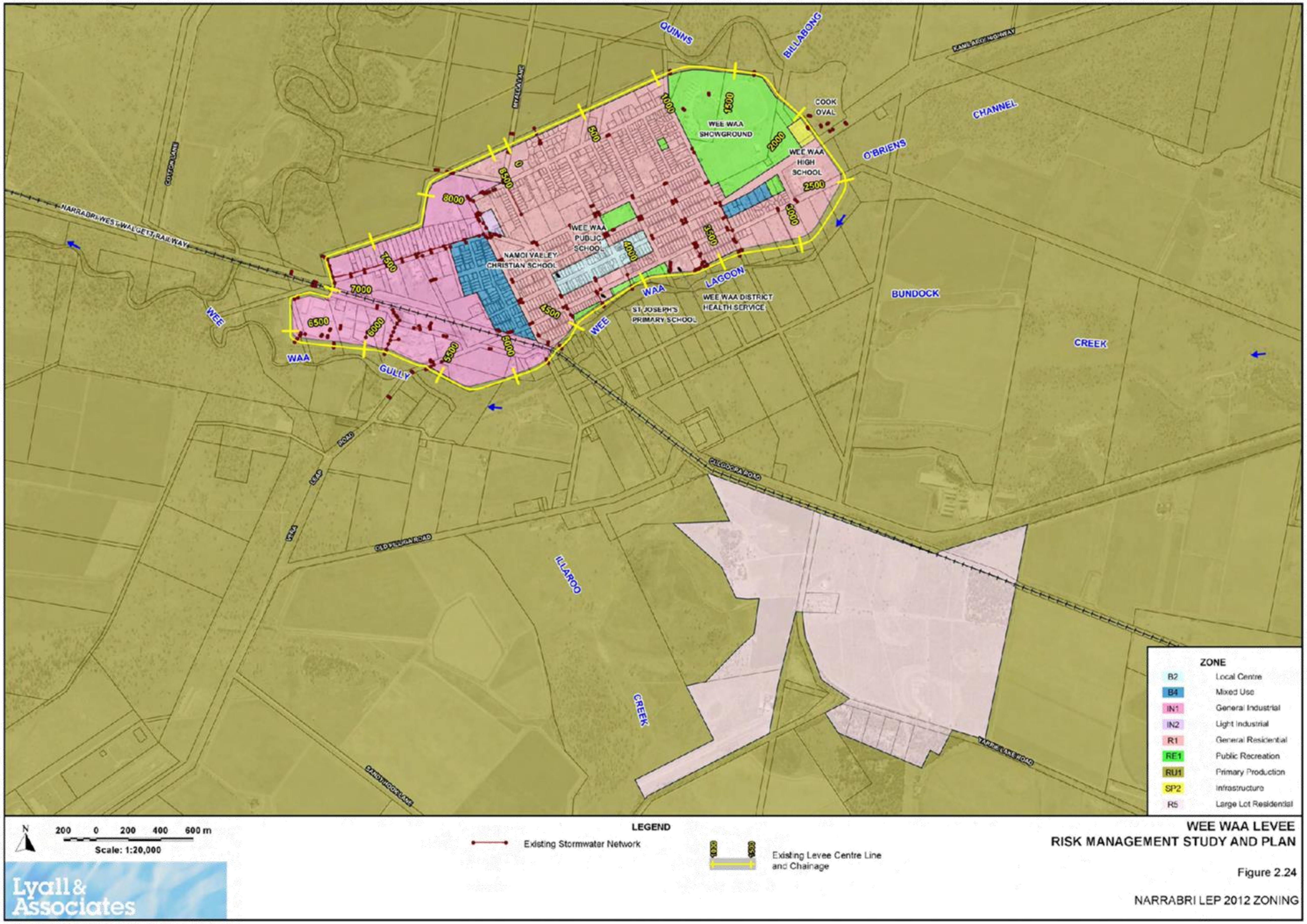
Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
NAMOI
RIVER
QUINNS
BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
WEE WAA GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.21
(Sheet 2 of 2)
POTENTIAL IMPACT OF A 10% INCREASE IN RAINFALL ON FLOODING AND DRAINAGE PATTERNS
1% AEP

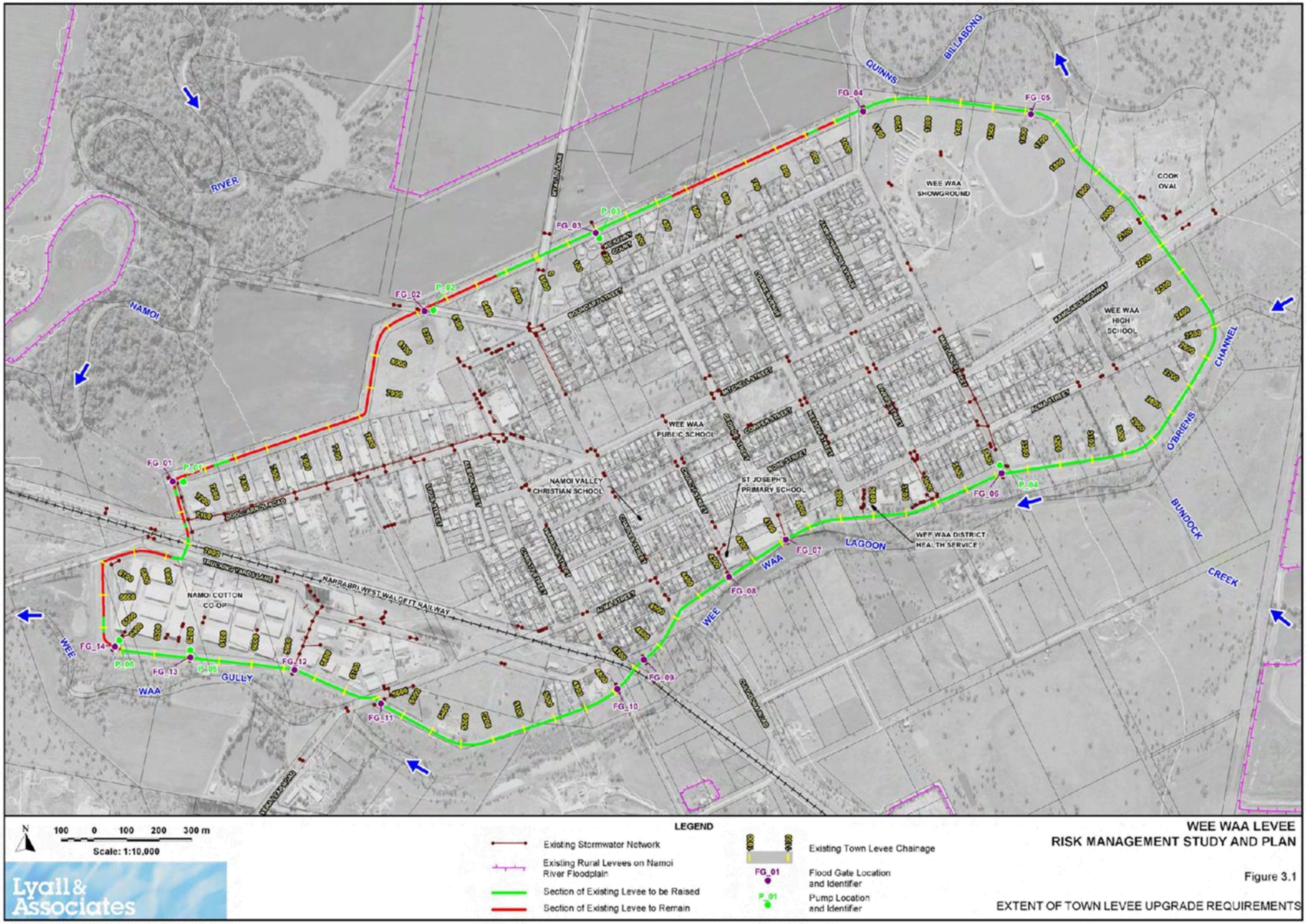

Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
NAMOI RIVER AT GLENCOE (GS419900)
PIAN CREEK
GUNIDGERA CREEK
NAMOI RIVER
RC01
RC02
RC03
RC04
RC05
RC06
RC07
RC08
RC09
RC10
RC11
RC12
RC13
RC14
RC15
REFER SHEET 2
QUINNS BILLABONG
O'BRIENS CHANNEL
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
CARPENDORE CREEK
MOLLEE CREEK
ILLAROO CREEK
NARRABRI-WEST-WALGETT-RAILWAY
KAMILAROI HIGHWAY
RIVER ROAD
CULGOORA ROAD
NICHOLSON'S AIRPORT
THE PINES
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LIDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
WaterNSW Stream Gauge
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.22
(Sheet 1 of 2)
POTENTIAL IMPACT OF A 30% INCREASE IN RAINFALL ON FLOODING AND DRAINAGE PATTERNS
1% AEP

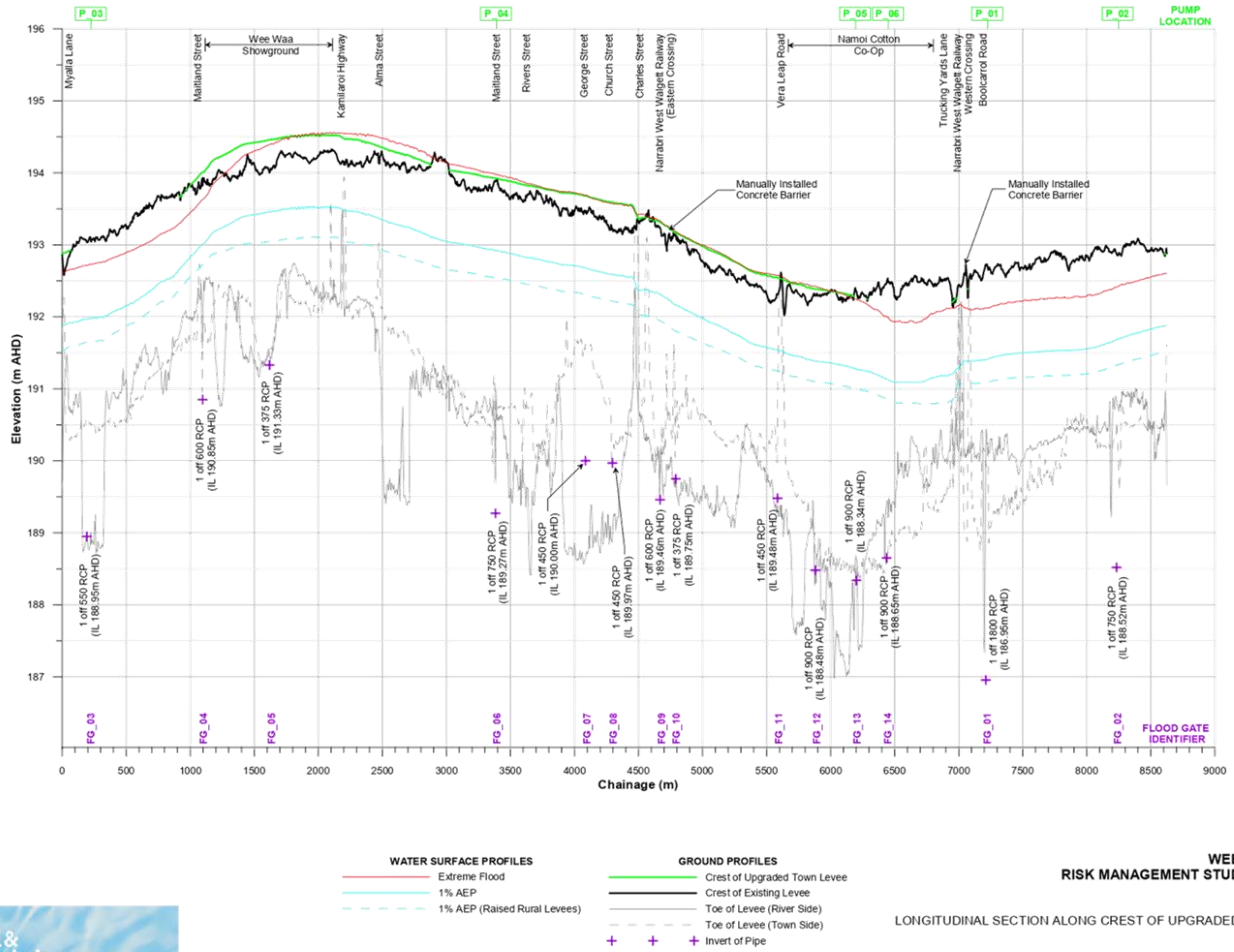

Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
NAMOI
RIVER
QUINNS
BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
WEE
WAA
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
TRUCKING YARDS LANE
GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LIDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.22
(Sheet 2 of 2)
POTENTIAL IMPACT OF A 30% INCREASE IN RAINFALL ON FLOODING AND DRAINAGE PATTERNS
1% AEP


LEGEND
Low Hazard
High Hazard
Floodway
Flood Fringe
Flood Storage
PIAN CREEK
CREEK
GUNIDGERA
NAMOI RIVER AT GLENCOE
(GS419900)
RIVER
NAMOI
RIVER
NAMOI
QUINNS
BILLABONG
O'BRIENS CHANNEL
REFER SHEET 2
WEE WAA LAGOON
WEE WAA GULLY
NARRABRI-WEST-WALGETT RAILWAY
KAMILAROI HIGHWAY
RIVER ROAD
CARPENDORE
CREEK
MOLLEE
CREEK
BUNDOCK
CREEK
BUNDOCK CREEK
NAMOI
RIVER
ILLAROO
CREEK
NICHOLSON'S
AIRPORT
THE PINES
NARRABRI-WEST-WALGETT RAILWAY
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
WaterNSW Stream Gauge
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.23
(Sheet 1 of 2)
FLOOD HAZARD AND HYDRAULIC CATEGORISATION OF FLOODPLAIN
1% AEP


LEGEND
Low Hazard
High Hazard
Floodway
Flood Fringe
Flood Storage
NAMOI
RIVER
QUINNS
BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
LAGOON
WEE WAA DISTRICT HEALTH SERVICE
ST JOSEPH'S PRIMARY SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI COTTON CO-OP
NARRABRI-WEST WALGETT RAILWAY
WEE
WAA
GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
The TUFLOW model results shown on this figure external to the Town Levee assume that the penstock gates are in their closed position and hence backwater flooding into the protected area of Wee Waa cannot occur. Conversely, the TUFLOW model results shown internal to the Town Levee assume that the river levels are not elevated and the penstock gates are in their open position. Refer Figures 2.15 to 2.18 which show flooding behaviour internal to the Town Levee under penstock gates closed conditions.
100 0 100 200 300 m
Scale: 1:10,000
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.23
(Sheet 2 of 2)
FLOOD HAZARD AND HYDRAULIC CATEGORISATION OF FLOODPLAIN
1% AEP


QUINNS
BILLABONG
KAMILAROI HIGHWAY
COOK OVAL
WEE WAA SHOWGROUND
CHANNEL
O'BRIENS
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
NARRABRI-WEST-WALGETT RAILWAY
LAGOON
WAA
WEE
WEE WAA DISTRICT HEALTH SERVICE
ST JOSEPH'S PRIMARY SCHOOL
BUNDOCK
CREEK
WEE
WAA
GULLY
ROAD
ILLAROO
CREEK
OLD PILLIGA ROAD
CULGOORA ROAD
YARRIE LAKE ROAD
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
ZONE
B2 Local Centre
B4 Mixed Use
IN1 General Industrial
IN2 Light Industrial
R1 General Residential
RE1 Public Recreation
RU1 Primary Production
SP2 Infrastructure
R5 Large Lot Residential
N
200 0 200 400 600 m
Scale: 1:20,000
LEGEND
Existing Stormwater Network
Existing Levee Centre Line and Chainage
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 2.24
NARRABRI LEP 2012 ZONING

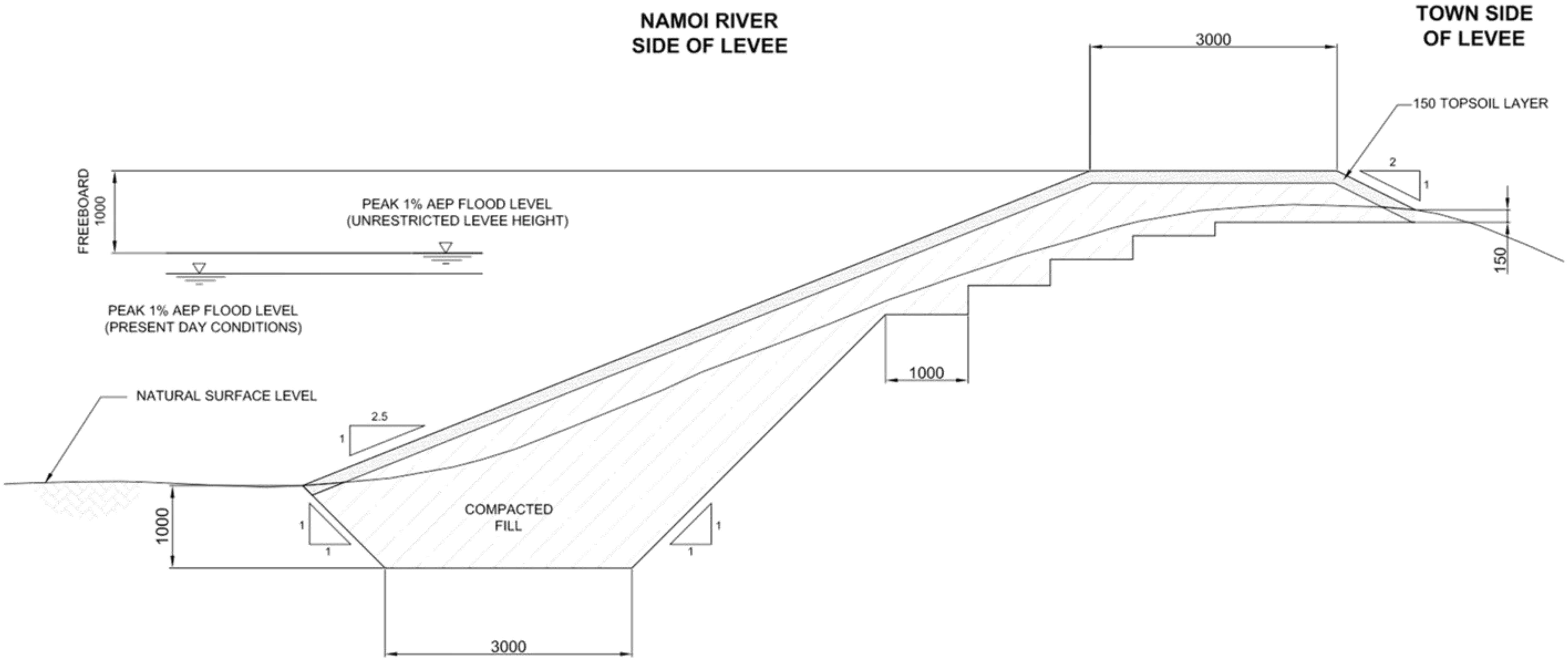

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 3.1
EXTENT OF TOWN LEVEE UPGRADE REQUIREMENTS
LEGEND
Existing Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Section of Existing Levee to be Raised
Section of Existing Levee to Remain
Existing Town Levee Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
NAMOI RIVER
QUINNS BILLABONG
COOK OVAL
WEE WAA SHOWGROUND
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
O'BRIENS CHANNEL
BUNDOCK CREEK
WEE WAA LAGOON
WEE WAA GULLY
FG_01 FG_02 FG_03 FG_04 FG_05 FG_06 FG_07 FG_08 FG_09 FG_10 FG_11 FG_12 FG_13 FG_14
P_01 P_02 P_03 P_04 P_05 P_06



WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure 3.2

LONGITUDINAL SECTION ALONG CREST OF UPGRADED TOWN LEVEE



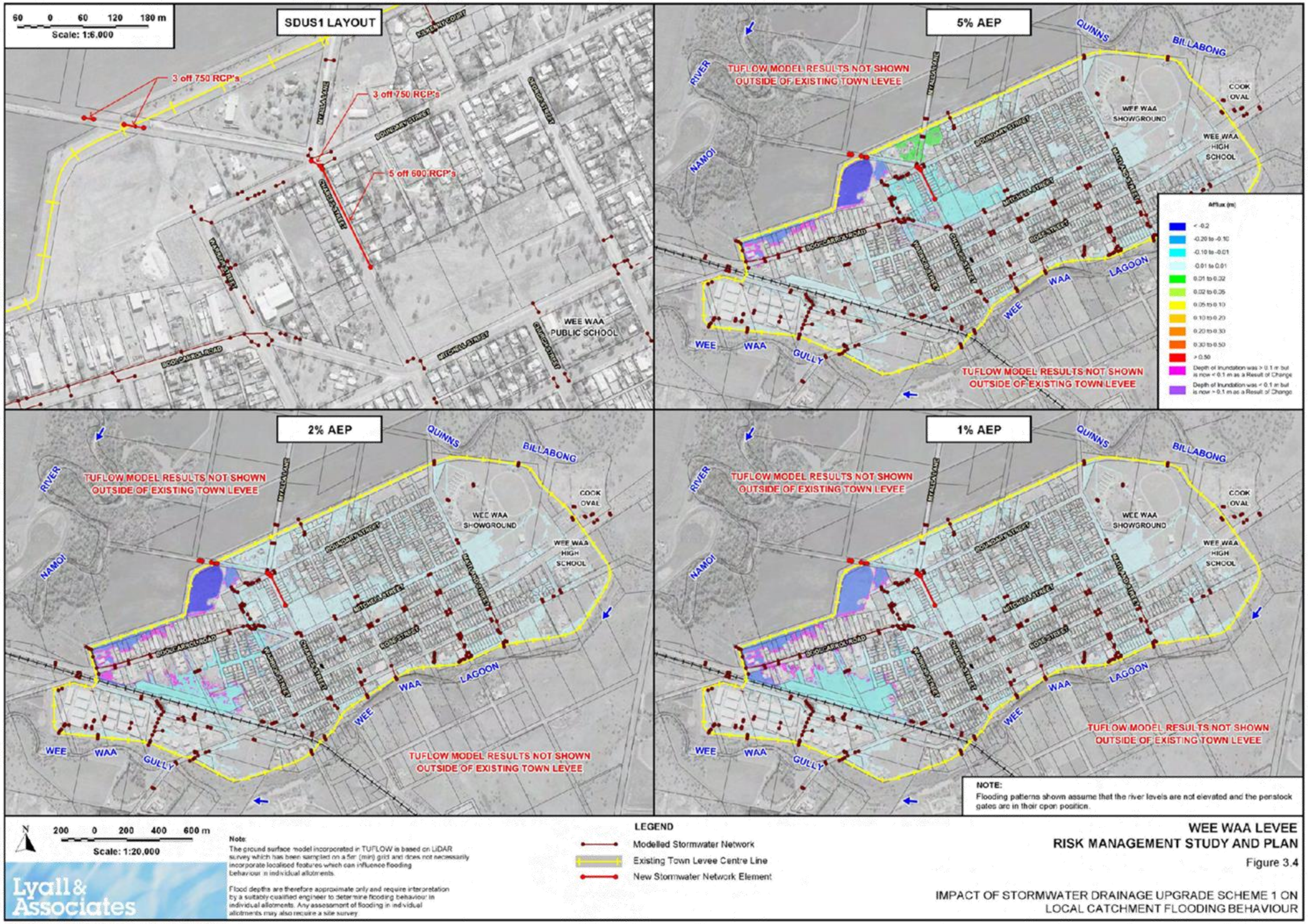
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Lyall & Associates

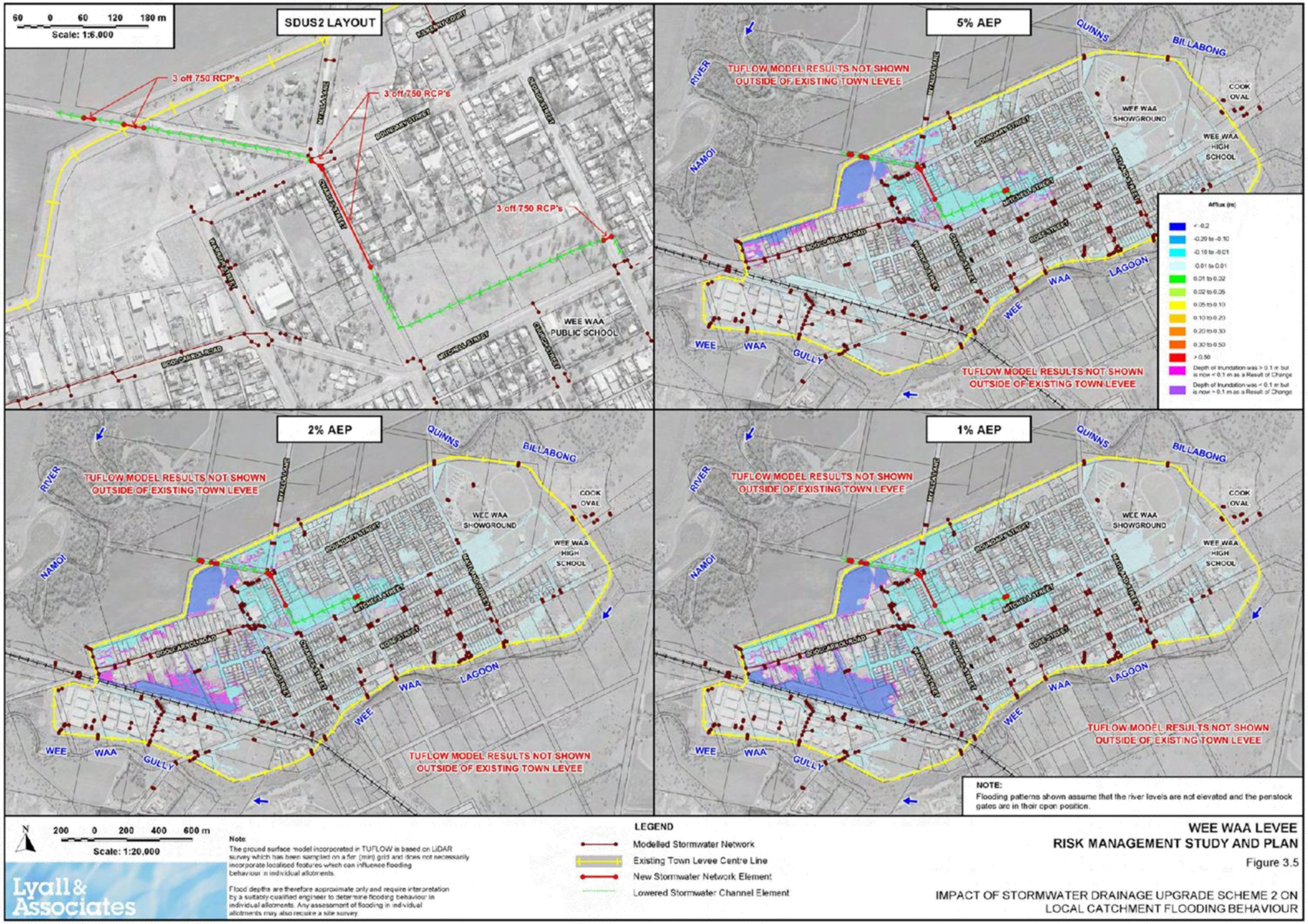
Note:
Vertical Scale: 1:50
Horizontal Scale: 1:50
All dimensions in millimetres.

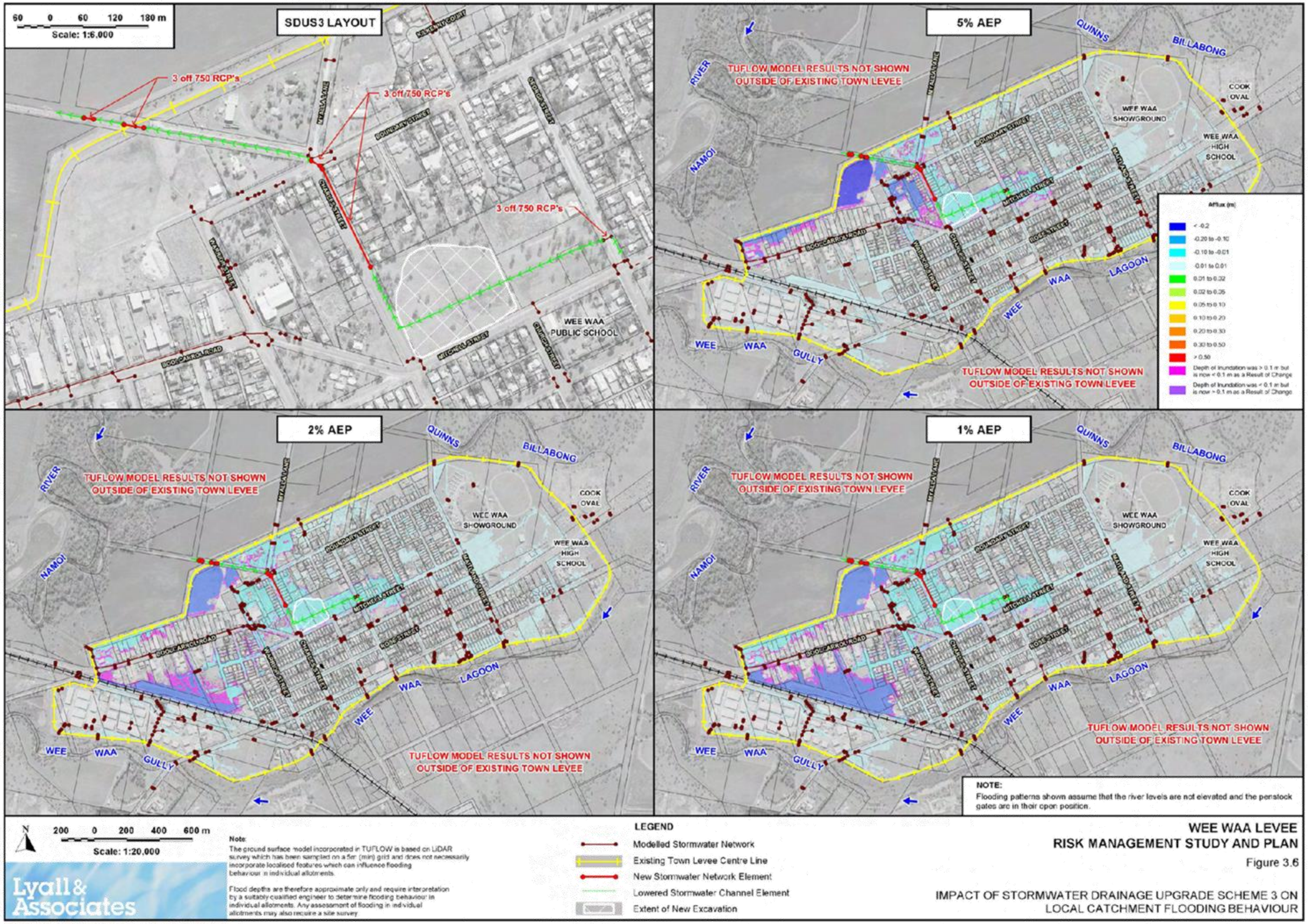
Figure 3.3

TYPICAL SECTION SHOWING TOWN LEVEE UPGRADE REQUIREMENTS

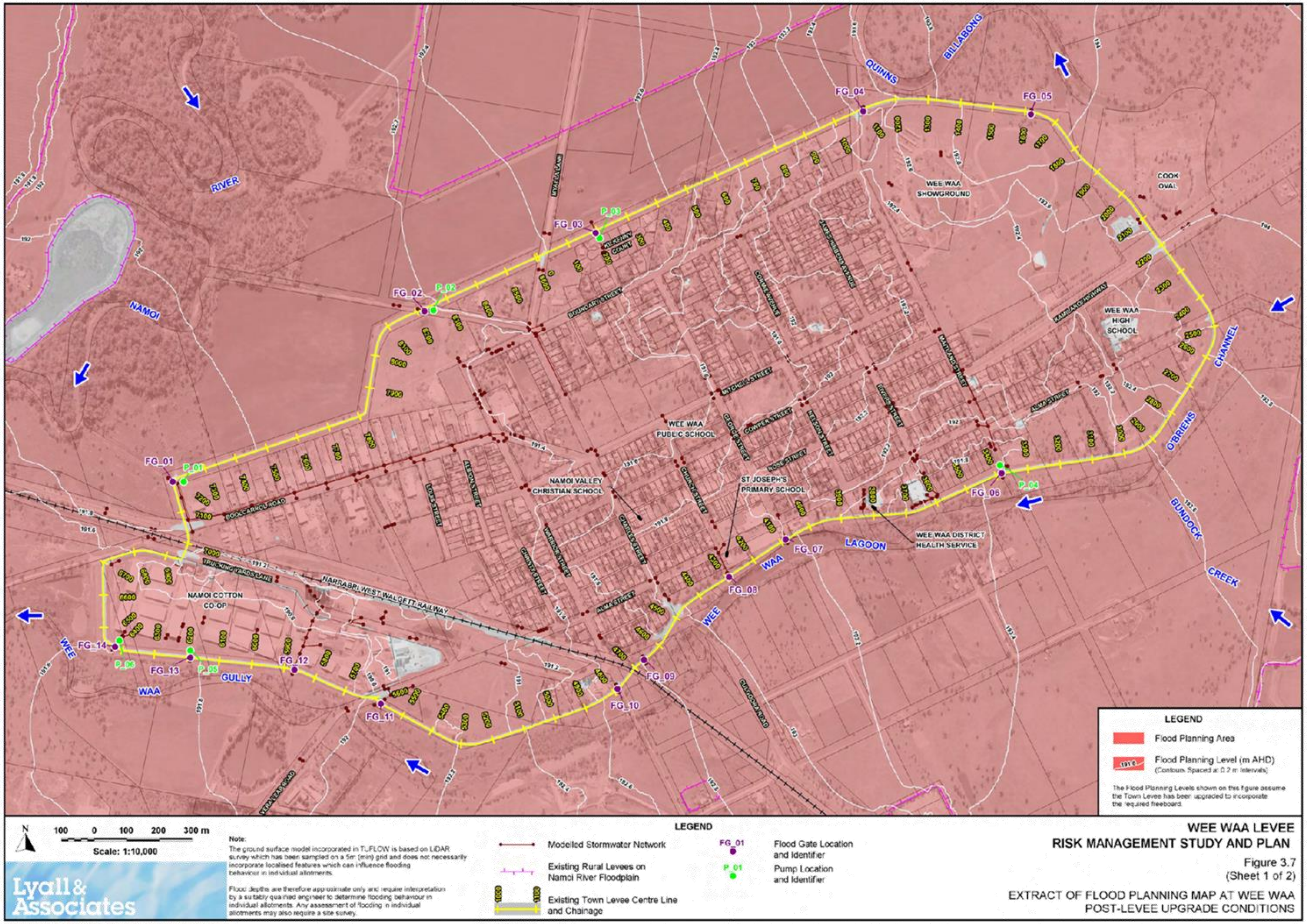


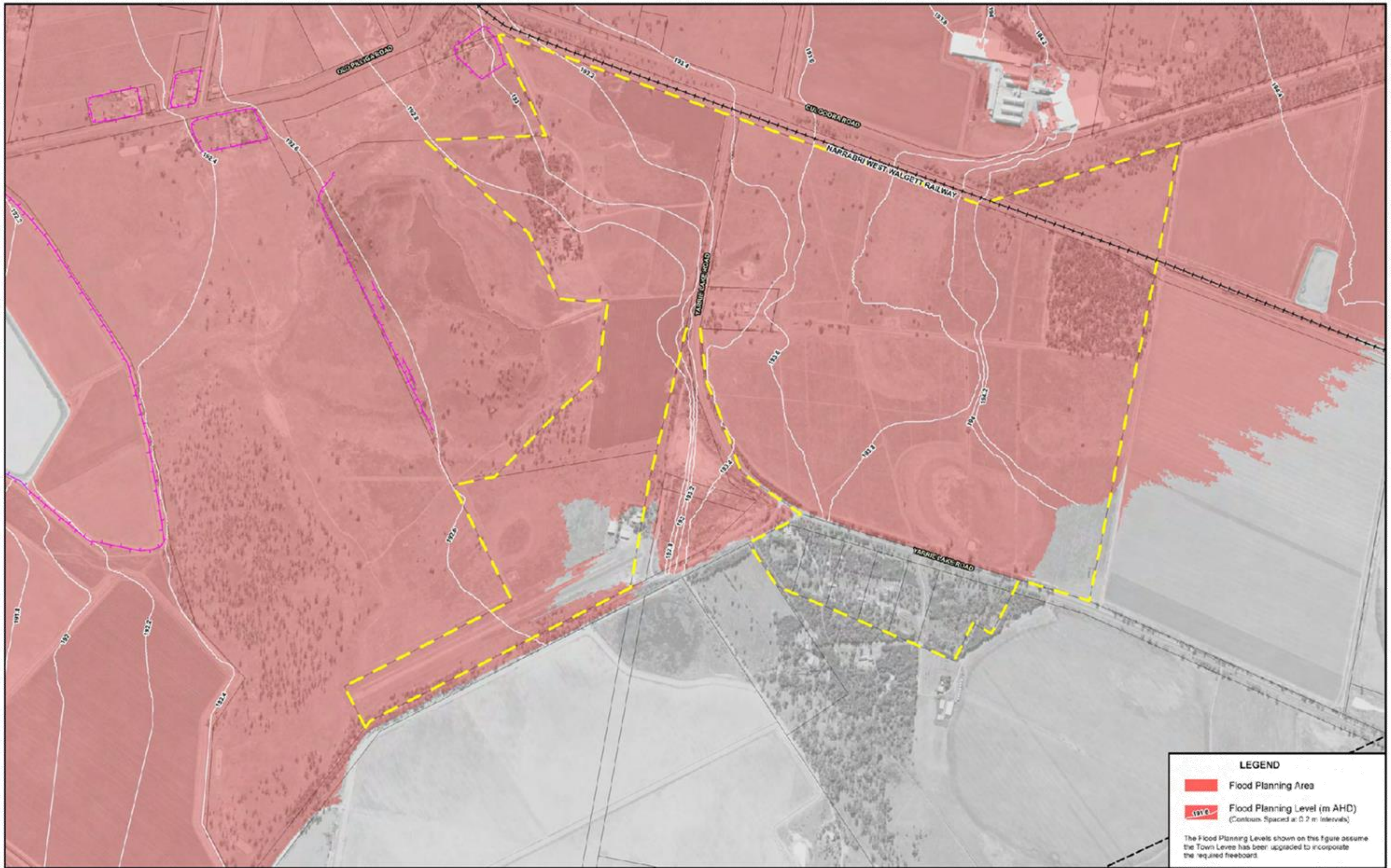
SDUS1 LAYOUT
60 0 60 120 180 m
Scale: 1:6,000
3 off 750 RCP's
3 off 750 RCP's
5 off 600 RCP's
WEE WAA PUBLIC SCHOOL
5% AEP
2% AEP
1% AEP
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
RIVER
NAMOI
QUINNS
BILLABONG
COOK OVAL
WEE WAA SHOWGROUND
WEE WAA HIGH SCHOOL
WEE WAA LAGOON
WEE WAA GULLY
Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Depth of Inundation was > 0.1 m but is now < 0.1 m as a Result of Change
Depth of Inundation was < 0.1 m but is now > 0.1 m as a Result of Change
NOTE:
Flooding patterns shown assume that the river levels are not elevated and the penstock gates are in their open position.
N
200 0 200 400 600 m
Scale: 1:20,000
Lyall & Associates
Note
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Town Levee Centre Line
New Stormwater Network Element
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 3.4
IMPACT OF STORMWATER DRAINAGE UPGRADE SCHEME 1 ON LOCAL CATCHMENT FLOODING BEHAVIOUR


SDUS2 LAYOUT
60 0 60 120 180 m
Scale: 1:6,000
3 off 750 RCP's
3 off 750 RCP's
3 off 750 RCP's
WEE WAA PUBLIC SCHOOL
5% AEP
2% AEP
1% AEP
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
QUINNS BILLABONG
RIVER
NAMOI
WEE WAA LAGOON
WEE WAA GULLY
COOK OVAL
WEE WAA SHOWGROUND
WEE WAA HIGH SCHOOL
NOTE:
Flooding patterns shown assume that the river levels are not elevated and the penstock gates are in their open position.
200 0 200 400 600 m
Scale: 1:20,000
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
Lyall & Associates
LEGEND
Modelled Stormwater Network
Existing Town Levee Centre Line
New Stormwater Network Element
Lowered Stormwater Channel Element
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 3.5
IMPACT OF STORMWATER DRAINAGE UPGRADE SCHEME 2 ON LOCAL CATCHMENT FLOODING BEHAVIOUR



SDUS3 LAYOUT
60 0 60 120 180 m
Scale: 1:6,000
3 off 750 RCP's
3 off 750 RCP's
3 off 750 RCP's
WEE WAA PUBLIC SCHOOL
5% AEP
2% AEP
1% AEP
TUFLOW MODEL RESULTS NOT SHOWN OUTSIDE OF EXISTING TOWN LEVEE
QUINNS BILLABONG
NAMOI RIVER
WEE WAA GULLY
WEE WAA LAGOON
COOK OVAL
WEE WAA SHOWGROUND
WEE WAA HIGH SCHOOL
Afflux (m)
NOTE:
Flooding patterns shown assume that the river levels are not elevated and the penstock gates are in their open position.
200 0 200 400 600 m
Scale: 1:20,000
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
Lyall & Associates
LEGEND
Modelled Stormwater Network
Existing Town Levee Centre Line
New Stormwater Network Element
Lowered Stormwater Channel Element
Extent of New Excavation
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 3.6
IMPACT OF STORMWATER DRAINAGE UPGRADE SCHEME 3 ON LOCAL CATCHMENT FLOODING BEHAVIOUR


NAMOI
RIVER
QUINNS
BILLABONG
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
WEE WAA
NAMOI COTTON CO-OP
NARRABRI-WEST WALGETT RAILWAY
WEE WAA GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
LEGEND
Flood Planning Area
Flood Planning Level (m AHD)
(Contours Spaced at 0.2 m Intervals)
The Flood Planning Levels shown on this figure assume the Town Levee has been upgraded to incorporate the required freeboard.
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 3.7
(Sheet 1 of 2)
EXTRACT OF FLOOD PLANNING MAP AT WEE WAA
POST-LEVEE UPGRADE CONDITIONS



Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

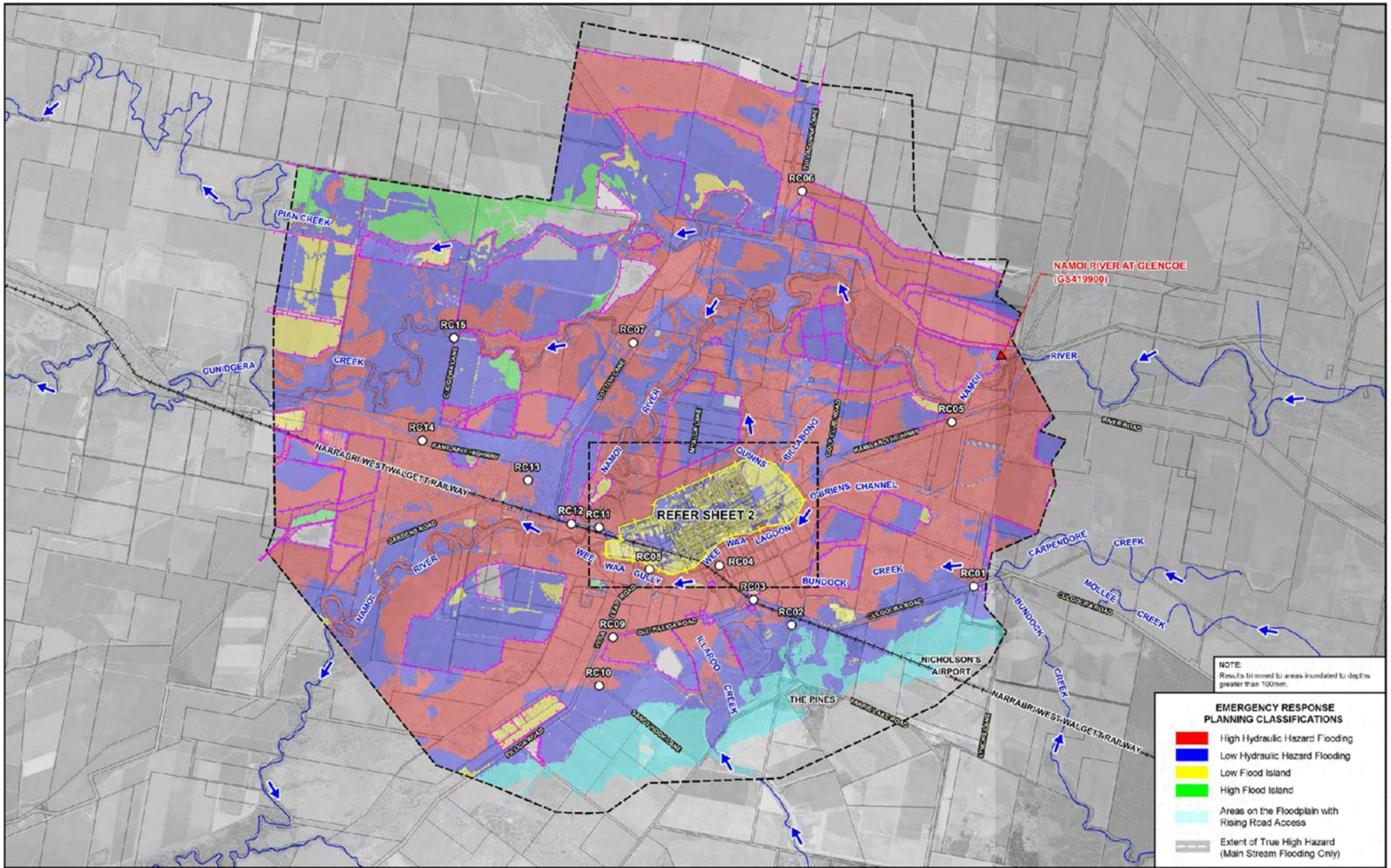
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

LEGEND
- Modelled Stormwater Network
- Existing Rural Levees on Namoi River Floodplain
- Land Zoned R5 - Large Lot Residential

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure 3.7
(Sheet 2 of 2)

EXTRACT OF FLOOD PLANNING MAP AT WEE WAA
POST-LEVEE UPGRADE CONDITIONS



N 600 0 600 1200 1800 m

Scale: 1:60,000

Lyall & Associates

Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

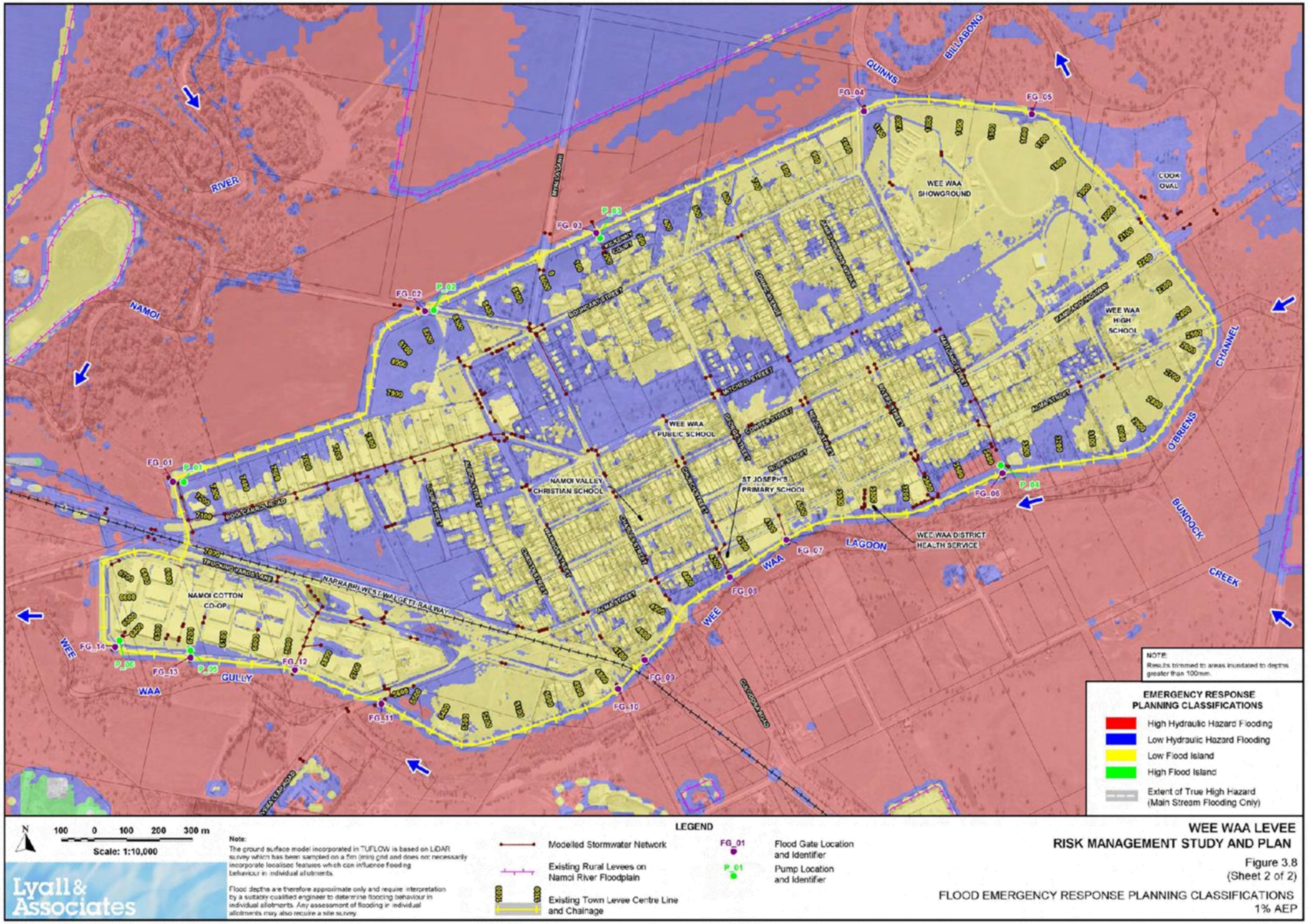
LEGEND

- Two-Dimensional Model Boundary
- WaterNSW Stream Gauge
- RC01 Low Point in Major Road and Identifier
- Existing Town Levee Centre Line
- Existing Rural Levees on Namoi River Floodplain

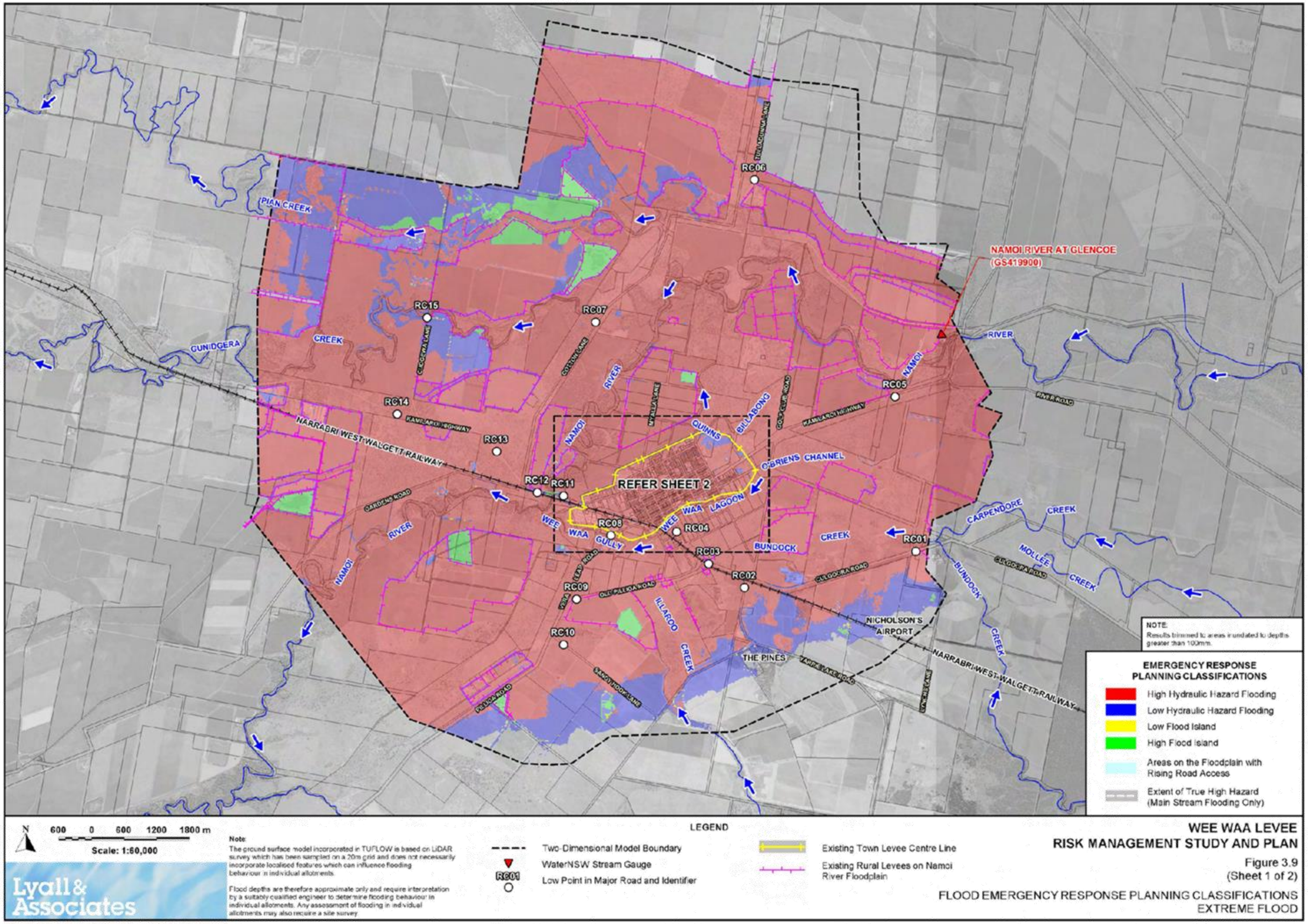
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

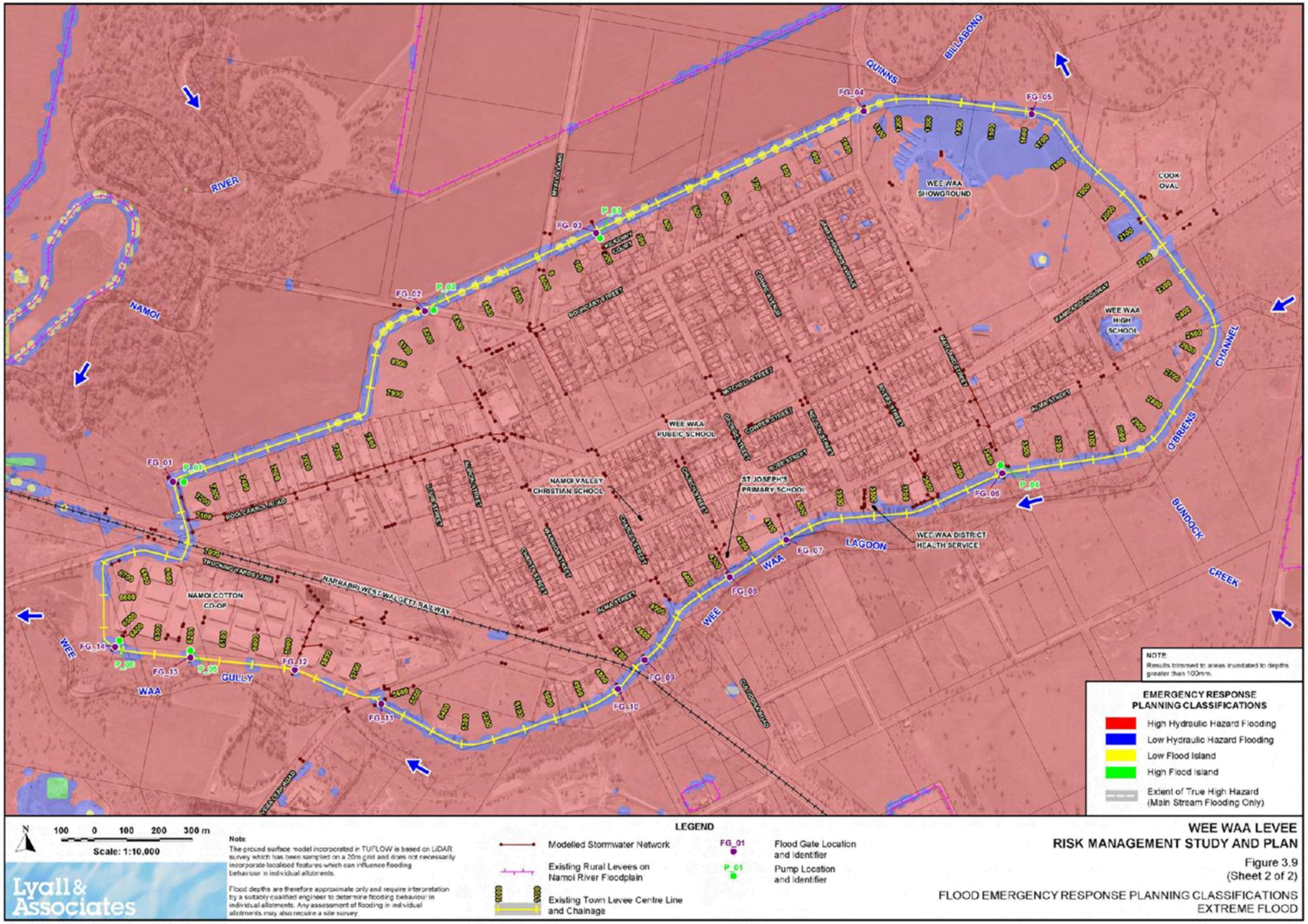
Figure 3.8
(Sheet 1 of 2)

FLOOD EMERGENCY RESPONSE PLANNING CLASSIFICATIONS
1% AEP



RIVER
NAMOI
QUINNS
BILLABONG
COOK OVAL
WEE WAA SHOWGROUND
WEE WAA HIGH SCHOOL
CHANNEL
O'BRIENS
BUNDOCK
CREEK
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
LAGOON
NAMOI COTTON CO-OP
NARRABRI-WEST-WALGETT RAILWAY
WEE
WAA
GULLY
FG_01
FG_02
FG_03
FG_04
FG_05
FG_06
FG_07
FG_08
FG_09
FG_10
FG_11
FG_12
FG_13
FG_14
P_01
P_02
P_03
P_04
P_05
P_06
NOTE:
Results trimmed to areas inundated to depths greater than 100mm.
EMERGENCY RESPONSE PLANNING CLASSIFICATIONS
High Hydraulic Hazard Flooding
Low Hydraulic Hazard Flooding
Low Flood Island
High Flood Island
Extent of True High Hazard (Main Stream Flooding Only)
N
100 0 100 200 300 m
Scale: 1:10,000
Lyall & Associates
Note:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 3.8
(Sheet 2 of 2)
FLOOD EMERGENCY RESPONSE PLANNING CLASSIFICATIONS
1% AEP

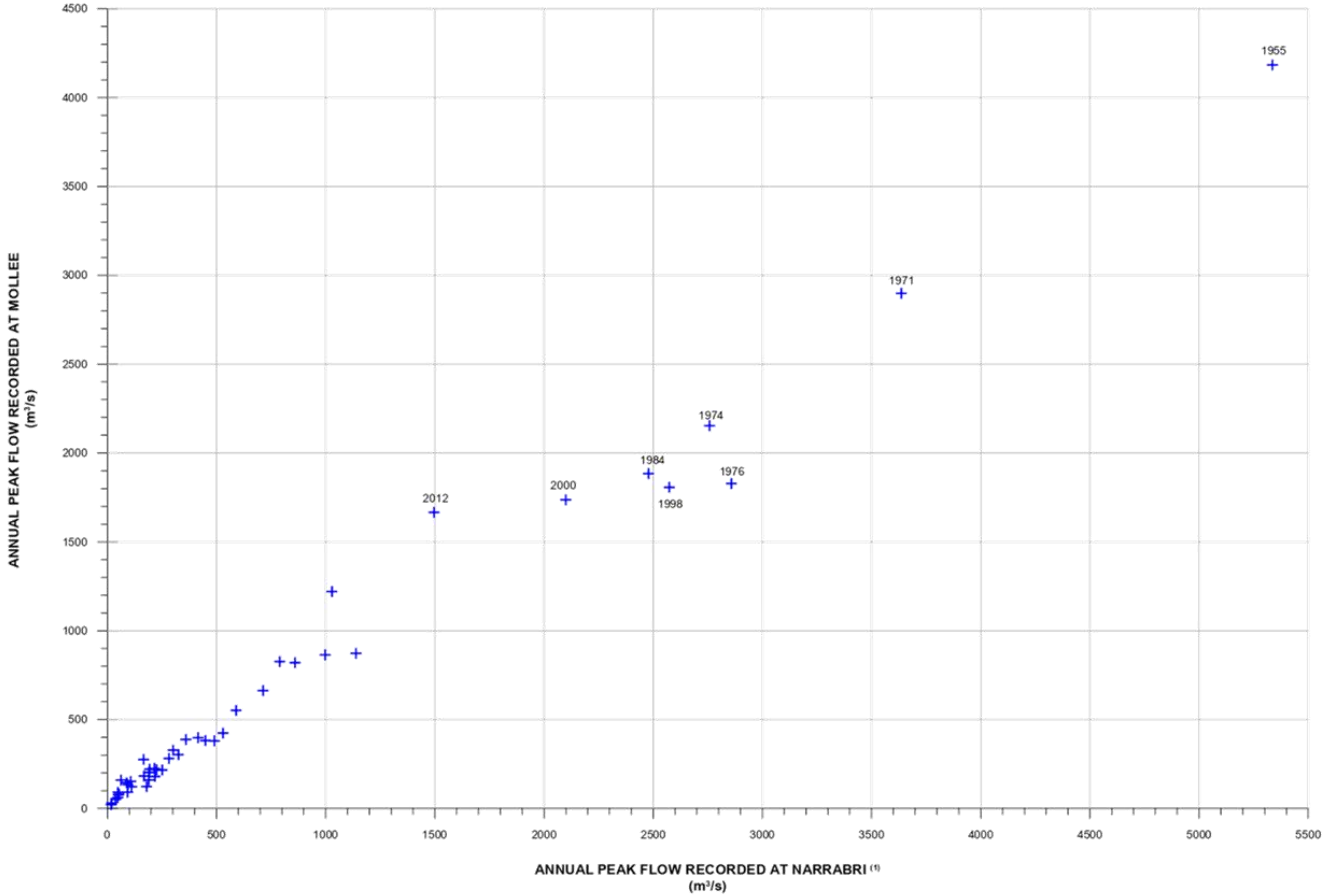

PIAN CREEK
GUNIDGERA
CREEK
RC15
RC07
RC06
NAMOI RIVER AT GLENCOE
(GS419900)
RIVER
NAMOI
RC05
RIVER ROAD
RC14
KAMILAROI HIGHWAY
NARRABRI-WEST-WALGETT RAILWAY
RC13
NAMOI
RIVER
QUINNS
BILLABONG
O'BRIENS CHANNEL
REFER SHEET 2
RC12
RC11
WEE
WAA
GULLY
RC08
WEE WAA LAGOON
RC04
RC03
RC02
RC01
BUNDOCK
CREEK
CARPENDORE
CREEK
MOLLEE
CREEK
BUNDOCK
CREEK
RIVER
NAMOI
RC09
RC10
ILLAROO
CREEK
THE PINES
NICHOLSON'S
AIRPORT
NARRABRI-WEST-WALGETT RAILWAY
NOTE:
Results trimmed to areas inundated to depths greater than 100mm.
EMERGENCY RESPONSE PLANNING CLASSIFICATIONS
High Hydraulic Hazard Flooding
Low Hydraulic Hazard Flooding
Low Flood Island
High Flood Island
Areas on the Floodplain with Rising Road Access
Extent of True High Hazard (Main Stream Flooding Only)
N
600 0 600 1200 1800 m
Scale: 1:60,000
Lyall & Associates
Note
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 20m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Two-Dimensional Model Boundary
WaterNSW Stream Gauge
RC01
Low Point in Major Road and Identifier
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 3.9
(Sheet 1 of 2)
FLOOD EMERGENCY RESPONSE PLANNING CLASSIFICATIONS
EXTREME FLOOD


EMERGENCY RESPONSE PLANNING CLASSIFICATIONS
High Hydraulic Hazard Flooding
Low Hydraulic Hazard Flooding
Low Flood Island
High Flood Island
Extent of True High Hazard (Main Stream Flooding Only)
NOTE: Results trimmed to areas inundated to depths greater than 100mm.
LEGEND
Modelled Stormwater Network
Existing Rural Levees on Namoi River Floodplain
Existing Town Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
Scale: 1:10,000
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure 3.9
(Sheet 2 of 2)
FLOOD EMERGENCY RESPONSE PLANNING CLASSIFICATIONS
EXTREME FLOOD
NAMOI RIVER
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
O'BRIENS CHANNEL
WEE WAA SHOWGROUND
WEE WAA HIGH SCHOOL
COOK OVAL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY

APPENDIX C

FLOOD STUDY UPDATE

LIST OF FIGURES (APPENDIX C)



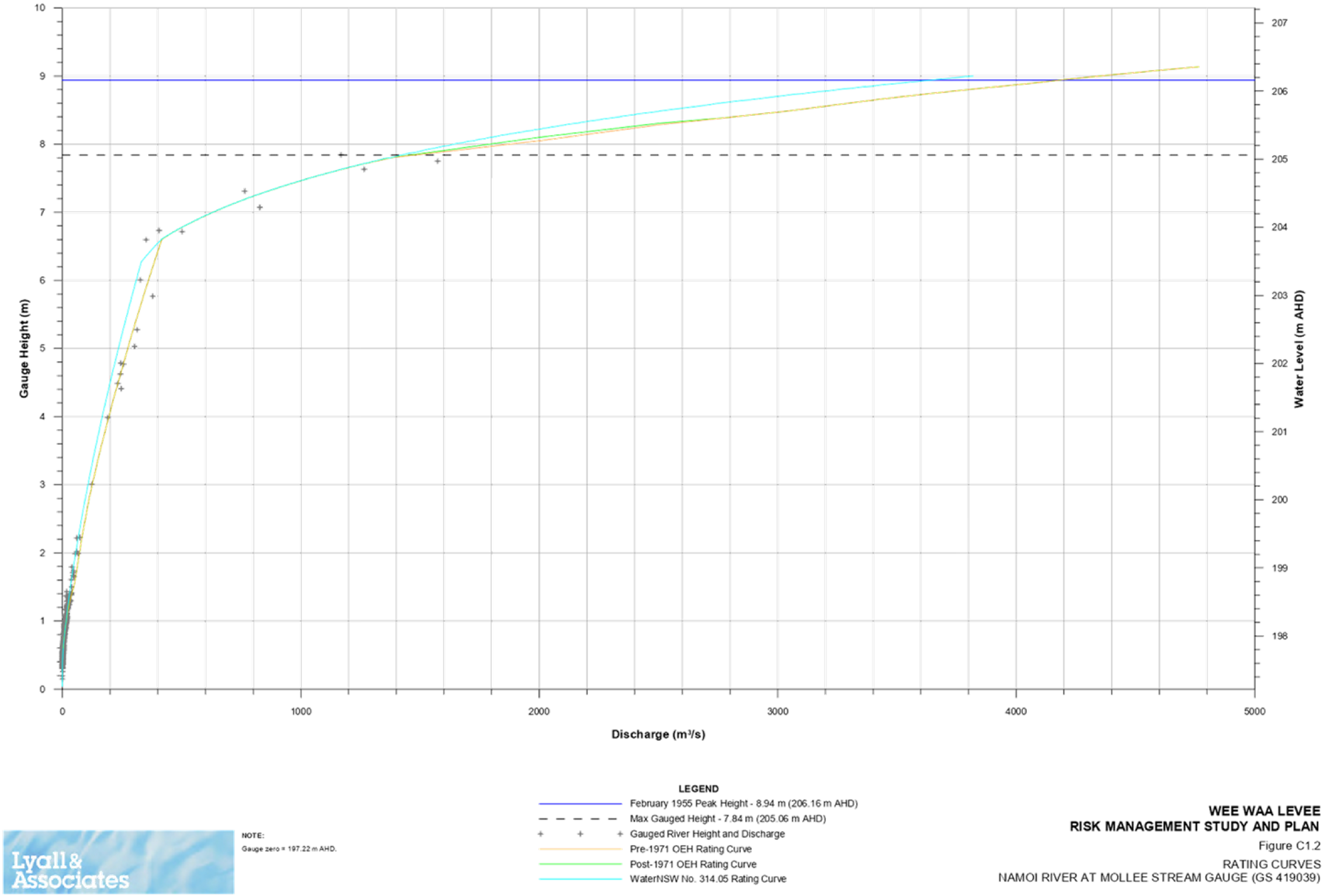
Lyall & Associates

NOTE:
1. Source: WRM, 2016.

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure C1.1

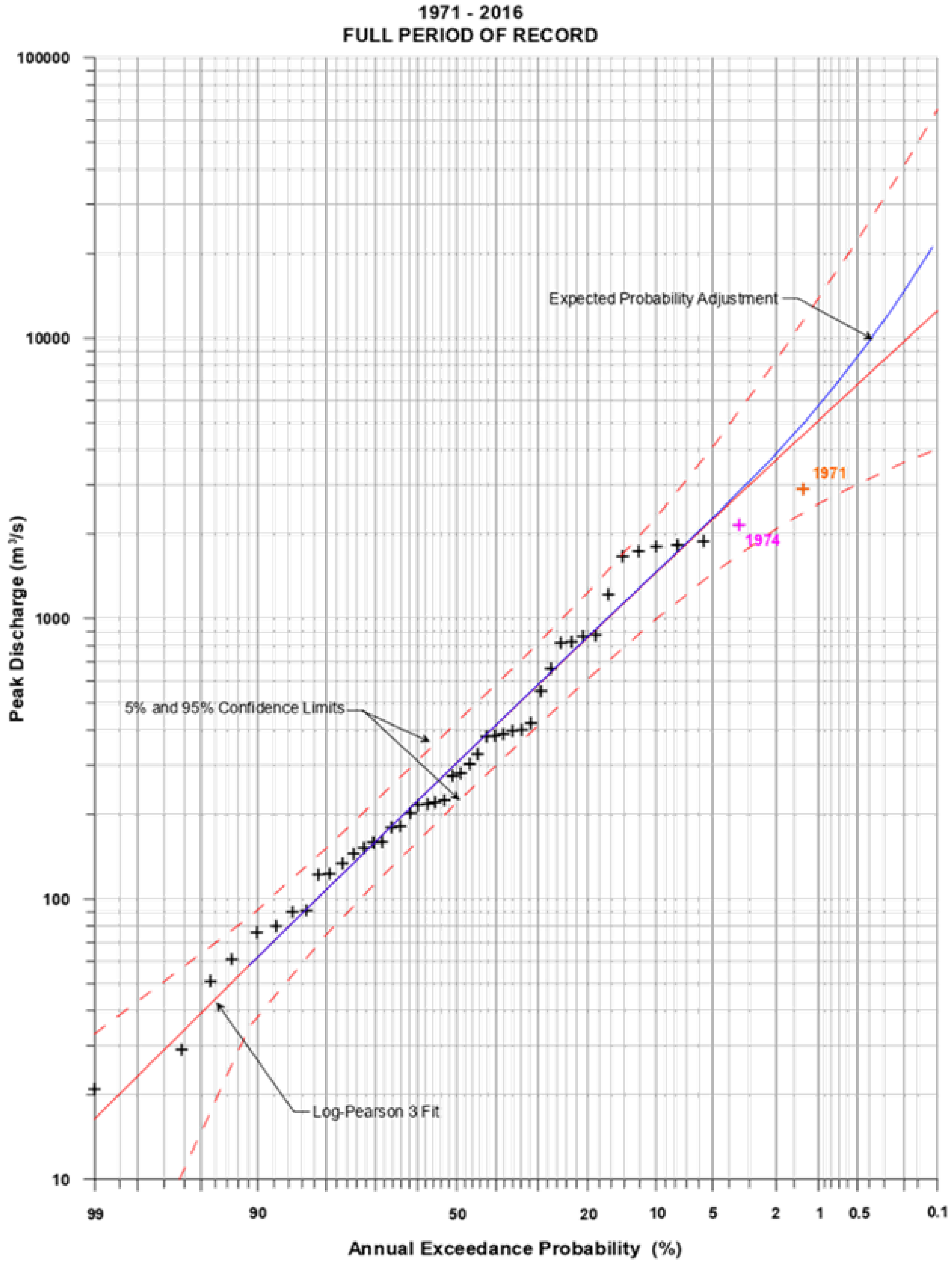
COMPARISON OF ANNUAL PEAK FLOWS
MOLLEE VERSUS NARRABRI STREAM GAUGES
PERIOD 1971-2015 AND 1955

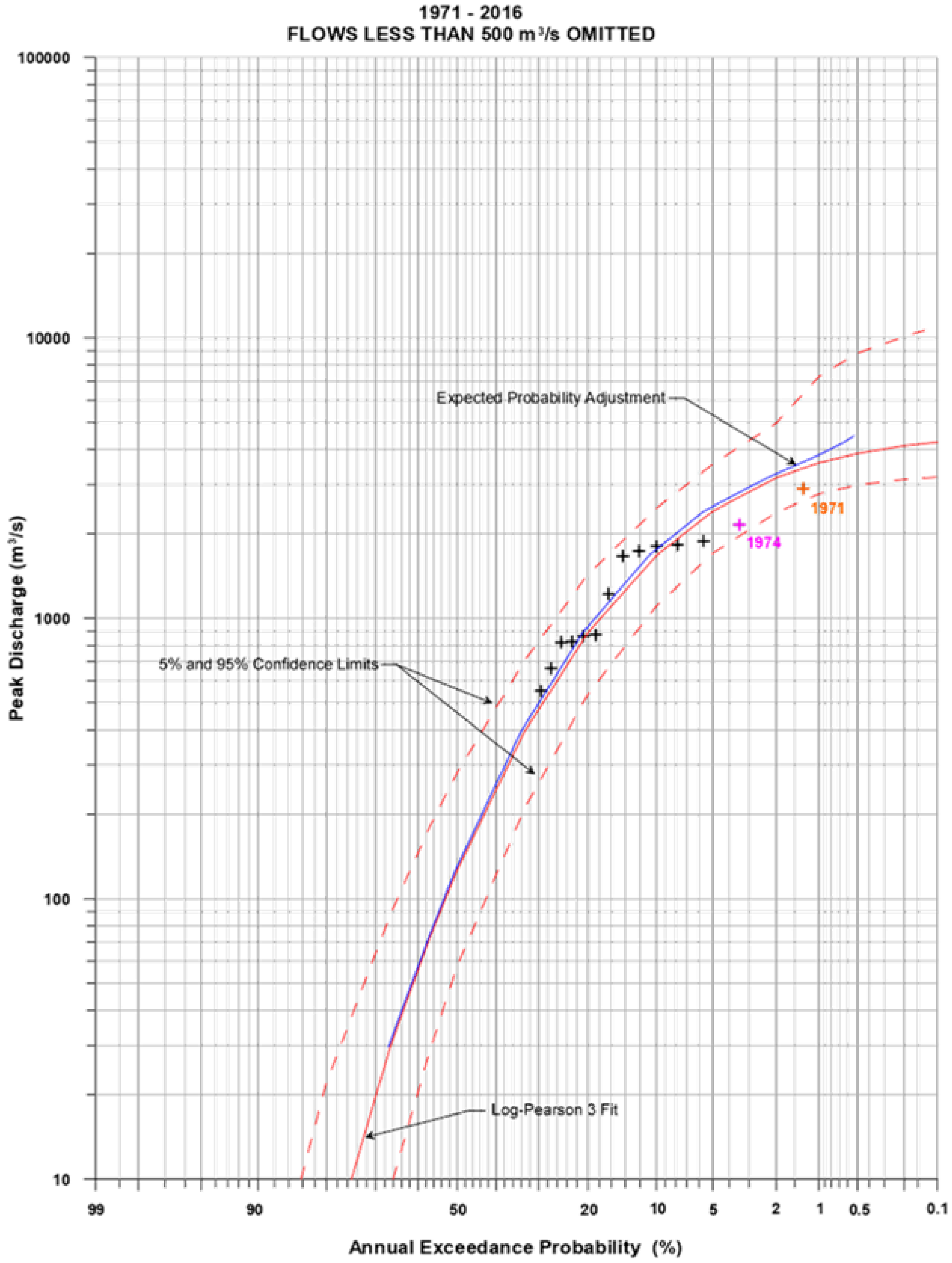


NOTE:
Gauge zero = 197.22 m AHD.

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure C1.2
RATING CURVES
NAMOI RIVER AT MOLLEE STREAM GAUGE (GS 419039)



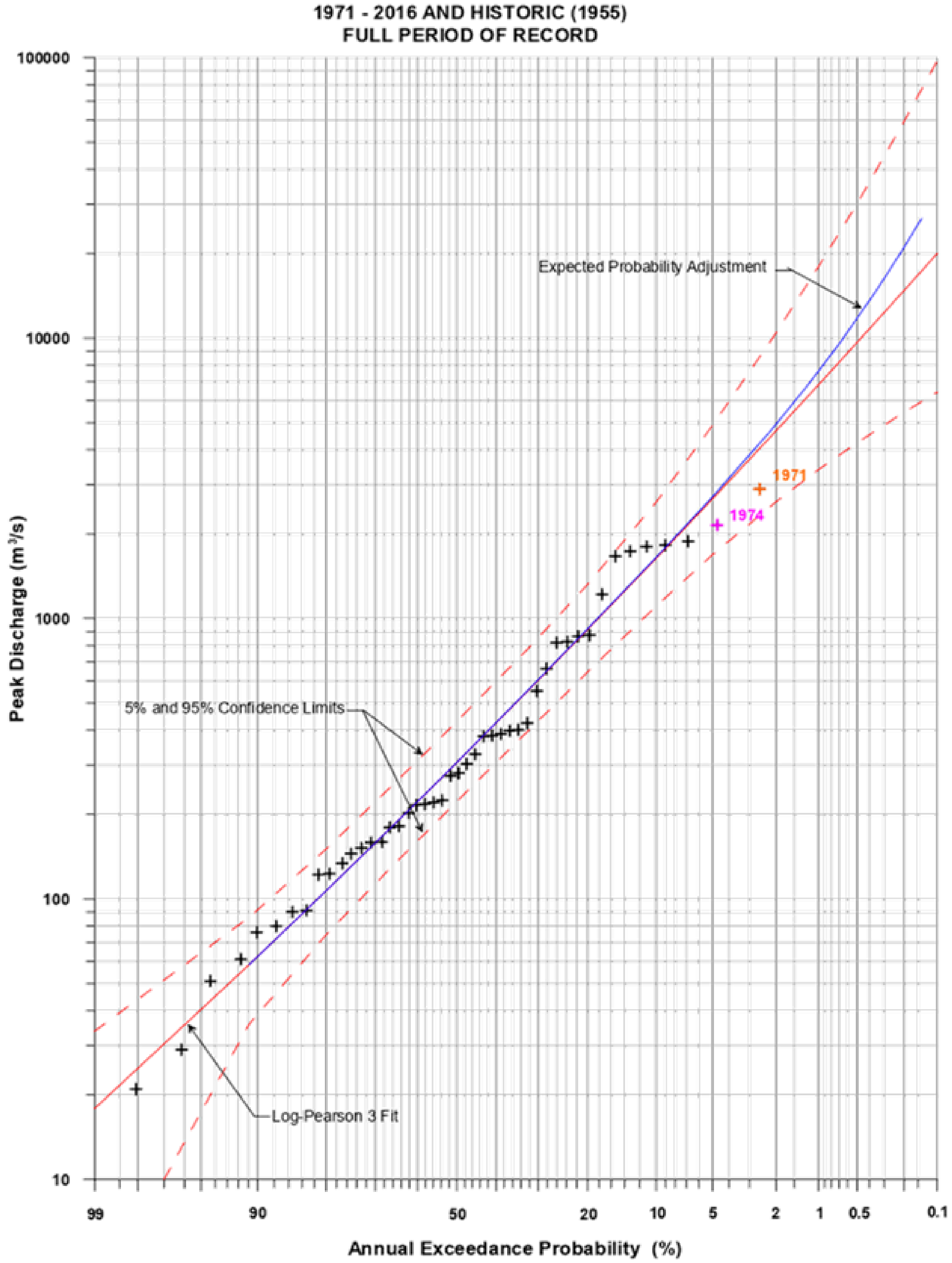


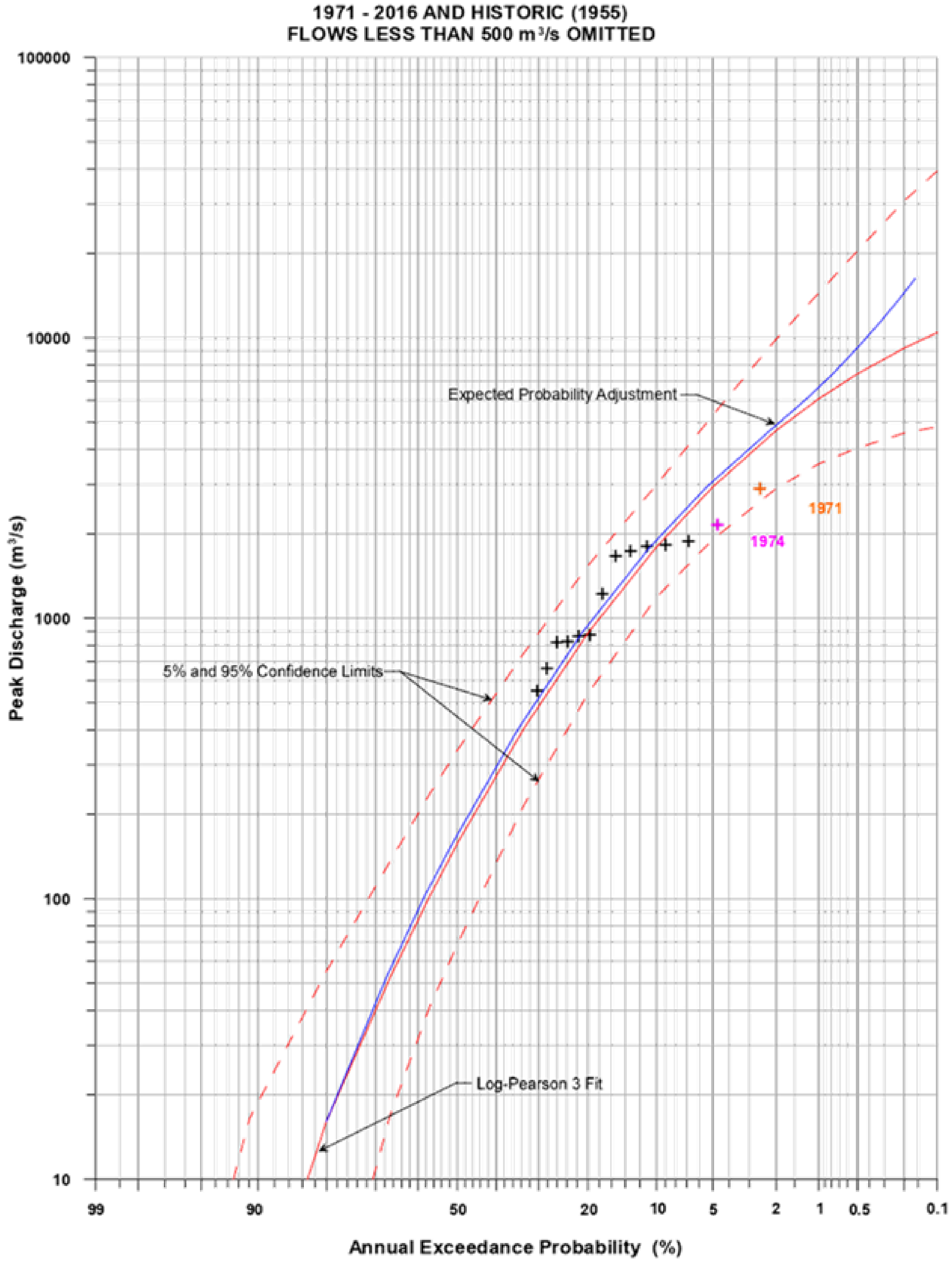
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure C1.3
(Sheet 1 of 3)

FLOOD FREQUENCY RELATIONSHIP
LOG-PEARSON 3 ANNUAL SERIES 1971-2016
NAMOI RIVER AT MOLLEE STREAM GAUGE (GS 419039)

Lyall & Associates

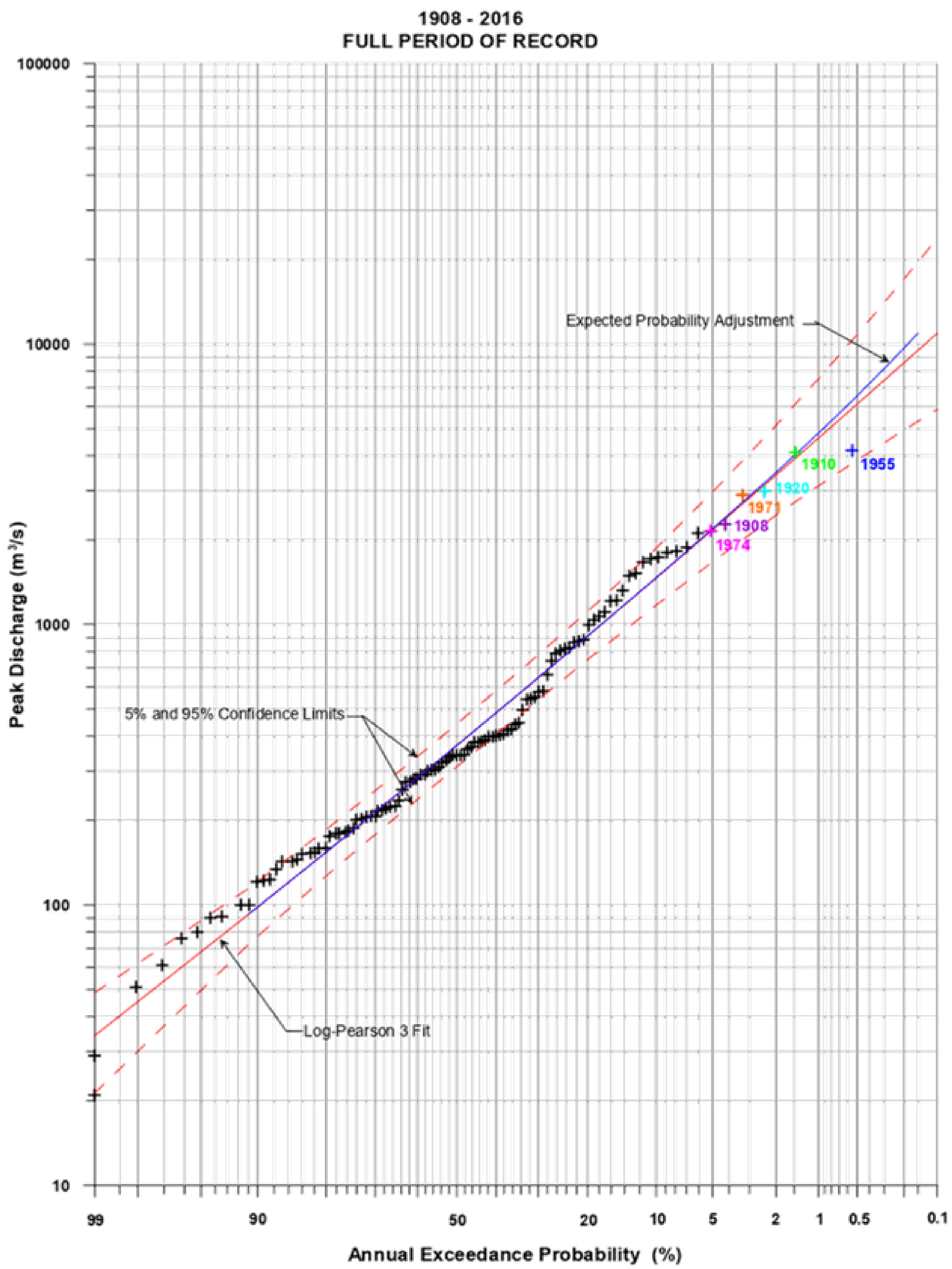


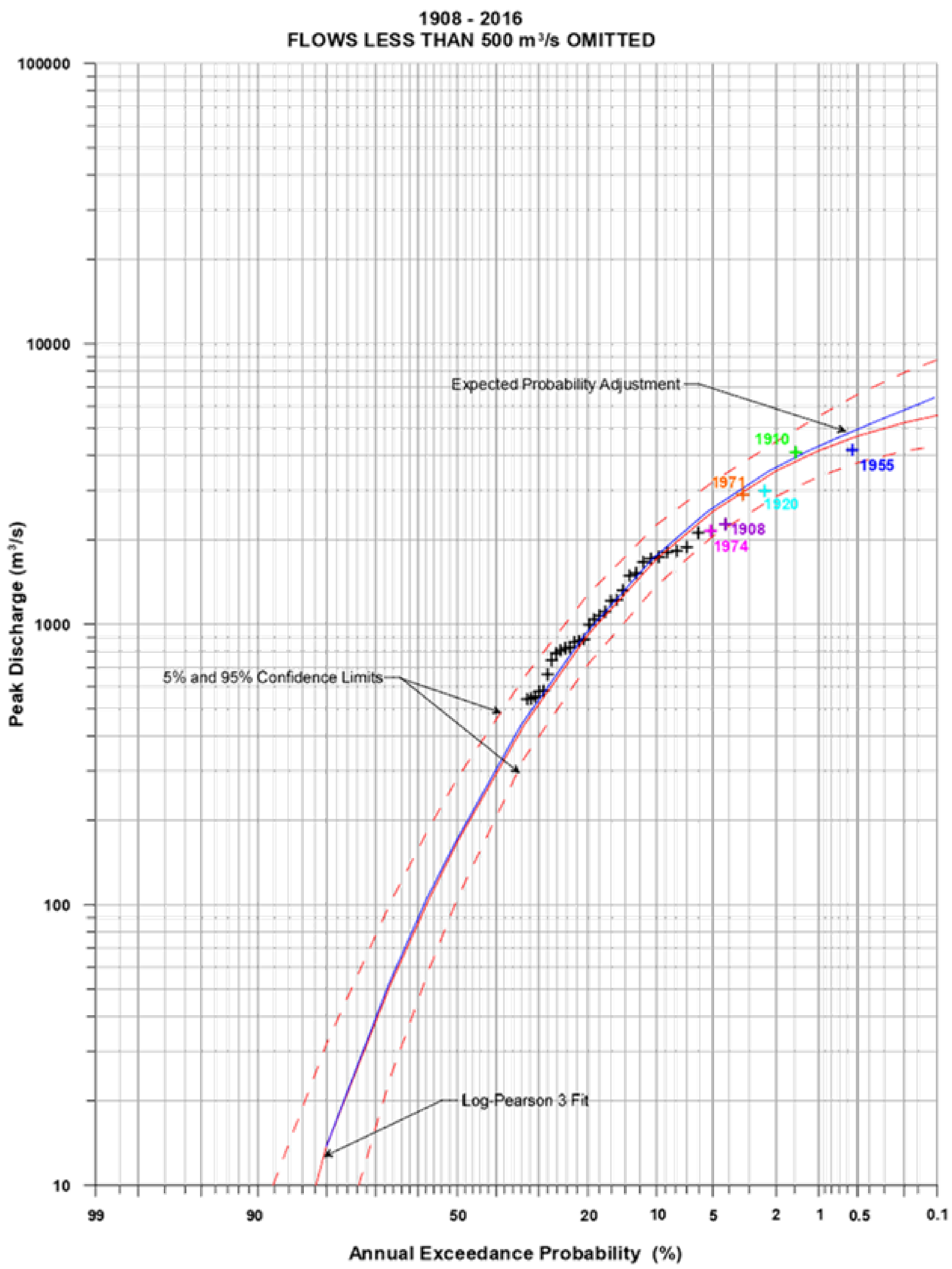


WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure C1.3
(Sheet 2 of 3)

FLOOD FREQUENCY RELATIONSHIP
LOG-PEARSON 3 ANNUAL SERIES 1971-2016
NAMOI RIVER AT MOLLEE STREAM GAUGE (GS 419039)



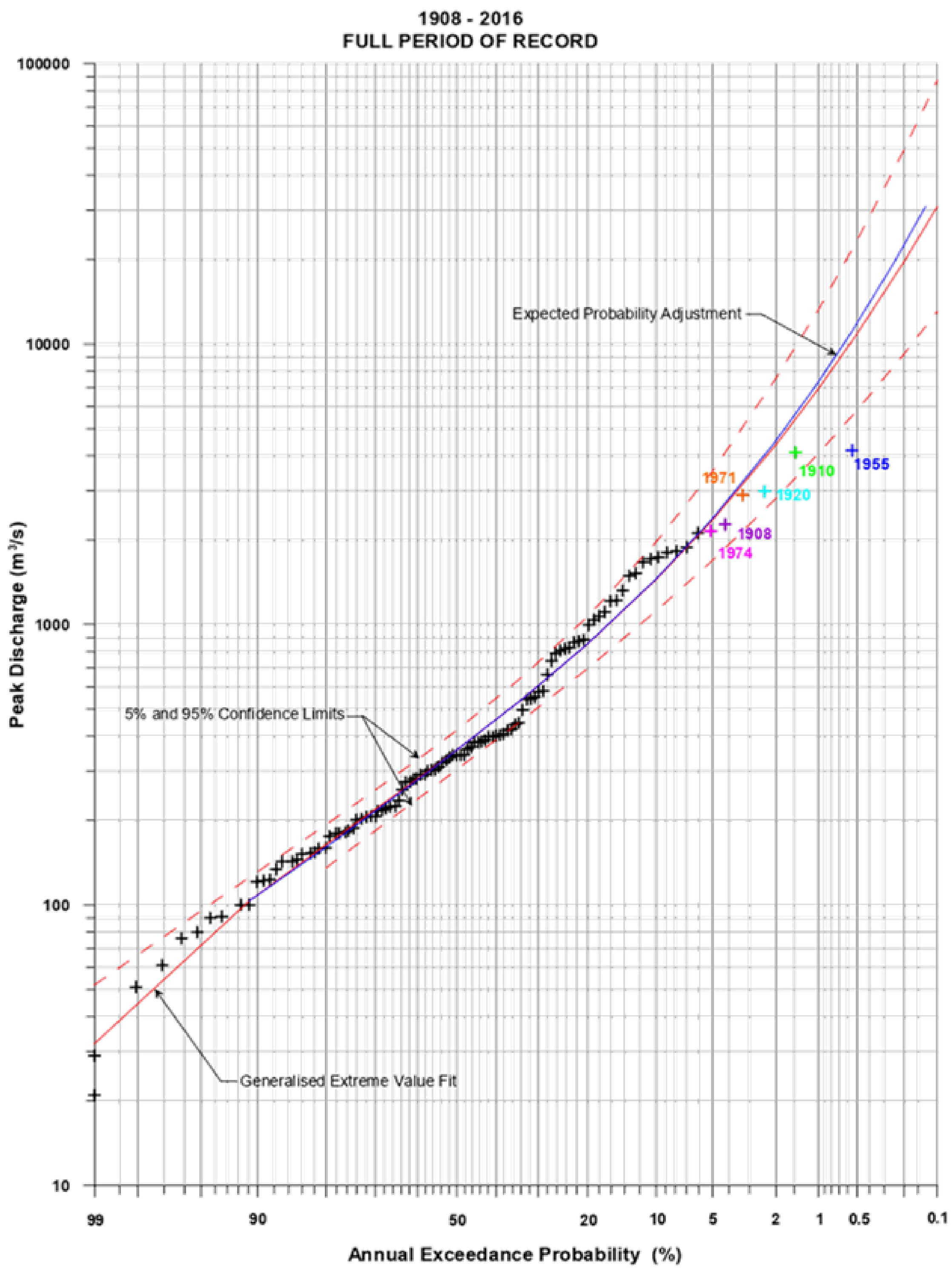


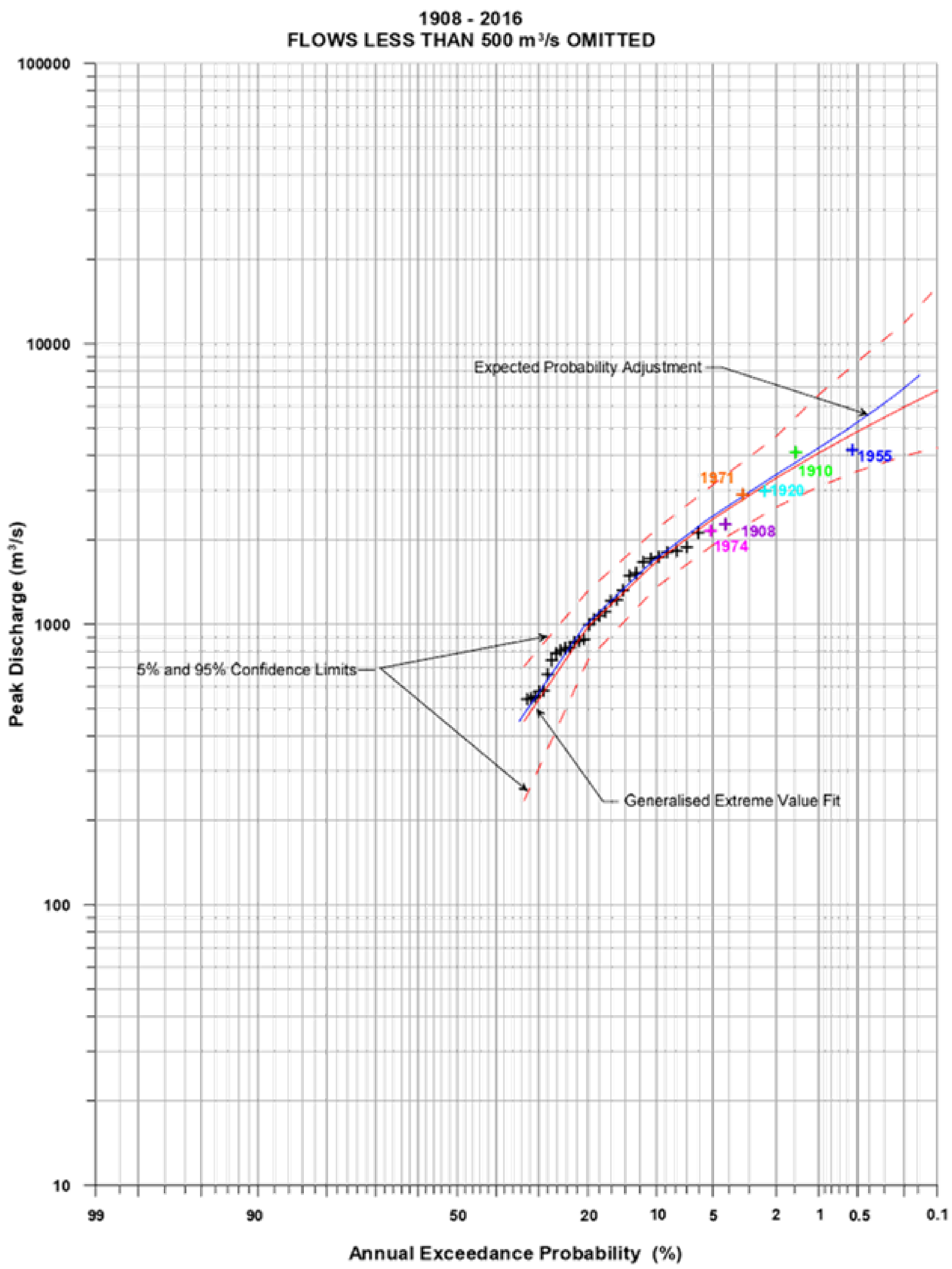
Lyall & Associates

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure C1.3
(Sheet 3 of 3)

FLOOD FREQUENCY RELATIONSHIP
LOG-PEARSON 3 ANNUAL SERIES 1971-2016
NAMOI RIVER AT MOLLEE STREAM GAUGE (GS 419039)



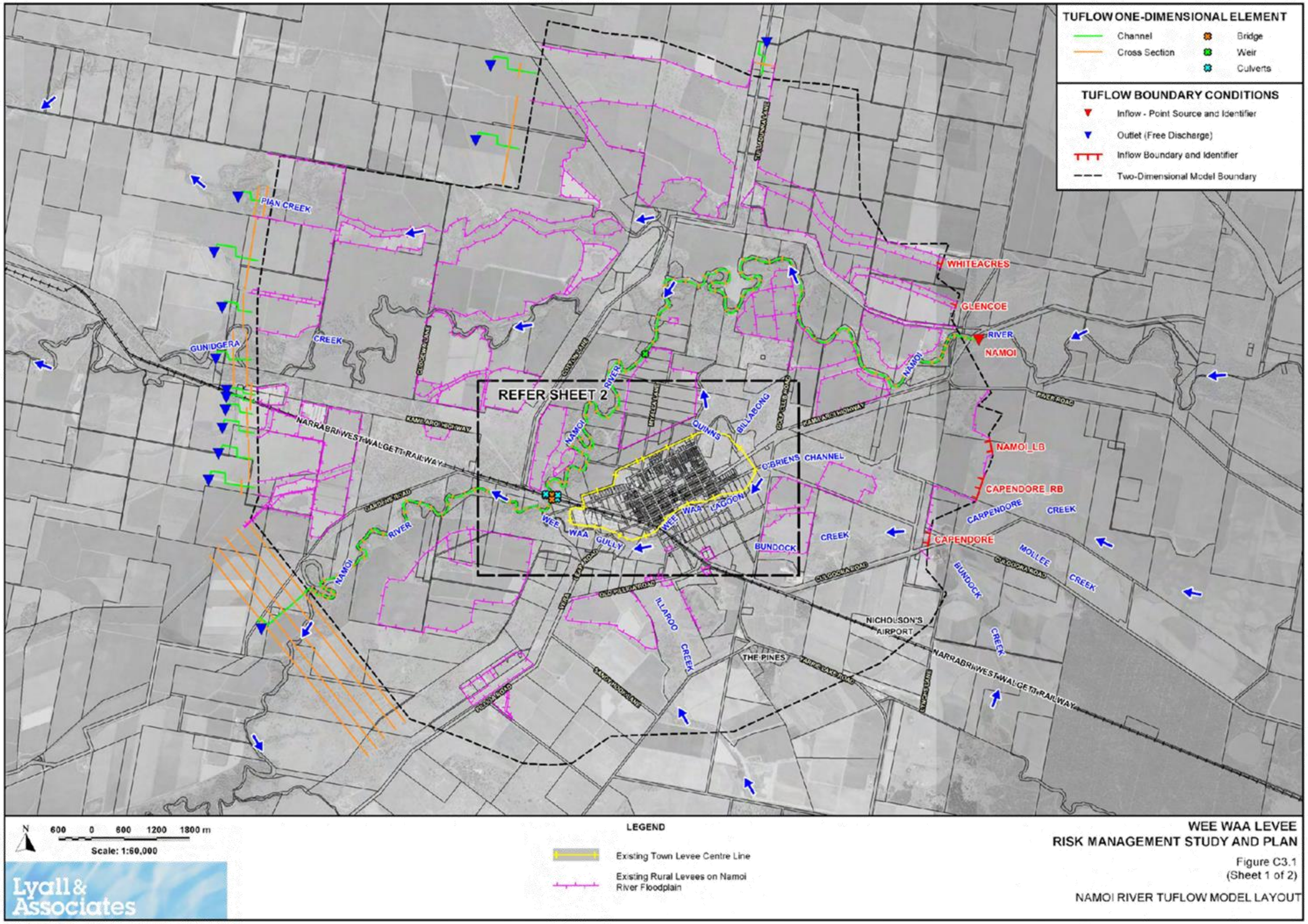


Lyall & Associates

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure C1.4

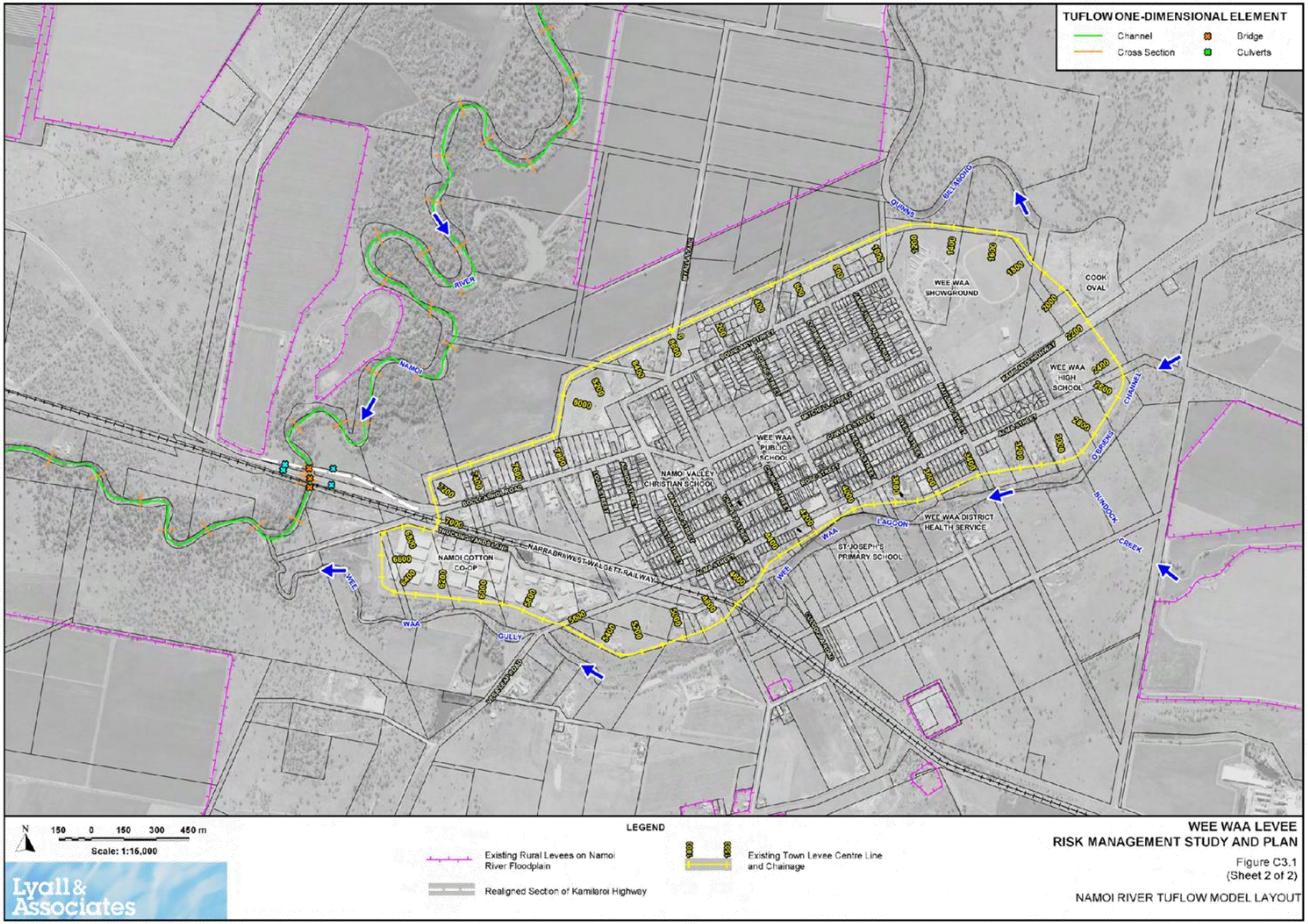
FLOOD FREQUENCY RELATIONSHIP
GENERALISED EXTREME VALUE ANNUAL SERIES 1971-2016
NAMOI RIVER AT MOLLEE STREAM GAUGE (GS 419039)

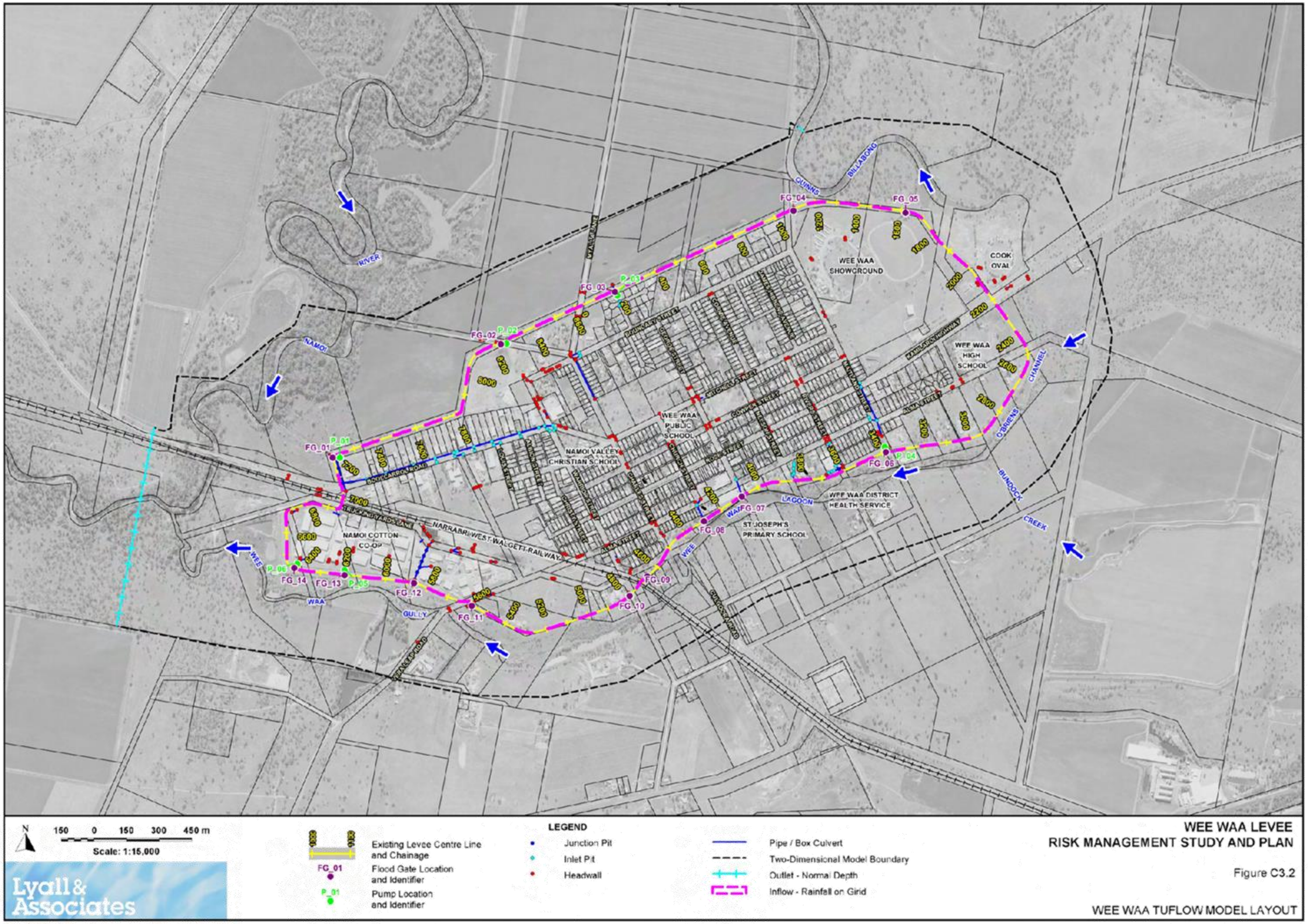


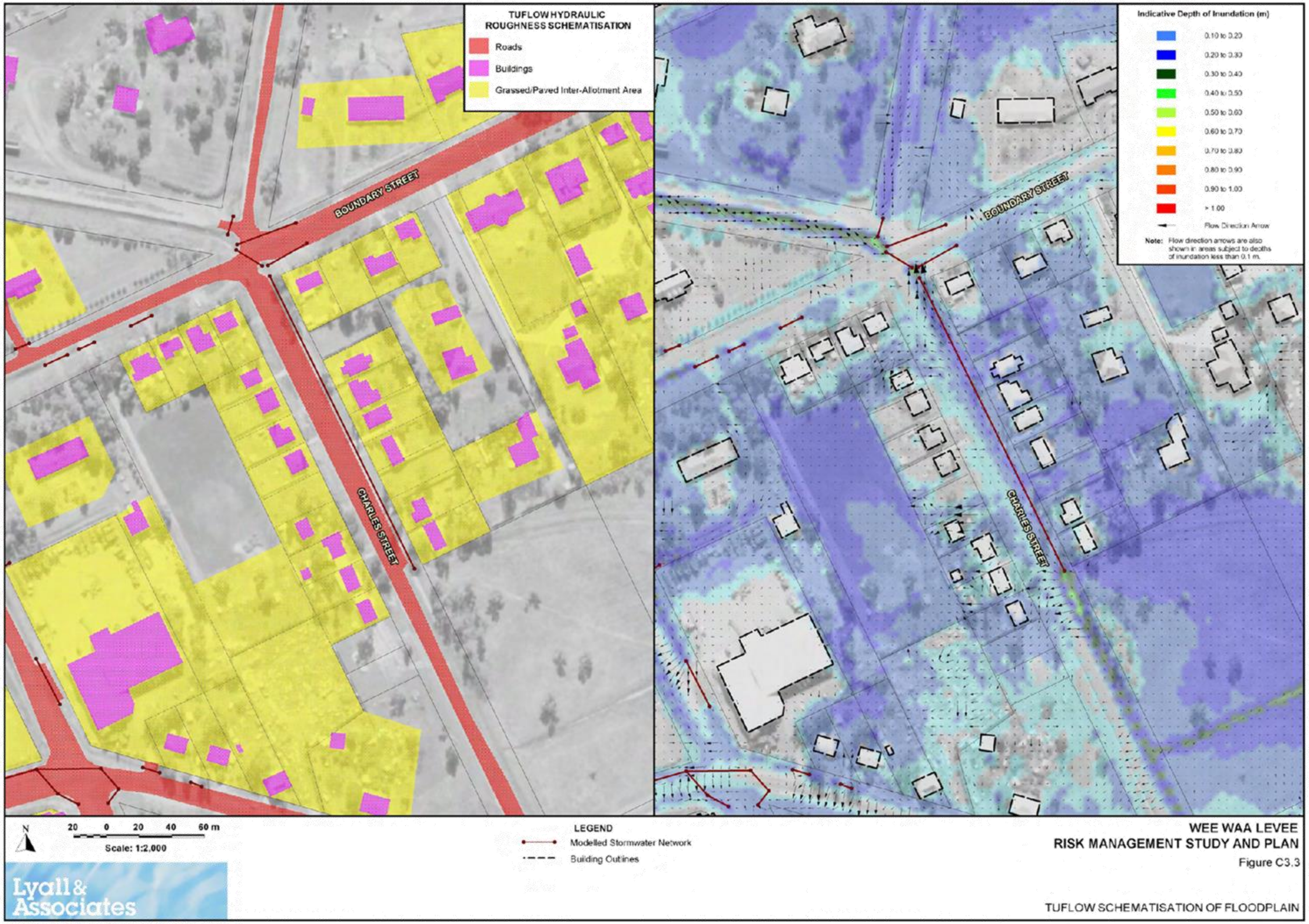
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

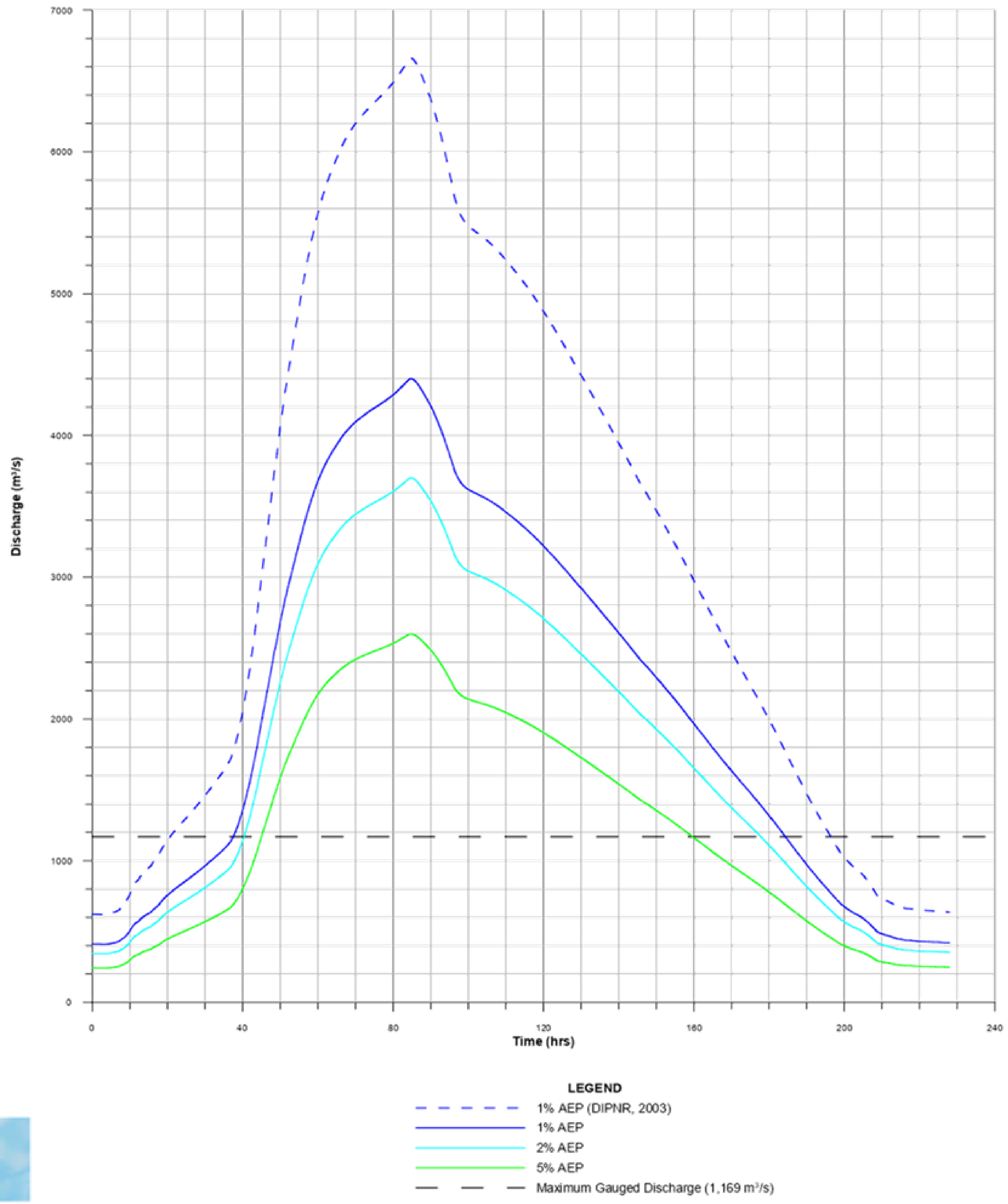
Figure C3.1
(Sheet 1 of 2)

NAMOI RIVER TUFLOW MODEL LAYOUT


TUFLOW ONE-DIMENSIONAL ELEMENT
Channel
Cross Section
Bridge
Culverts
Scale: 1:16,000
LEGEND
Existing Rural Levees on Namoi River Floodplain
Realigned Section of Kamilaroi Highway
Existing Town Levee Centre Line and Chainage
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure C3.1
(Sheet 2 of 2)
NAMOI RIVER TUFLOW MODEL LAYOUT
Lyall & Associates
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
ST JOSEPH'S PRIMARY SCHOOL
NAMOI COTTON CO-OP
NARRABRI-WEST WALGETT RAILWAY


WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
ST JOSEPH'S PRIMARY SCHOOL
NAMOI COTTON CO-OP
NARRABRI-WEST WALGETT RAILWAY
NAMOI RIVER
QUINNS BILLABONG
O'BRIENS CHANNEL
BUNDOCK CREEK
WEE WAA LAGOON
WEE WAA GULLY
150 0 150 300 450 m
Scale: 1:15,000
LEGEND
Existing Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
Junction Pit
Inlet Pit
Headwall
Pipe / Box Culvert
Two-Dimensional Model Boundary
Outlet - Normal Depth
Inflow - Rainfall on Girid
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure C3.2
WEE WAA TUFLOW MODEL LAYOUT


TUFLOW HYDRAULIC ROUGHNESS SCHEMATISATION
Roads
Buildings
Grassed/Paved Inter-Allotment Area
BOUNDARY STREET
CHARLES STREET
Indicative Depth of Inundation (m)
0.10 to 0.20
0.20 to 0.30
0.30 to 0.40
0.40 to 0.50
0.50 to 0.60
0.60 to 0.70
0.70 to 0.80
0.80 to 0.90
0.90 to 1.00
> 1.00
Flow Direction Arrow
Note: Flow direction arrows are also shown in areas subject to depths of inundation less than 0.1 m.
N
20 0 20 40 60 m
Scale: 1:2,000
LEGEND
Modelled Stormwater Network
Building Outlines
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure C3.3
TUFLOW SCHEMATISATION OF FLOODPLAIN



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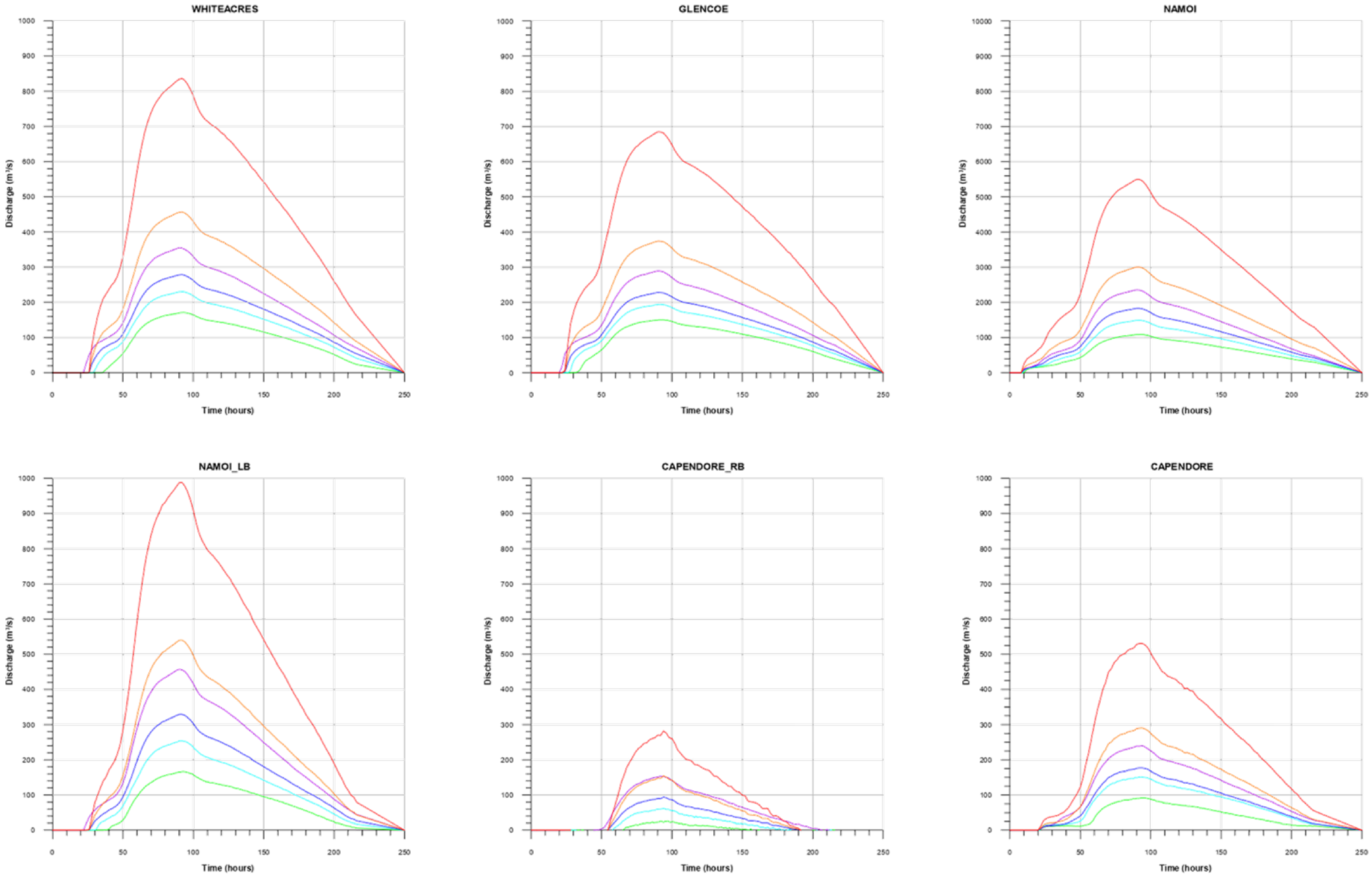
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure C4.1

DESIGN DISCHARGE HYDROGRAPHS
NAMOI RIVER AT MOLLEE STREAM GAUGE (GS 419039)



NOTE:
Refer Figures B4.1 for location of discharge hydrographs.

LEGEND

Extreme Flood	1% AEP
0.2% AEP	2% AEP
0.5% AEP	5% AEP

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

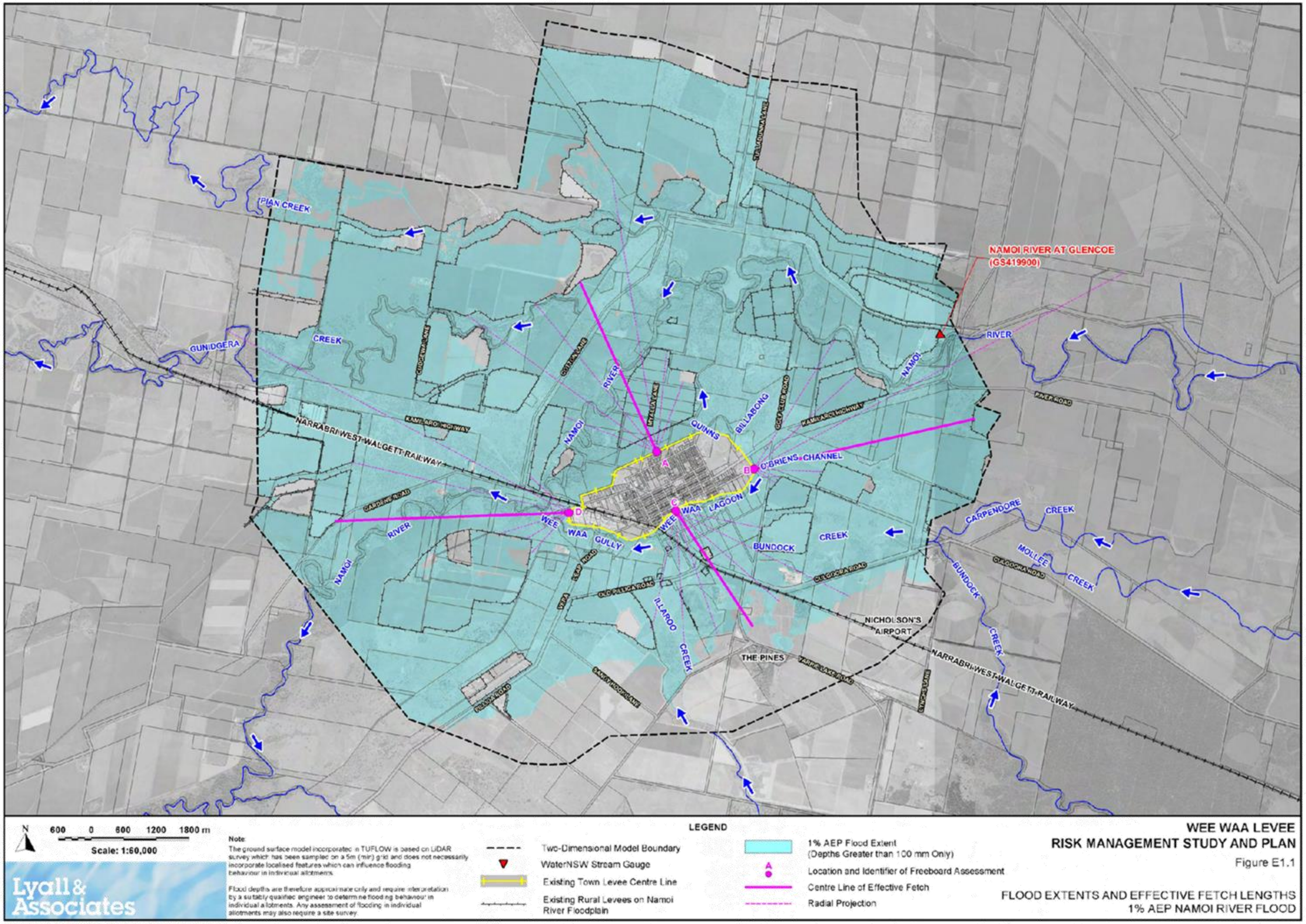
Figure C4.2

DESIGN DISCHARGE HYDROGRAPHS
NAMOI RIVER FLOODPLAIN UPSTREAM OF WEE WAA

APPENDIX E

FREEBOARD ANALYSIS

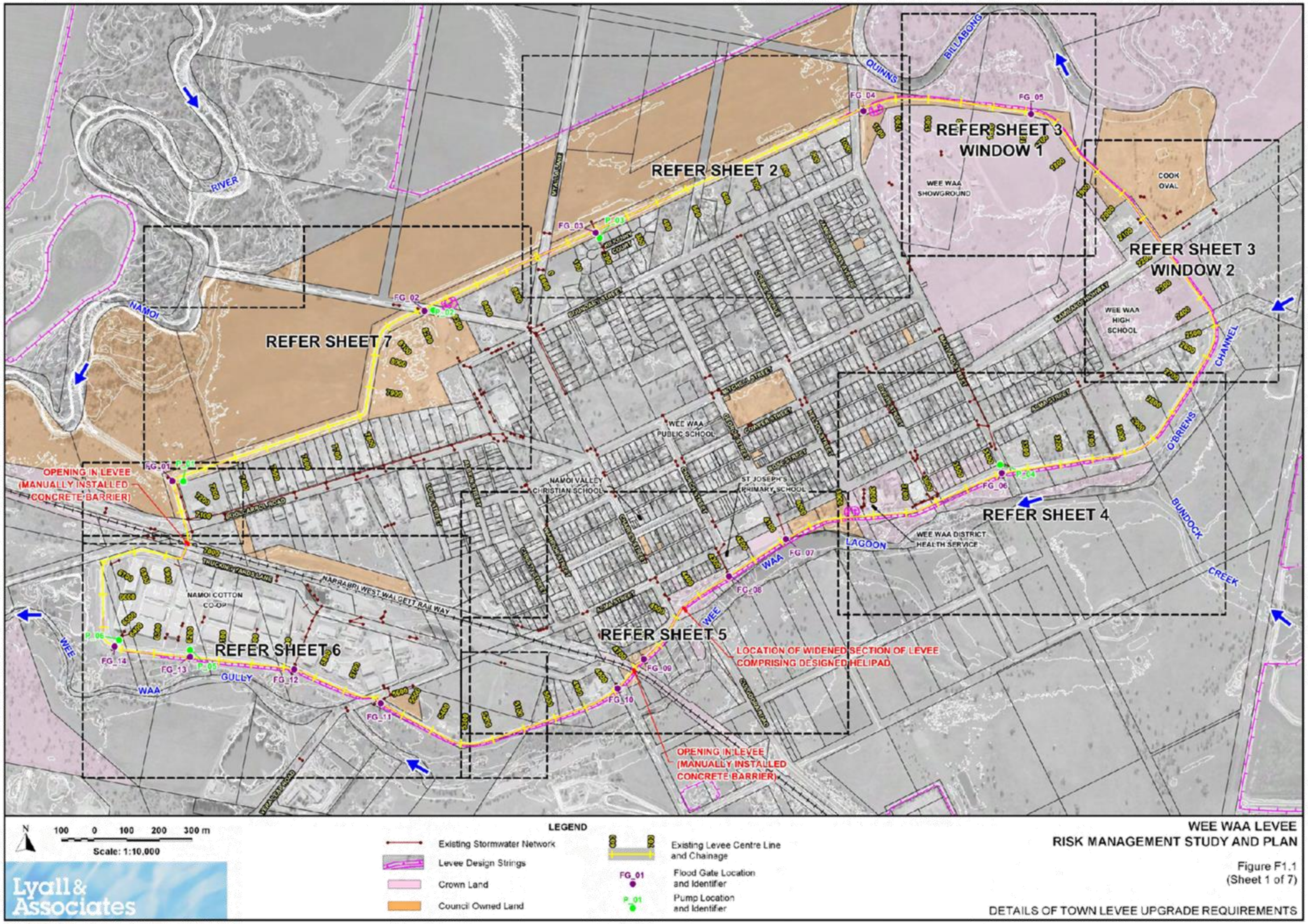
LIST OF FIGURES (APPENDIX E)

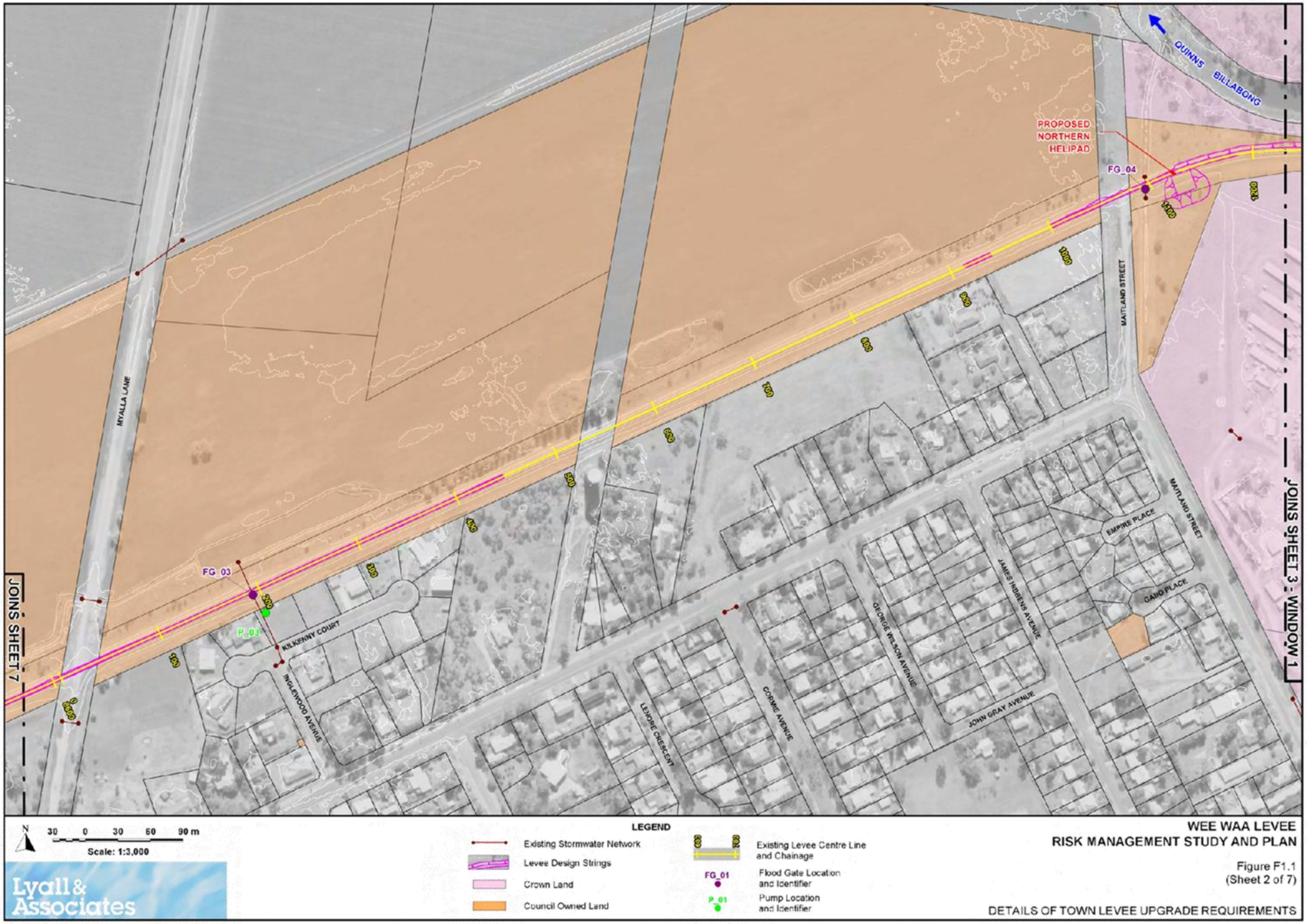

PIAN CREEK
GUNIDGERA
CREEK
NAMOI
RIVER
NAMOI RIVER AT GLENCOE
(GS419900)
RIVER
NAMOI
QUINNS
BILLABONG
O'BRIENS CHANNEL
NARRABRI-WEST WALGETT RAILWAY
KAMILAROI HIGHWAY
WEE WAA LAGOON
WEE WAA GULLY
RIVER
NAMOI
BUNDOCK
CREEK
CARPENDORE
CREEK
MOLLEE
CREEK
BUNDOCK
CREEK
ILLAROO
CREEK
NICHOLSON'S
AIRPORT
THE PINES
NARRABRI-WEST-WALGETT-RAILWAY
600 0 600 1200 1800 m
Scale: 1:60,000
N
Note
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5m (min) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
Lyall & Associates
LEGEND
Two-Dimensional Model Boundary
WaterNSW Stream Gauge
Existing Town Levee Centre Line
Existing Rural Levees on Namoi River Floodplain
1% AEP Flood Extent (Depths Greater than 100 mm Only)
Location and Identifier of Freeboard Assessment
Centre Line of Effective Fetch
Radial Projection
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure E1.1
FLOOD EXTENTS AND EFFECTIVE FETCH LENGTHS
1% AEP NAMOI RIVER FLOOD

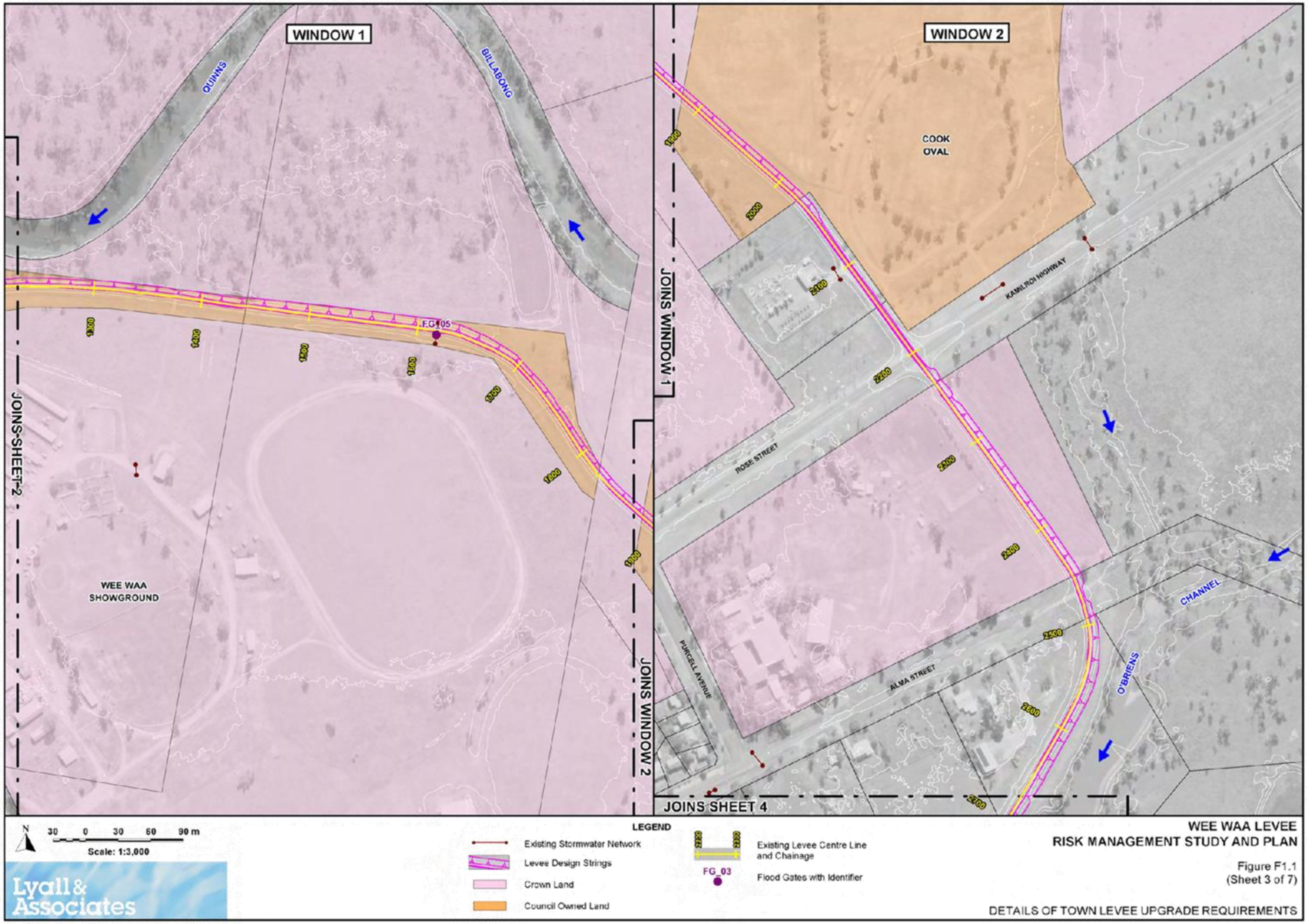
APPENDIX F

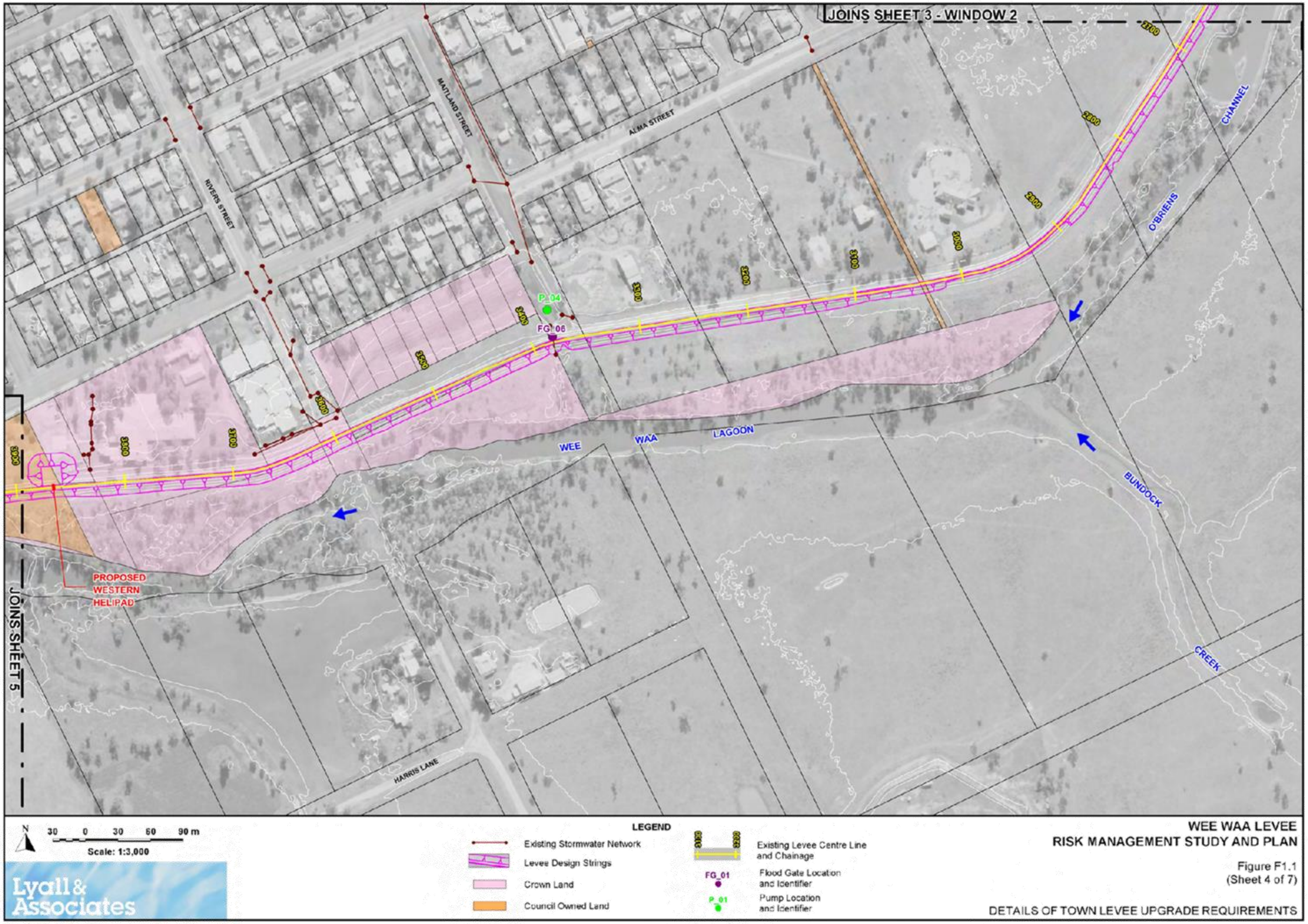
PRELIMINARY DETAILS OF TOWN LEVEE UPGRADE REQUIREMENTS

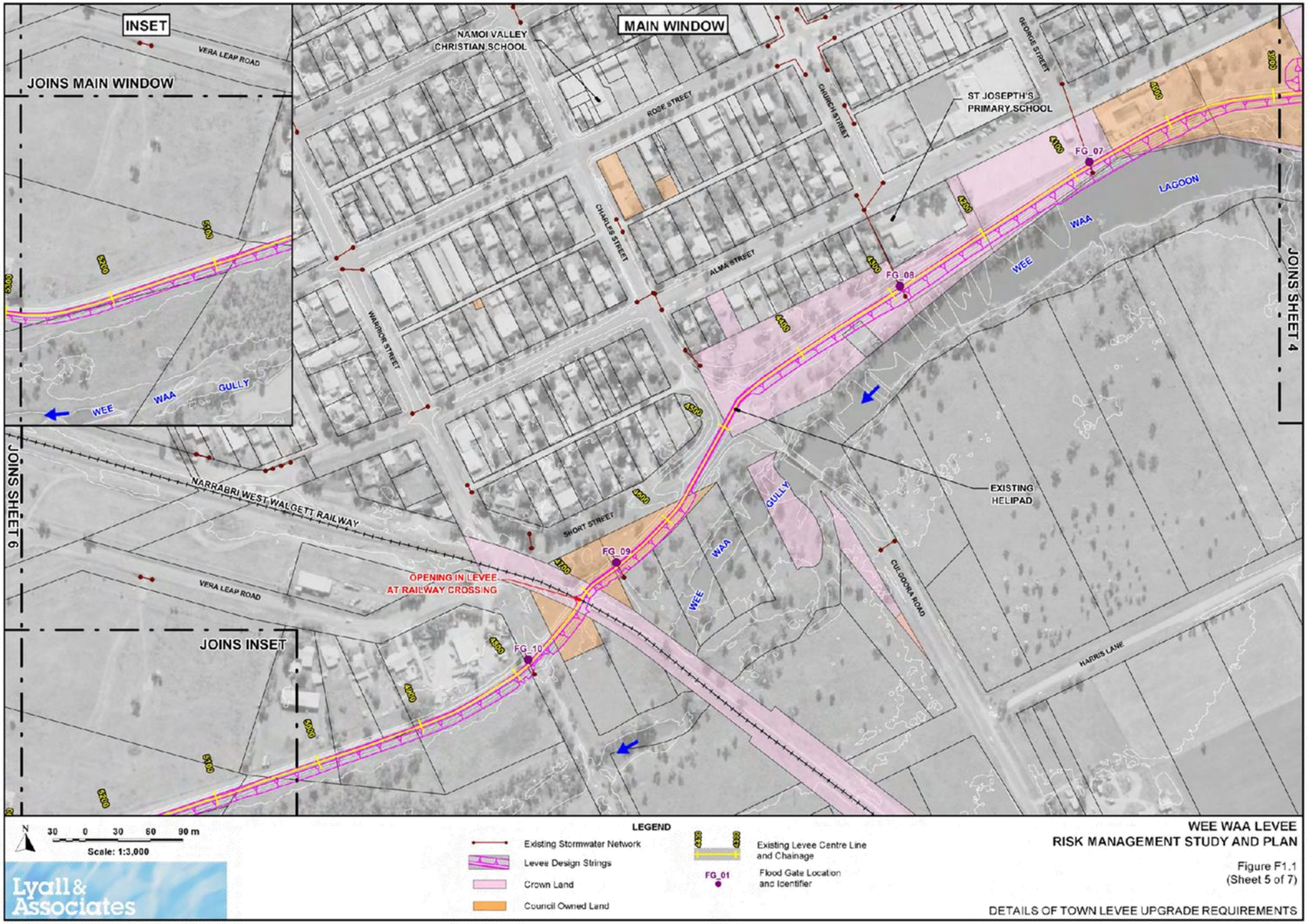
LIST OF FIGURES (APPENDIX F)


REFER SHEET 2
REFER SHEET 3
WINDOW 1
REFER SHEET 3
WINDOW 2
REFER SHEET 4
REFER SHEET 5
REFER SHEET 6
REFER SHEET 7
OPENING IN LEVEE
(MANUALLY INSTALLED
CONCRETE BARRIER)
LOCATION OF WIDENED SECTION OF LEVEE
COMPRISING DESIGNED HELIPAD
WEE WAA SHOWGROUND
COOK OVAL
WEE WAA HIGH SCHOOL
WEE WAA PUBLIC SCHOOL
NAMOI VALLEY CHRISTIAN SCHOOL
ST JOSEPH'S PRIMARY SCHOOL
WEE WAA DISTRICT HEALTH SERVICE
NAMOI COTTON CO-OP
NARRABRI WEST WALGETT RAILWAY
NAMOI RIVER
WEE WAA LAGOON
WEE WAA GULLY
BUNDOCK CREEK
O'BRIENS CHANNEL
QUINNS BILLABONG
Scale: 1:10,000
100 0 100 200 300 m
LEGEND
Existing Stormwater Network
Levee Design Strings
Crown Land
Council Owned Land
Existing Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure F1.1
(Sheet 1 of 7)
DETAILS OF TOWN LEVEE UPGRADE REQUIREMENTS


QUINNS BILLABONG
PROPOSED NORTHERN HELIPAD
FG_04
FG_03
P_03
MYALLA LANE
MAITLAND STREET
KILKENNY COURT
INGLEWOOD AVENUE
LENORE CRESCENT
CORMIE AVENUE
GEORGE WILSON AVENUE
JAMES HIBBENS AVENUE
JOHN GRAY AVENUE
EMPIRE PLACE
CABO PLACE
JOINS SHEET 7
JOINS SHEET 3 - WINDOW 1
Scale: 1:3,000
30 0 30 60 90 m
LEGEND
Existing Stormwater Network
Levee Design Strings
Crown Land
Council Owned Land
Existing Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure F1.1
(Sheet 2 of 7)
DETAILS OF TOWN LEVEE UPGRADE REQUIREMENTS


WINDOW 1
QUINNS
BILLABONG
FG_05
1300
1400
1500
1600
1700
1800
1900
JOINS-SHEET-2
WEE WAA SHOWGROUND
JOINS WINDOW 2
WINDOW 2
JOINS WINDOW 1
COOK OVAL
1900
2000
2100
2200
2300
2400
2500
2600
2700
KAMILROI HIGHWAY
ROSE STREET
CHANNEL
O'BRIENS
PURCELL AVENUE
ALMA STREET
JOINS SHEET 4
30 0 30 60 90 m
Scale: 1:3,000
Lyall & Associates
LEGEND
Existing Stormwater Network
Levee Design Strings
Crown Land
Council Owned Land
Existing Levee Centre Line and Chainage
FG_03
Flood Gates with Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure F1.1
(Sheet 3 of 7)
DETAILS OF TOWN LEVEE UPGRADE REQUIREMENTS

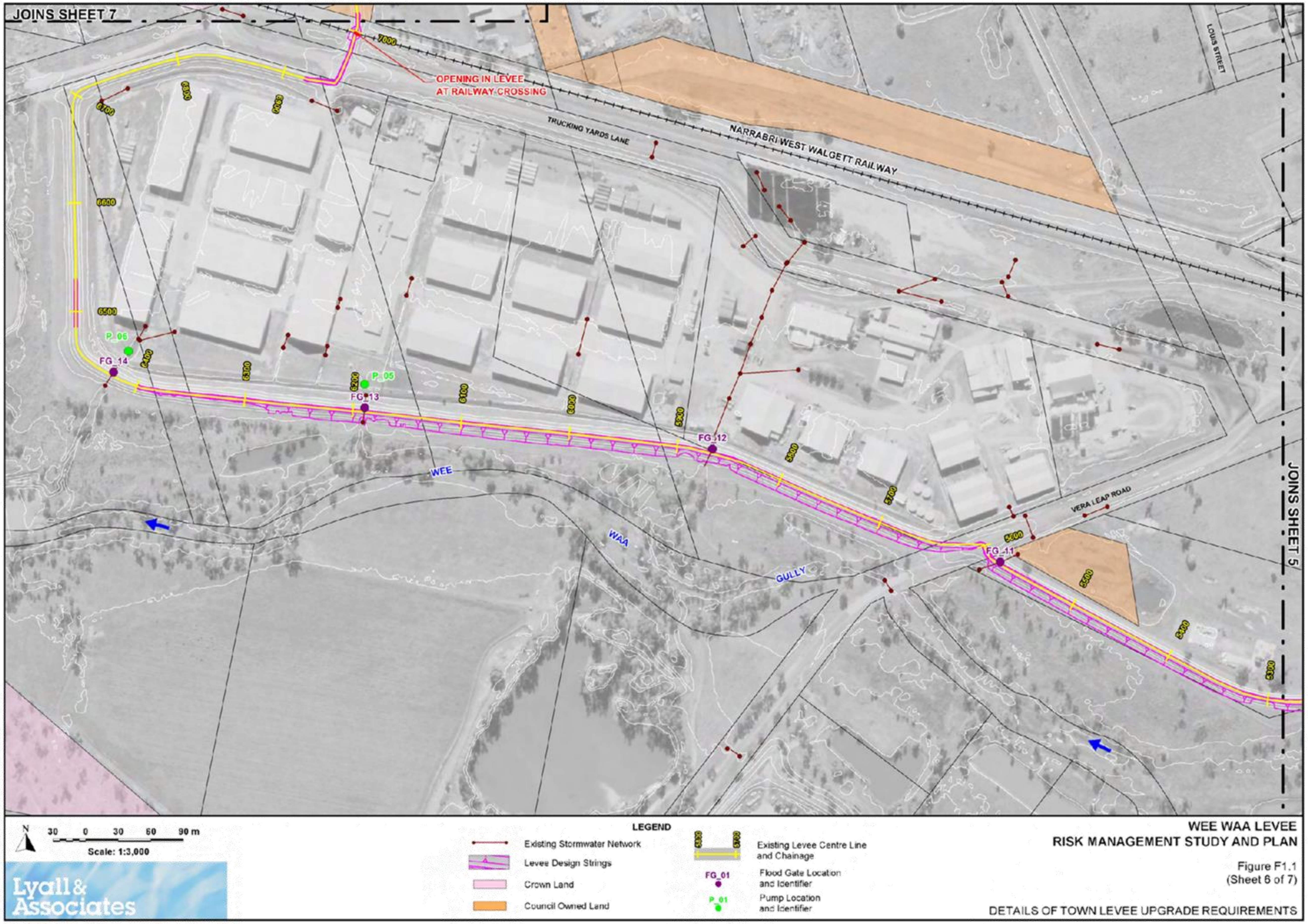

JOINS SHEET 3 - WINDOW 2
JOINS SHEET 5
ALMA STREET
MAITLAND STREET
RIVERS STREET
HARRIS LANE
CHANNEL
O'BRIENS
WEE WAA LAGOON
BUNDOCK CREEK
P_04
FG_06
PROPOSED WESTERN HELIPAD
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
30 0 30 60 90 m
Scale: 1:3,000
Lyall & Associates
LEGEND
Existing Stormwater Network
Levee Design Strings
Crown Land
Council Owned Land
Existing Levee Centre Line and Chainage
FG_01 Flood Gate Location and Identifier
P_01 Pump Location and Identifier
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure F1.1
(Sheet 4 of 7)
DETAILS OF TOWN LEVEE UPGRADE REQUIREMENTS

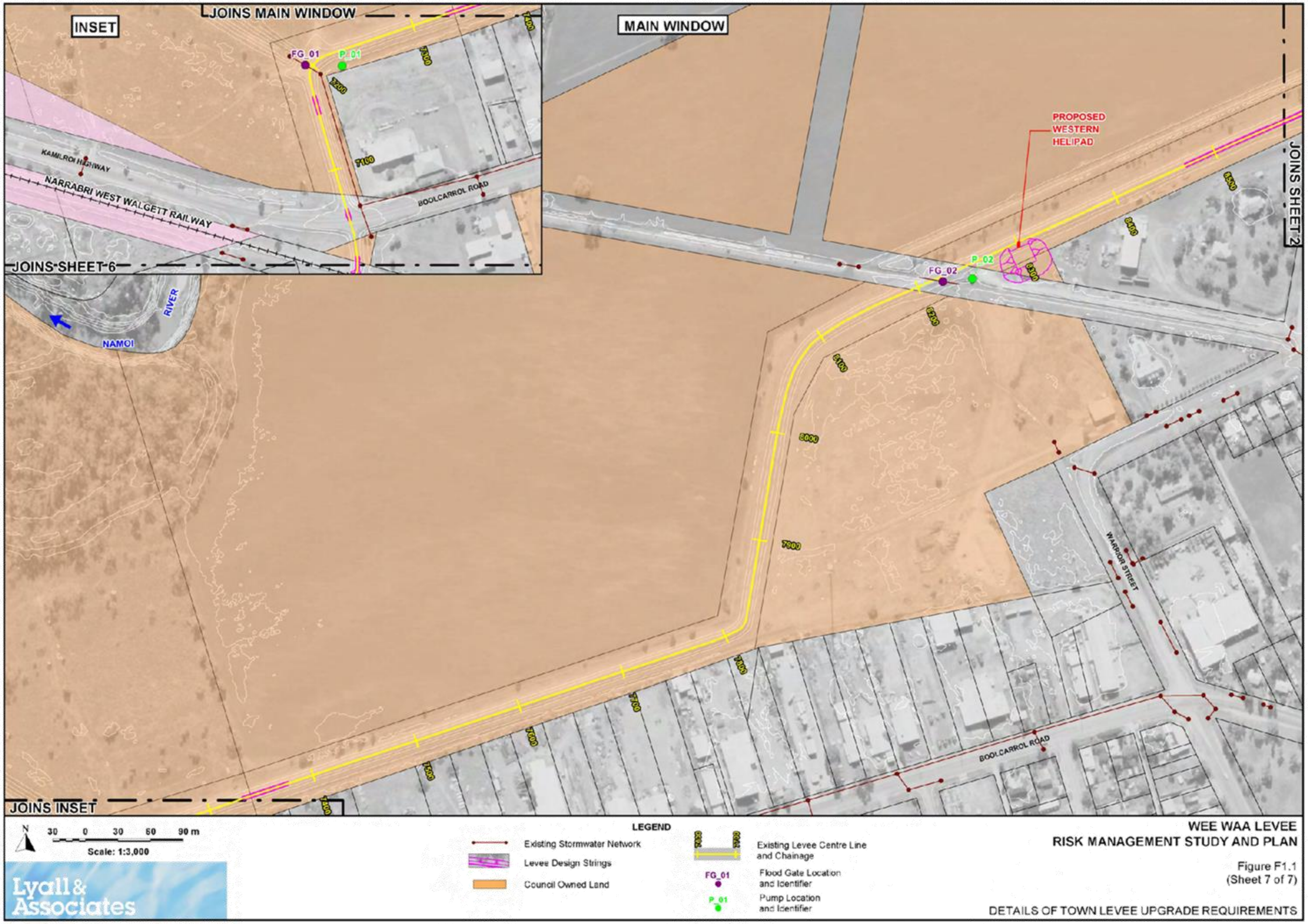


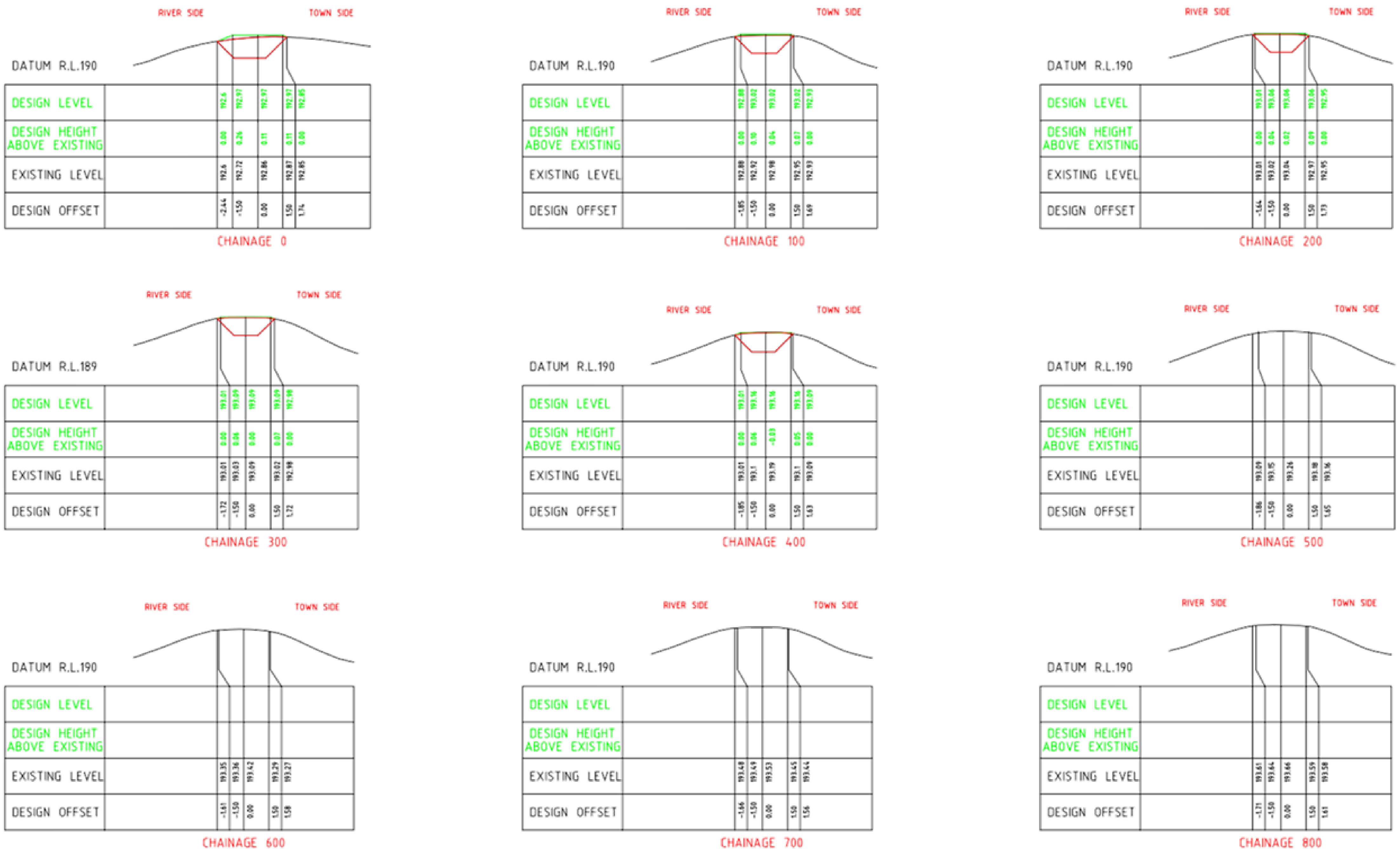
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.1
(Sheet 5 of 7)

DETAILS OF TOWN LEVEE UPGRADE REQUIREMENTS


JOINS SHEET 7
OPENING IN LEVEE AT RAILWAY CROSSING
TRUCKING YARDS LANE
NARRABRI WEST WALGETT RAILWAY
LOUIS STREET
VERA LEAP ROAD
WEE
WAA
GULLY
JOINS SHEET 5
P_06
P_05
FG_14
FG_13
FG_12
FG_11
Scale: 1:3,000
30 0 30 60 90 m
LEGEND
Existing Stormwater Network
Levee Design Strings
Crown Land
Council Owned Land
Existing Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure F1.1
(Sheet 6 of 7)
DETAILS OF TOWN LEVEE UPGRADE REQUIREMENTS


INSET
JOINS MAIN WINDOW
MAIN WINDOW
JOINS SHEET 6
JOINS SHEET 2
JOINS INSET
FG_01
P_01
FG_02
P_02
KAMILROI HIGHWAY
NARRABRI WEST WALGETT RAILWAY
BOOLCARROL ROAD
WARRIOR STREET
NAMOI
RIVER
PROPOSED
WESTERN
HELIPAD
Scale: 1:3,000
30 0 30 60 90 m
LEGEND
Existing Stormwater Network
Levee Design Strings
Council Owned Land
Existing Levee Centre Line and Chainage
Flood Gate Location and Identifier
Pump Location and Identifier
Lyall & Associates
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN
Figure F1.1
(Sheet 7 of 7)
DETAILS OF TOWN LEVEE UPGRADE REQUIREMENTS



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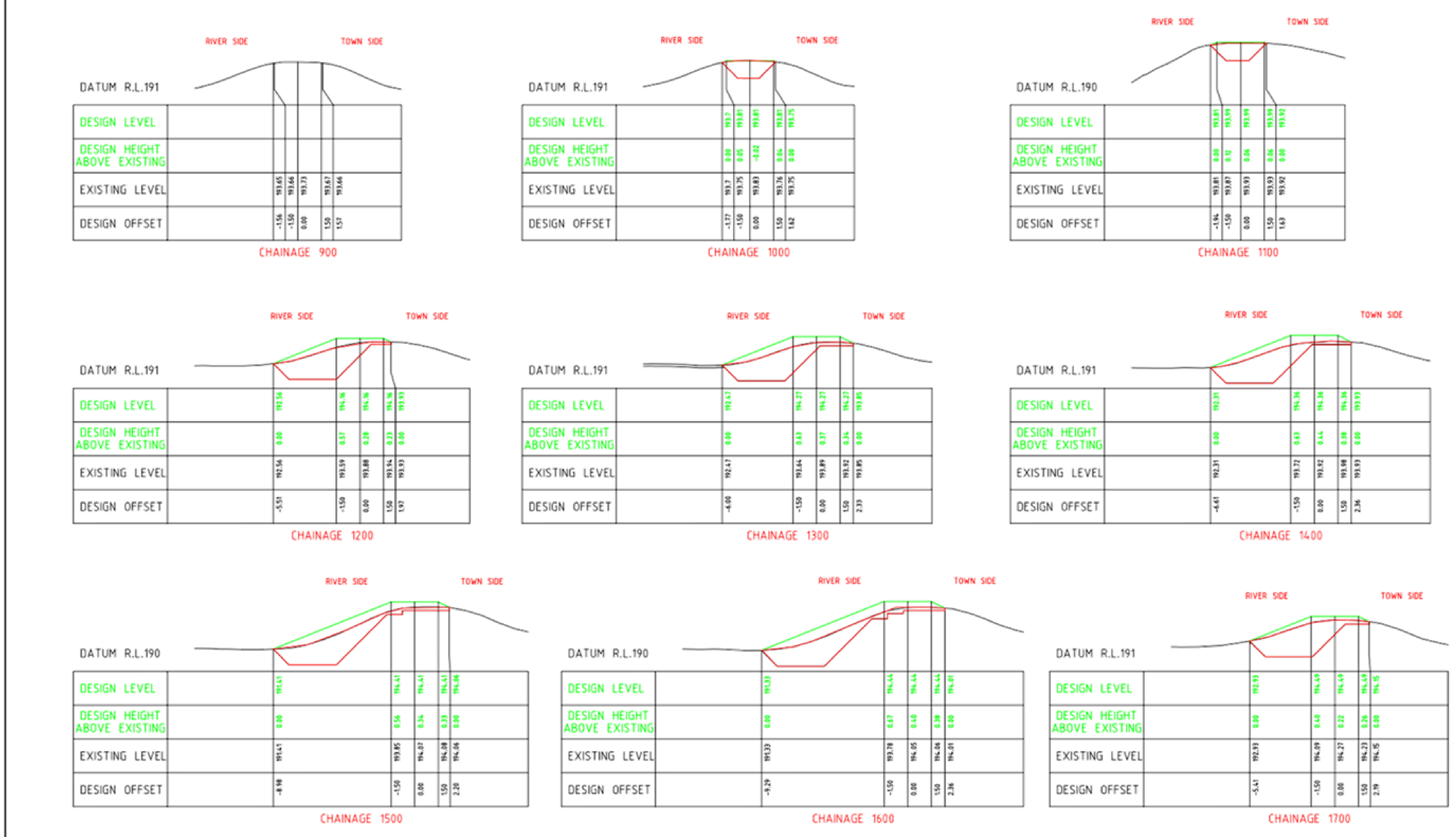
Scale
Vertical 1:250
Horizontal 1:250

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 1 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS



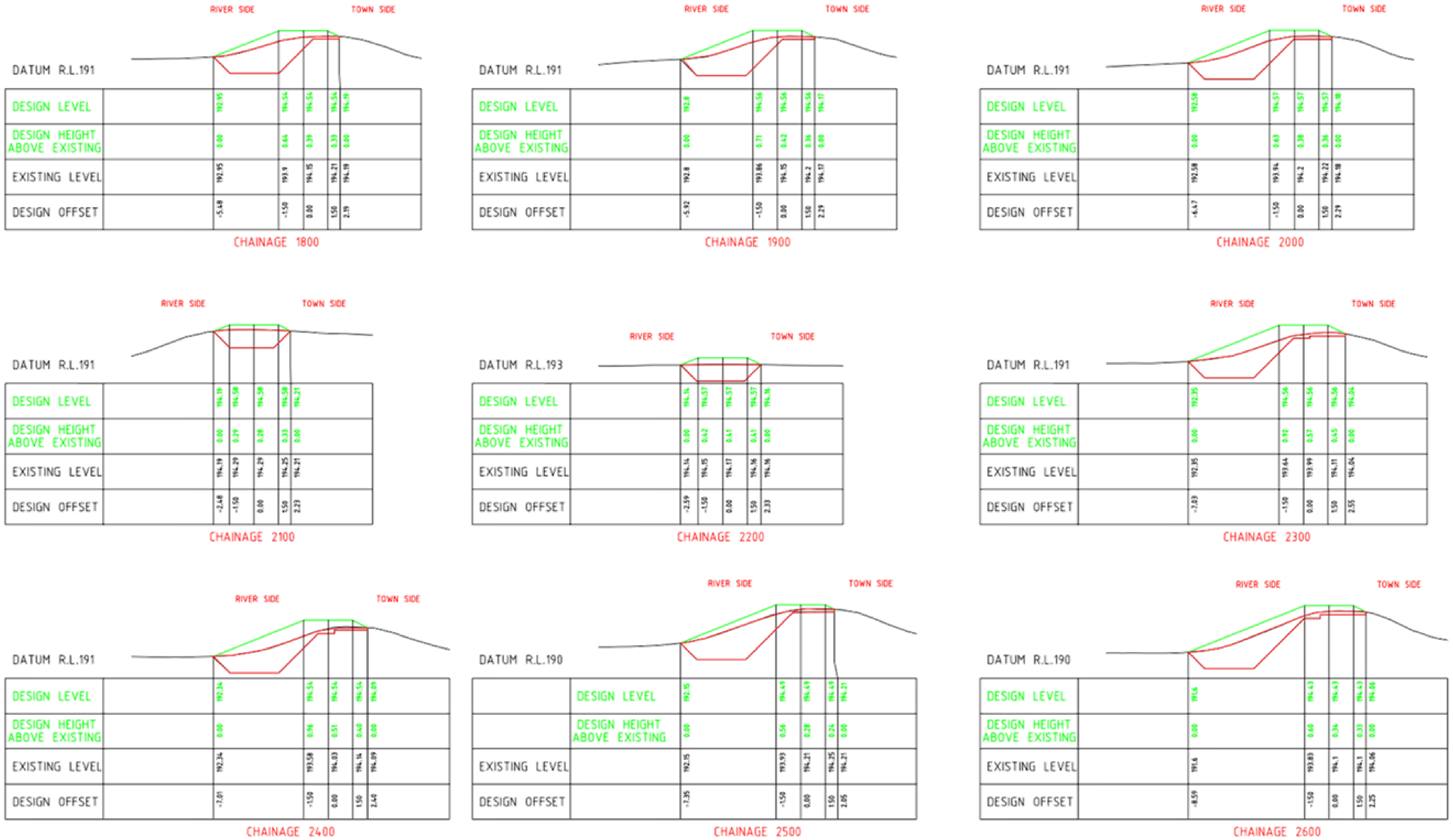
Lyall & Associates

Scale
Vertical 1:250
Horizontal 1:250

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 2 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS



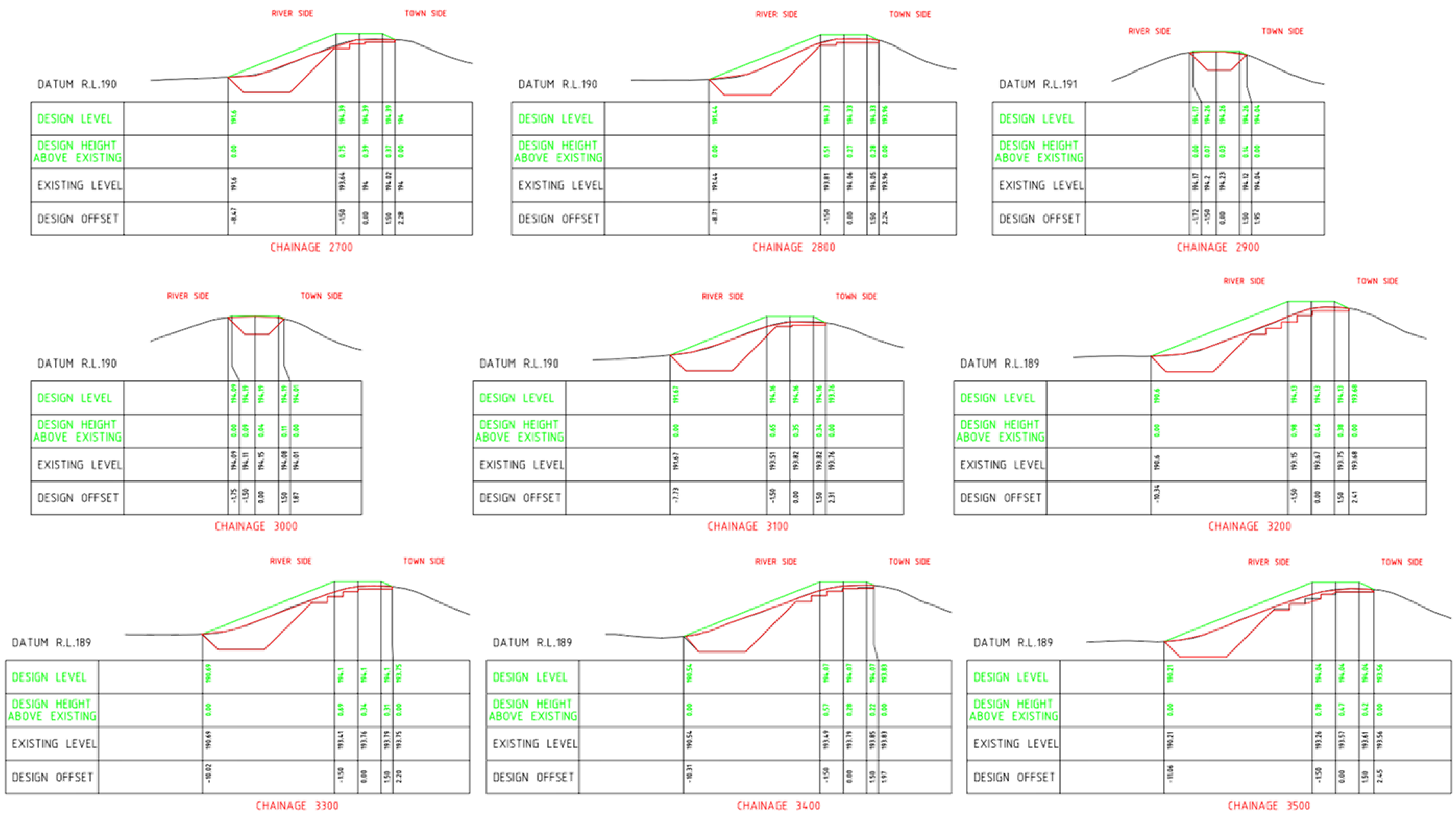
Lyall & Associates

Scale
Vertical 1:250
Horizontal 1:250

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 3 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS



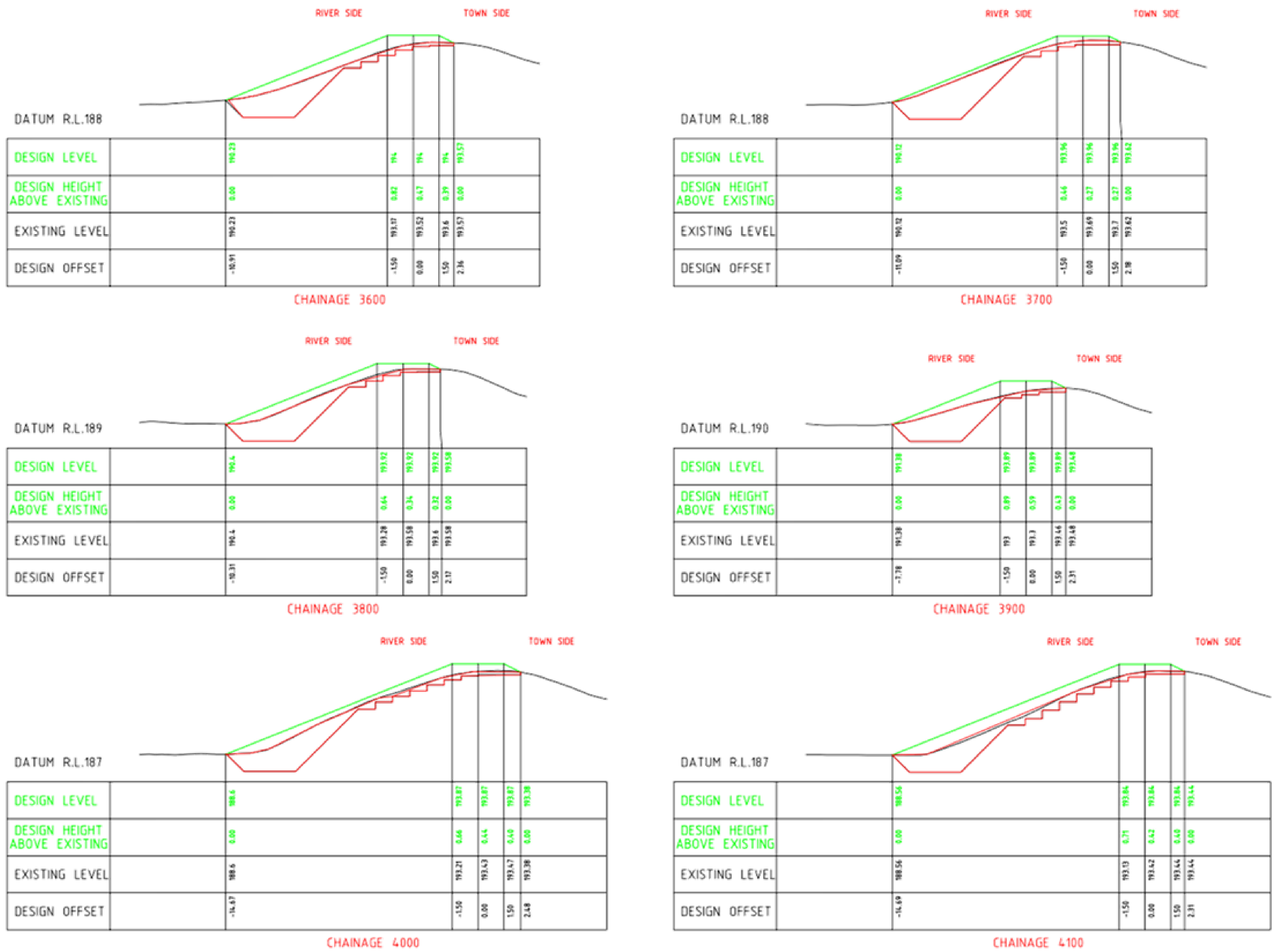
Lyall & Associates

Scale
Vertical 1:250
Horizontal 1:250

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 4 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS



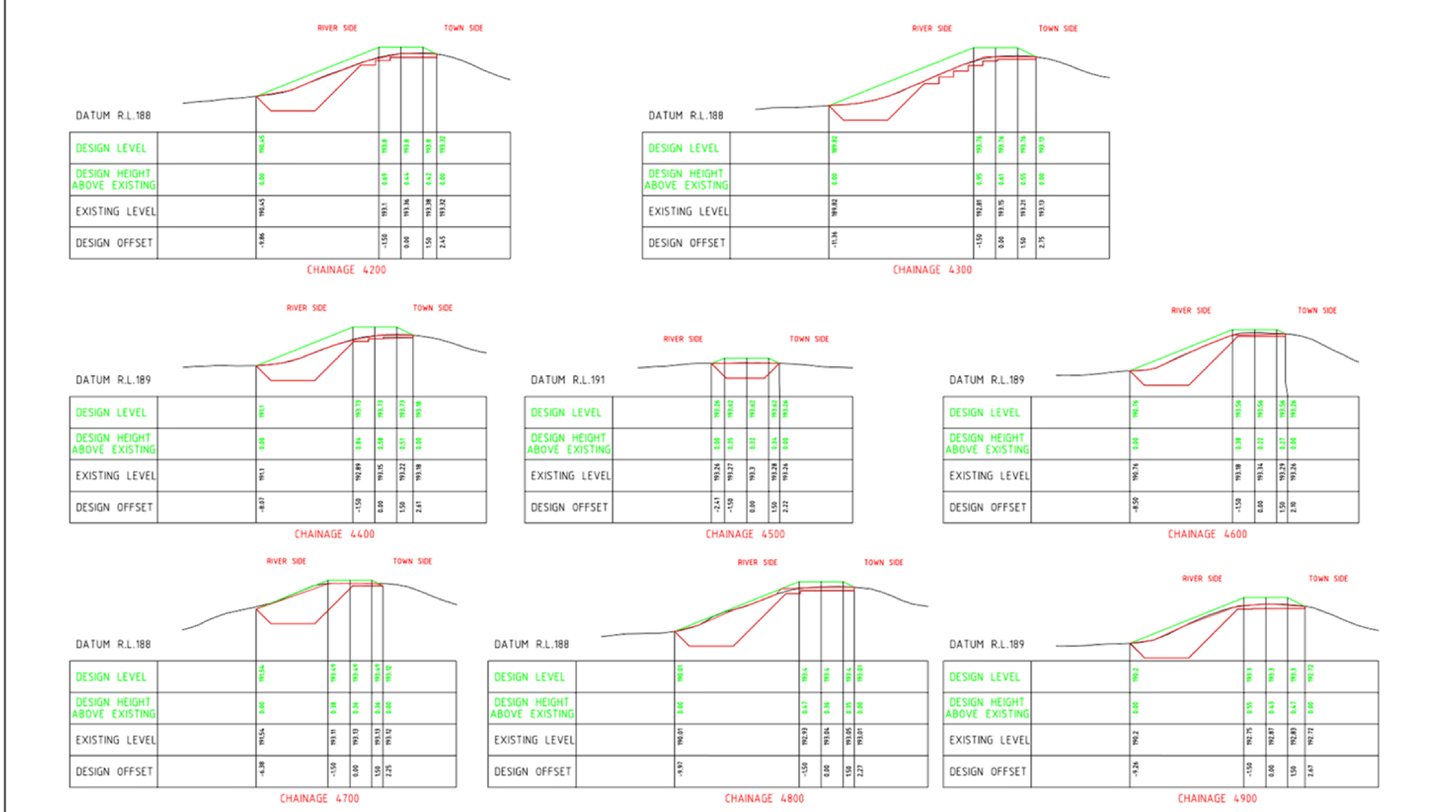
WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 5 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS

Lyall & Associates

Scale
Vertical 1:250
Horizontal 1:250



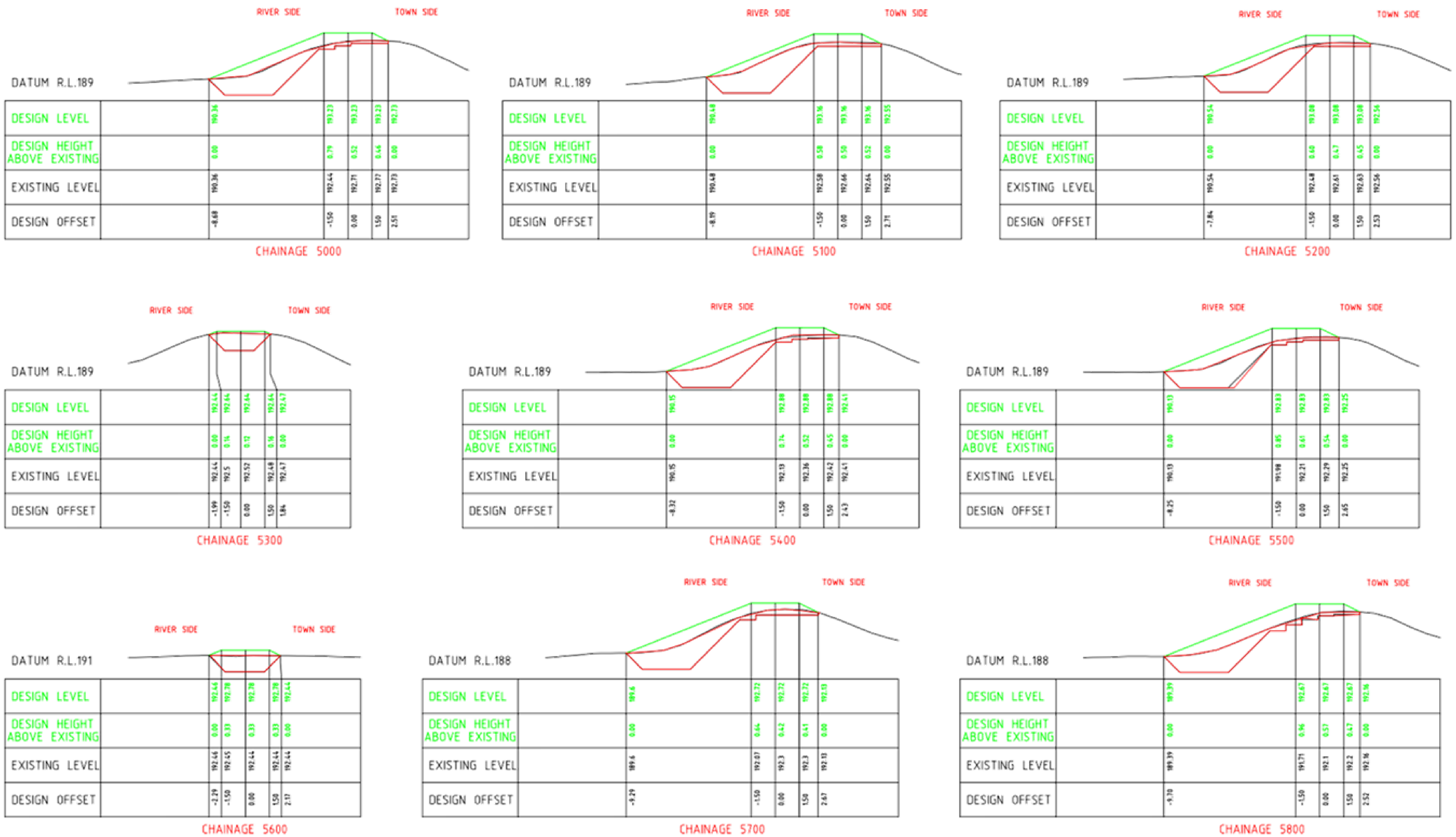
Lyall & Associates

Scale
Vertical 1:250
Horizontal 1:250

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 6 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS



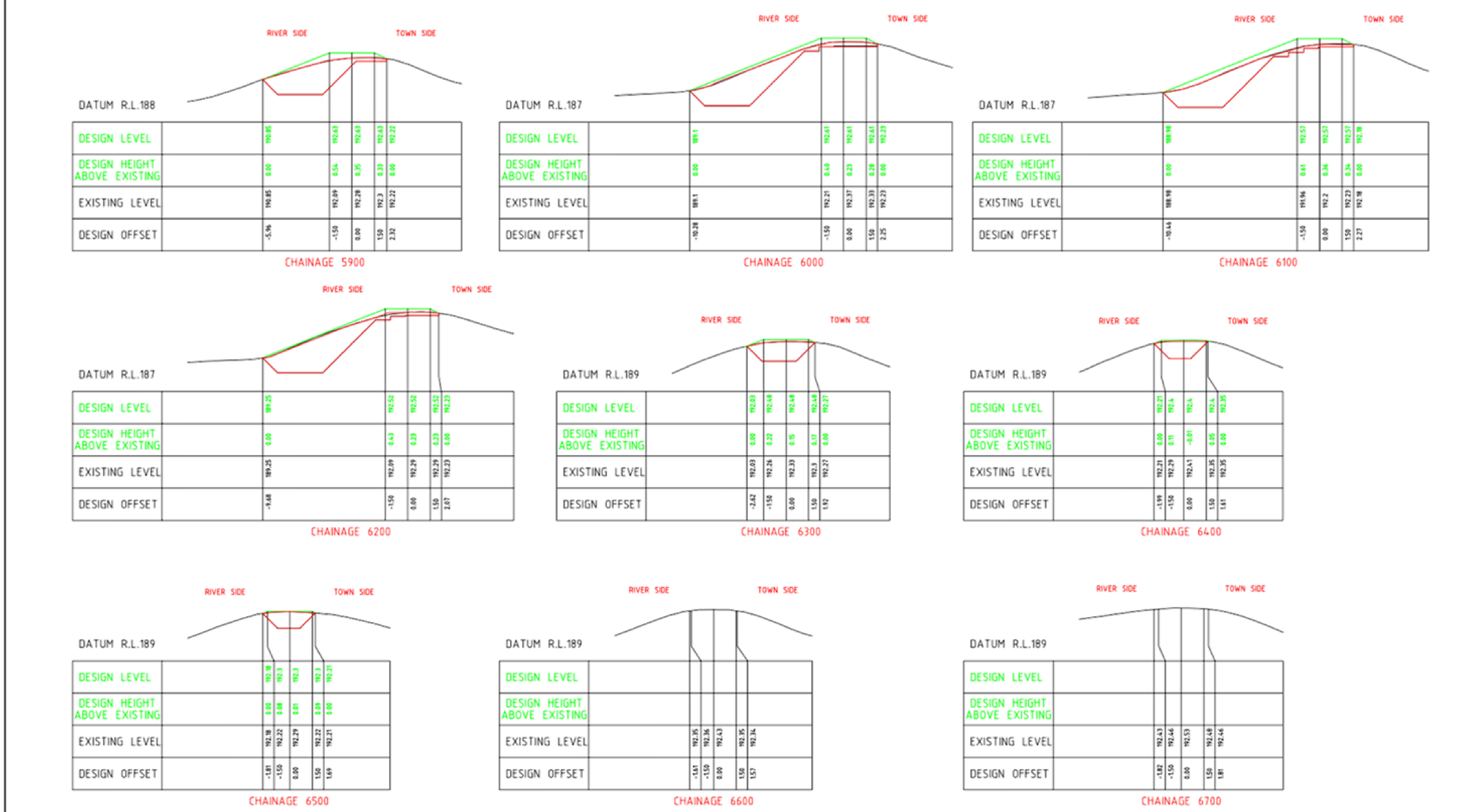
Lyall & Associates

Scale
Vertical 1:250
Horizontal 1:250

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 7 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS



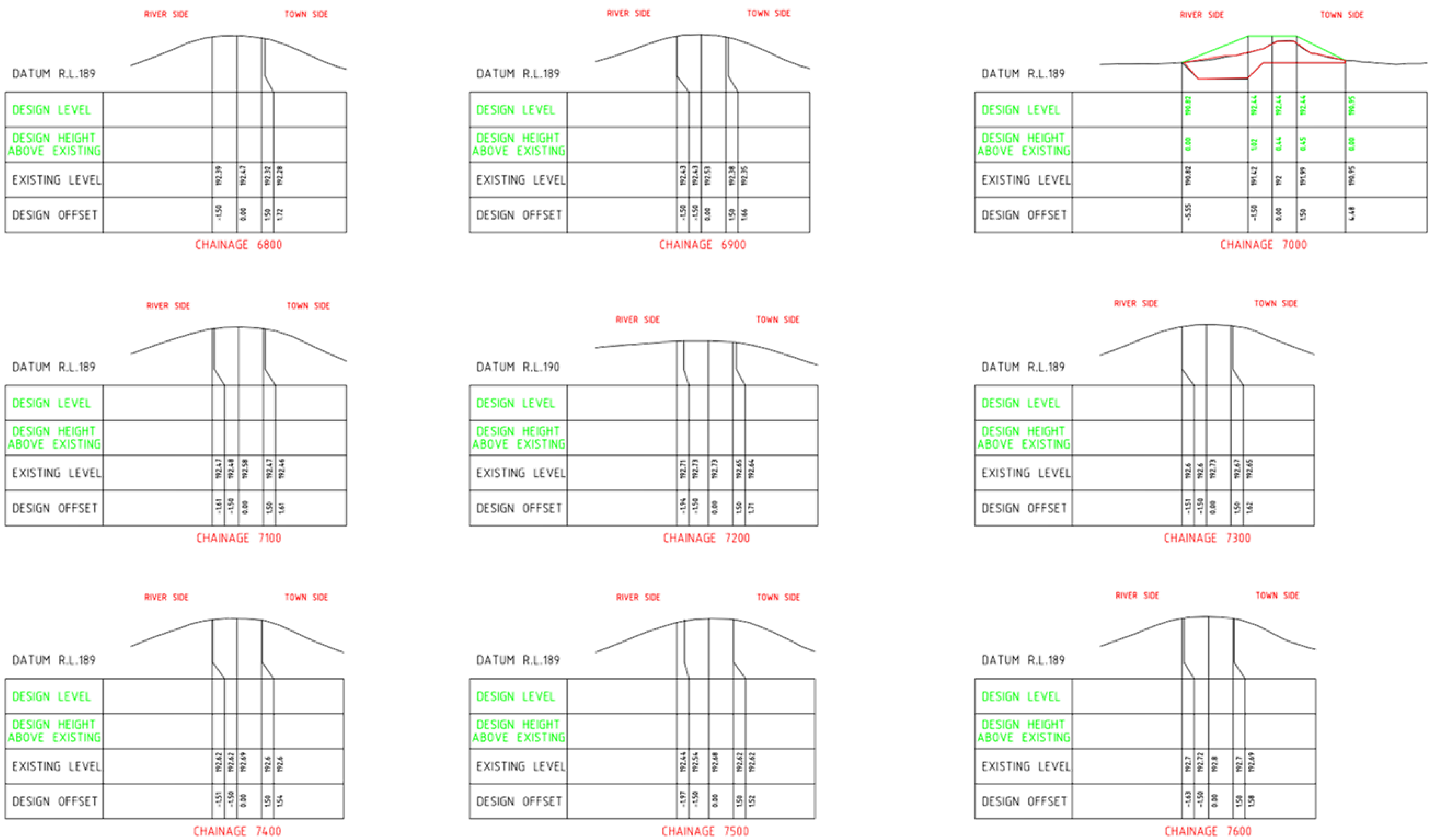
Lyall & Associates

Scale
Vertical 1:250
Horizontal 1:250

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 8 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS



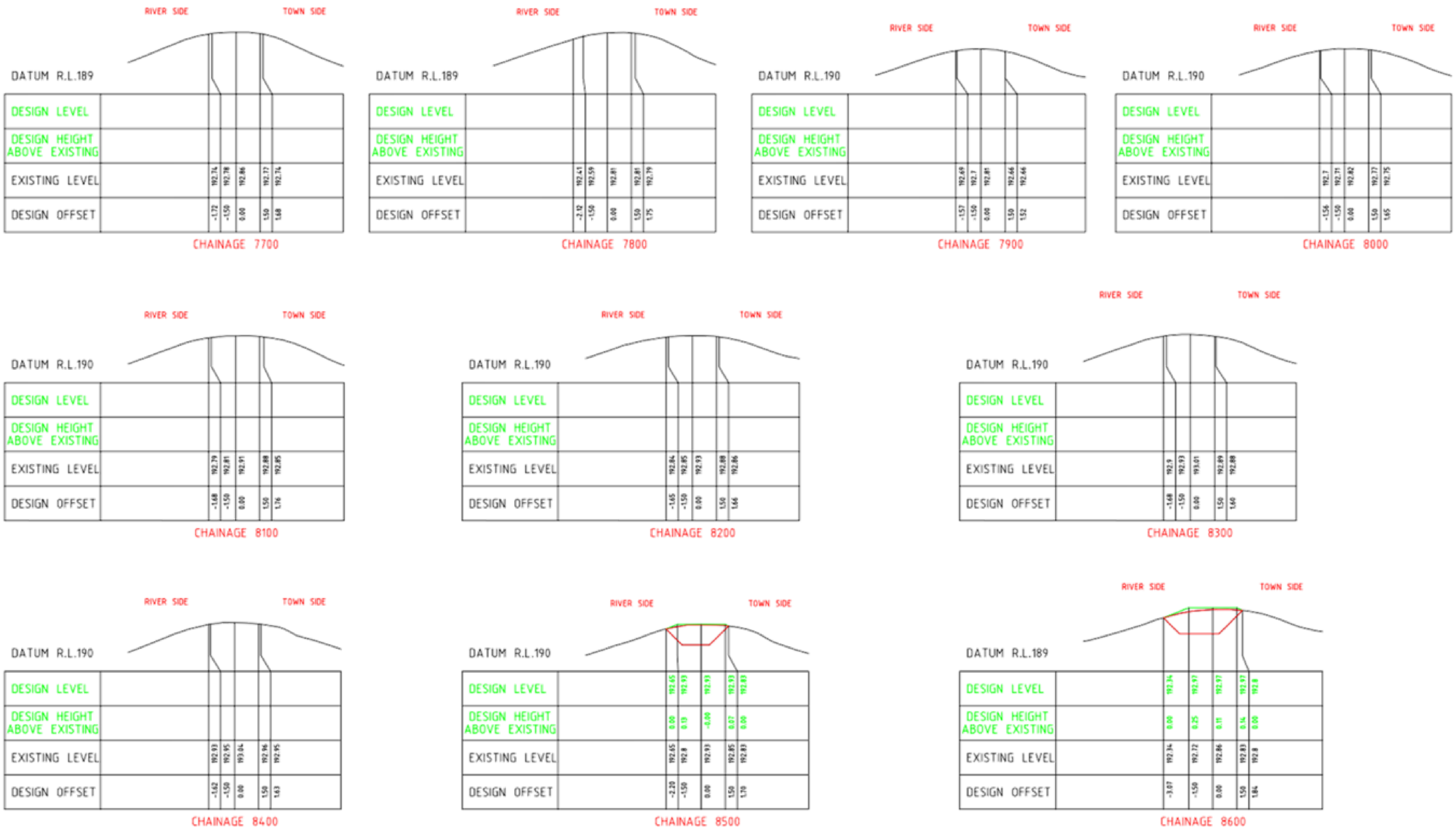
Lyall & Associates

Scale
Vertical 1:250
Horizontal 1:250

WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 9 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS



WEE WAA LEVEE
RISK MANAGEMENT STUDY AND PLAN

Figure F1.2
(Sheet 10 of 10)

CROSS SECTIONS SHOWING
TOWN LEVEE UPGRADE REQUIREMENTS

Lyall & Associates

Scale
Vertical 1:250
Horizontal 1:250

Lyall & Associates

stormwater & flood risk management
engineering design & documentation
hydrologic & hydraulic modelling
expert advice & peer review
river engineering

Narrabri Shire Council
PO BOX 261
NARRABRI NSW 2124 Job No. EE409

Attn: Ms Cara Stoltenberg

18 June 2019

Dear Cara,

Re: Wee Waa Levee Risk Management Study and Plan

This letter sets out our response to the comments that were made by Mr Stuart Holle, Principal Civil Engineer of GCA Engineering Solutions in his letter of 4 April 2019 in which he recommends that an alternative approach for setting the freeboard allowance for the ring levee at Wee Waa be adopted to that which is set out in the draft *Wee Waa Levee Risk Management Study and Plan* report dated February 2019 (**Lyall & Associates, 2019**).

1. Methodology Adopted as part of Lyall & Associates, 2019

Table 1 at the end of this letters provides a breakdown of the various components comprising the freeboard allowance that was computed as part of Lyall & Associates, 2019.[1] We note that the methodology that was adopted for deriving the freeboard allowance for the ring levee at Wee Waa is the same as that which was adopted by NSW Public Works (now NSW Public Works Advisory) in 2010 as part of its assessment of the levee upgrade requirements for Wagga Wagga. A copy of the report that was prepared by NSW Public Works at the time is provided as **Attachment A** to this letter.

The freeboard allowance presented in Lyall & Associates, 2019 was derived by multiplying the maximum height allowance for each individual design variable (refer **Column B** of **Table 1**) by its estimated probability of occurrence (**Column C**) to determine the individual joint probability freeboard allowance (**Column D**). The total freeboard allowance, which is the sum of the joint probability allowance for the seven design variables was computed as being 1040 mm, which was rounded down to 1.0 m for the purpose of developing the strategic design of the ring levee upgrade. We note that this value is the same as the current design freeboard allowance for the ring levee, albeit that it is benchmarked off the 1971 flood which has an estimated Annual Exceedance Probability (**AEP**) of about 4 per cent (i.e. a 1 in 25 year event).

2. Methodology Recommended by Mr Holle

Mr Holle recommends an alternative methodology for calculating the total freeboard allowance, which involves the following steps:

- **Step 1** - Determine the total maximum freeboard by summing the maximum allowances for the individual design variables (computed to be 1.5 m) (**Column E**).
- **Step 2** - Determine the probability of all variables occurring at the same time by multiplying the probabilities of occurrence of the individual design variables (computed to be 0.03%) (**Column F**).

[1] For comparison purposes, the freeboard requirements reported in this letter are for Location B only.

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Principal: S A Button BE(Hons) MEngSc
Lyall & Associates Consulting Water Engineers ABN 93 257 653 251 trading as Lyall & Associates

- **Step 3** - Multiply the total maximum freeboard allowance (1.5 m) by the probability of all variables occurring at the same time (0.03) to obtain a total freeboard allowance of 0.05 m (**Column G**).

As this approach resulted in a very small freeboard allowance, Mr Holle then assessed different combinations and permutations of the seven design variables assuming they do not all occur coincident with one another and concluded that the total maximum freeboard allowance should be 0.58 m, which was derived using only the "Uncertainties in Flood Peak Flood Level Estimates" and "Levee Settlement" design variables (refer **Columns H** to **J** of **Table 1**).

3. Comments on Mr Holle's Recommended Approach

We cannot support Mr Holle's recommended approach as it significantly reduces the significance of the design variables that have an assigned probability of occurrence of 100%. For example, even though the "Uncertainties in Flood Peak Flood Level Estimates" and "Levee Settlement" design variables have an assigned probability of occurrence of 100%, his method results in a freeboard allowance which is much less, which in our opinion is illogical. We also don't believe it is prudent to select one or more design variables in the joint probability analysis while ignoring others as this is somewhat subjective in nature and to our knowledge is not based on any at-source field data.

Given the approach that has been adopted as part of Lyall & Associates, 2019 is the same as has been adopted by NSW Public Works Advisory for the design of the upgrade requirements for the levee upgrade at Wagga Wagga (and quite possibly others), we are comfortable with recommending its adoption for Wee Waa. Furthermore, we wish to highlight that the flood risk at Wee Waa is considered to be very high given the impact that an overtopping event would have on the town. While it will cost more to incorporate a 1 m freeboard allowance to peak 1% AEP (1 in 100 year) flood levels into the design of the ring levee upgrade (when compared to say a 0.5-0.6 m freeboard), we believe that the benefits that it would provide the community in reducing the flood risk justify its adoption.

If it would assist the Floodplain Risk Management Committee in its review of the draft report and its findings, we suggest that Council contact Mr Fred Spain from the NSW Public Works Advisory who could undertake a peer review of the two approaches to assessing the freeboard requirement for the ring levee at Wee Waa. Mr Spain's email address is fred.spain@finance.nsw.gov.au.

We trust that our responses to comments made by Mr Holle will assist the Floodplain Risk Management Committee in its review of draft *Wee Waa Levee Risk Management Study and Plan* report. However, please do not hesitate to contact the undersigned should you wish to discuss any aspect of this letter.

Yours faithfully
Lyall & Associates Consulting Water Engineers

Scott Button
Principal

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TABLE 1
FREEBOARD ALLOWANCE AT LOCATION B

Design Variable	Lyall & Associates, 2019			Holle (All Design Variable)			Holle (Maximum)		
	Maximum Allowance (m)	Probability of Occurrence	Joint Probability Allowance (m)	Maximum Allowance (m)	Probability of Occurrence	Joint Probability Allowance (m)	Maximum Allowance (m)	Probability of Occurrence	Joint Probability Allowance (m)
[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]	[I]	[J]
Wave Action (Run-up)	0.41	0.5	0.21	0.41	0.5				
Wave Action (Set-up)	0.10	0.5	0.05	0.10	0.5				
Local Water Surge	0.01	0.5	0.01	0.01	0.5				
Uncertainties in Peak Flood Level Estimates	0.56	1	0.56	0.56	1		0.56	1	
Levee Settlement	0.02	1	0.02	0.02	1		0.02	1	
Levee Defects	0.10	0.5	0.05	0.10	0.5				
Future Climate Change	0.27	0.5	0.14	0.27	0.5				
Total			**1.04**	**1.47**	**0.03**	**0.047**	**0.58**	**1**	**0.58**

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ATTACHMENT A

Public Works
NSW Water Solutions

WAGGA WAGGA LEVEE UPGRADE
FLOOD FREEBOARD

Report Number: DC 10096
Thursday, November 04, 2010

Wagga Wagga City Council

City of Wagga Wagga

NSW Public Works

Wagga Wagga Levee Upgrade

Flood Freeboard

Report number: DC 10096

Thursday, November 04, 2010

Document Control

Issue / Revision	Author	Reviewer	Approved for Issue	
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ATTACHMENTS

1. Introduction

This report addresses the freeboard requirements for the proposed Wagga Wagga Levee upgrade works. The freeboard allowances contribute to the overall Design Levee Levels (profile) for the entire length of the levee systems at Wagga Wagga (Main Levee) and North Wagga Wagga (North Wagga Levee).

The City of Wagga Wagga is situated on the south bank of the Murrumbidgee River and North Wagga Wagga is on land enclosed between the Northern flood plain and the river. North Wagga Wagga is only slightly higher than the surrounding flood plain. The Murrumbidgee River is a major tributary of the Murray River system and drains some 100,000 km^2 in the southern inland area of New South Wales. Rising on the western slopes of the Snowy Mountains, the Murrumbidgee River has a catchment area of some 26,400 km^2 at the city of Wagga Wagga.

The Main Levee currently provides protection from inundation up to a level of approximately equivalent to the August 1974 flood event plus a freeboard of 1 metre. Temporary levees have been constructed around the village of North Wagga Wagga since at least the mid 1930's. The North Wagga Wagga levees were formalised as more permanent structures in 1990 so as provide protection up to approximately 0.5 to 1 metre below the level of the August 1974 flood event. Refer to Attachment 1 for the height of the existing Wagga levee system crest levels.

The existing Main Levee consists of a 9km long levee constructed generally as an earthfill embankment, with a portion consisting of a reinforced concrete wall type levee. Levees at North Wagga Wagga (with inclusion of Bank Two) total approximately 5.8km in length. These levees are of the earthfill embankment type.

The design flood levels, with appropriate freeboard allowance, are assigned in accordance with flood levels determined for a range of ARI events, as provided in the flood study (and its addendum) completed by Webb, McKeown and Associates in 2004 and 2009 respectively. The design levels as depicted in Figure 1 are superimposed onto the length of the existing/extended levee alignment of the Main Levee and North Wagga Wagga Levee to determine the degree of levee rising required at each particular location. This will influence the type of levee option to be considered in the proposed option study. The design levee profiles will be determined using the following design flood events:-

- Main Levee – 100 year ARI flood event; and
- North Wagga Wagga Levee – 20 year ARI flood event.

Additional to these design flood levels, appropriate freeboard allowances will be added. This report details the determination of the appropriate freeboard allowance and the recommended freeboard values for each levee.

2. Freeboard

Freeboard is incorporated into the final design height of the levee and is expressed as the incremental difference in height between the level of the flood the levee is designed to protect against, and the design crest level of the levee.

The purpose of freeboard is to provide a reasonable certainty that the risk exposure associated with a particular design flood is actually provided. Generally, freeboards are added to levee crest levels to allow for:-

- Uncertainties in the estimates of flood levels, such as inadequacies in the historical data;
- Increases in flood level as a result of wind and wave action;
- Differences in flood levels due to 'local factors' such as local water surge;
- Post construction settlement, which effectively reduces the long term level of the levee;
- Reduction in crest level due to defects in the levee and surface erosion, plus effects of vehicle, animal or pedestrian crossings and lack of levee maintenance;
- Potential changes in rainfall patterns as a result of climate change; and
- Computational uncertainties, inadequacies in survey data and other sources of error.

It has been common practice to adopt a freeboard of 1 metre for typical earth embankment type levees, and 0.6 metres for retaining wall type levees or levees constructed as sealed roads, however the freeboard allowance factors listed above can differ substantially for different sections of a single levee, according to such factors as type of levee, exposure to wave action etc. Thus applying a standard freeboard allowance for a levee is considered simplistic, and in many instances, overly conservative.

There are no formal freeboard standards adopted in Australia, and estimates of acceptable freeboard for the Wagga Wagga Levee are made based on a Joint Probability Analysis. This consists of matrix of design variables and associated probabilities. The exercise indicates that the commonly adopted freeboard could be reduced without significantly affecting the risk of providing protection for Wagga Wagga against the selected design flood.

3. Freeboard Components

The flood freeboard is calculated from a number of specific components, each of which can be determined with some precision or reasonably estimated from past performance. Each of these components are described below.

3.1 Wave Action

Where the levee face is exposed to a large expanse of flood water, significant waves can be generated under windy conditions. These waves, when superimposed onto the design flood level, may overtop the levee.

The design wind and wave action estimation carried out in this study have been based on the Australian Wind Loading Standard - AS/NZS1170.2 (2002) - and guidelines for estimation of waves for shallow water reservoirs - USBR (1992).

3.1.1 Fetch

Fetch is the distance a wave is assumed to travel from the point of origin to a point of impact. The distance is limited by the land surrounding the body of water. The fetch in turn, determines the extent of exposure to wind that a wave will have such that the longer the fetch, the greater will be the wave height.

As the extent of flood water is limited by the irregular "shoreline", an effective fetch (F) must be calculated to determine an average horizontal distance in the general direction of the wind over water, corrected for flood geometry over which a wind acts to generate the waves. The method determines an effective fetch for a single point on the levee from various points on the "shoreline", where waves can originate. Distances are calculated for a 90° arc from the nominated point on the levee. The effective fetch is used to calculate wave properties.

Determining the longest effective fetch is a trial and error process, whereby a number of positions on the levee are selected and the calculation of maximum effective fetch carried out using the following equation :-

$$F = \frac{\sum x_i \cos\alpha_i}{\sum \cos\alpha_i}$$

where :-

F = Effective fetch (km)

X_i = length of projection of radial (i) on the central radial

α_i = angle between the central radial from the dam and radial (i).

It has been assumed that the design wind can originate from any direction.

An example of the method of calculation is shown in Figure 4.

Effective fetch for the Wagga Wagga levees has been determined for each of the two levees and corresponding design flood events, ie :-

- Main Levee – 100 yr ARI flood event
- North Wagga Wagga Levee – 20 yr ARI flood event.

In the case of the Main Levee, it is assumed that the area within the North Wagga Wagga Levee is inundated such that fetch distances to the north of the Main Levee are extended to the perimeter of the inundation area. In the case of the North Wagga Wagga Levee (20 yr ARI design flood event) the Main Levee will offer some protection to the south of the North Wagga Wagga Levee.

In each case, three representative points on the levee were assessed as potential maximum effective fetch locations and effective fetch distances calculated. These are shown on Figure 2 (Main Levee) and Figure 3 (North Wagga Wagga Levee) and are denoted as fetches A, B and C. The calculated fetch distances are given in Table 3.1.

Table 3.1 Effective Fetch

Levee	Flood Event	Fetch (km)
Main Levee	100 yr ARI (see Figure 2)	A = 6.28 km B = 4.25 km C = 4.27 km
North Wagga Levee (incl. Bank 2)	20 yr ARI (see Figure 3)	A = 1.87 km B = 3.01 km C = 1.83 km

3.1.2 Design Wind

The height of waves generated for a given wind speed are limited by wind duration and fetch distance. Wave heights progressively increase under constant wind action, as they move along the fetch, until a maximum limiting value is reached. A certain duration of wind is required to generate waves over the given fetch distance.

For the maximum design flood levels (ie 100 yr ARI and 20 yr ARI respectively) a moderate wind is proposed – one that can be reasonably expected to occur concurrently with the maximum flood levels. This moderate wind is adopted as the 1 year ARI wind.

Values for maximum design winds at Wagga Wagga, for a range of ARI events, are given in Table 3.2 This design wind speed information was obtained from Section 3 of the Australian Wind Loading Standard – AS/NZS-1170.2 (2002).

Table 3.2 Design Wind Speeds

Wind Event (ARI)	Design Wind Speed (m/sec)
1	17
10	22
100	26

3.1.3 Wave Height

Wave heights are function of the water depth, wind speed, wind fetch length, river velocity and current influences.

A significant wave, which defines the design wave height, is defined as a fictitious wave with a height and period equal to the average height and period of the highest one-third of the actual waves that pass a fixed point. The height of this wave is a major component used in determining the required freeboard value. The period and height of this wave are termed significant wave period (Ts) and significant wave height (Hs), respectively.

The following equations from Saville, are used to determine the significant wave height and the corresponding significant wave period :-

$$gH_s/U^2 = 0.0026\ (gF/U^2)^{0.47}$$

$$gT^2/U = 0.46\ (gF/U^2)^{0.28}$$

where

H_s = significant wave height (feet)

T = significant wave period Ts (seconds)

F = effective fetch Fe (miles)

g = acceleration due to gravity (79,036.36 miles/hr2)

U = average integrated wind velocity over water (miles per hour)

These equations can be used for developing graphical diagrams for forecasting wave heights and wave periods. The wave period (T) can be determined from Figure 6 (Ref 9).

The wave length can be determined from the following deep water equation :-

$$L = 1.56\ T^2$$

where

L = wave length (metres)

T = wave period (seconds)

In the case of significant flooding at Wagga Wagga, the flooded areas are deemed to be sufficiently deep to permit the development of deep water waves. The body of water is assessed to be "deep" compared to the wave length when water depth exceeds 0.5L.

Estimated wave heights and wave periods for the Wagga Wagga levee, at the design 1 year ARI wind speed, are given in Table 3.3 and Attachment 2.

Table 3.3 Wagga Wagga Levee – Wave Heights

Levee	Effective Fetch (km)	Hs (m)	T(sec)
Main Levee	A = 6.28	0.88	3.2
(100 yr ARI flood event)	B = 4.25	0.73	2.85
	C = 4.72	**0.91**	**3.2**
North Levee	A = 1.87	0.48	2.3
(20 yr ARI flood event)	B = 3.01	**0.59**	**2.5**
	C = 1.83	0.53	2.5

3.1.4 Wind Set-up

When wind blows over a water surface it exerts a horizontal shear stress on the water, driving it in the wind direction. This results in water piling up on the leeward end and a lowering of the water on the windward side. The effect is defined as wind set up (S).

Wind set up is calculated from the Zuider Zee equation :-

$$\mathbf{S = U^2F/1400D}$$

where

S = wind set-up or height above still water (feet)

U = integrated average wind velocity over water (miles/hr)

F = wind fetch (miles)

D = average water depth (assumed to be 16 feet (5 metres))

Wind set-up is added as a component of the minimum freeboard required. Values of wind set-up for the Wagga Wagga Levees are given in Table 3.4

Table 3.4 Design Wind Set-up

Wind Event (ARI)	Main Levee Wind Set-up (m)	North Wagga Levee Wind Set-up (m)
1	0.07	0.04
10	0.12	0.06
100	0.18	0.09

3.1.5 Wave Run-up

When a wave reaches a sloping embankment (e.g. levee) it will break on the embankment and run up the slope. The height it runs up the slope is governed by the angle of the slope, the roughness and permeability of the surface and wave characteristics. This vertical height is called wave run-up (**R**) and is the maximum height that the water reaches above the still water flood level.

Rockfill protected slopes act as wave energy dissipators, thereby reducing the extent of run-up. Well vegetated slopes also offer enhanced protection. Smooth slopes provide less resistance, thereby increasing the run-up extent. Vertical (or near vertical) walls prevent wave run-up.

To determine the maximum extent of wave run-up, the wave run-up ratio (**R/Ho**) is derived from work completed by Saville and others (Ref 10), such that wave run-up can be calculated from the formula:-

R = Ho * (R/Ho)

where

R = wave run-up on an embankment (vertical height)

Ho = wave height, Refer to Figure 5.

R/Ho = run-up ratio.

The wave run-up ratio can be calculated from Figure 11 (Ref 2) which represents the relationships between wave run-up ratios (**R/Ho**), wave height (**Ho**), wave period (**T**) and slope of embankment. A copy of this figure is included, as Figure 7, in this report.

Two sets of curves are included in the figure, representing relatively permeable rubble mounds (e.g. rockfill embankments) and smooth slopes (e.g. bare earth slopes).

In the assessment of freeboard for the Wagga Wagga Levees, the following interpolations have been adopted :-

- Very well vegetated slopes, with some shrub and/or tree protection are estimated to be similar to rubble mound (rockfill) slopes.
- Moderately vegetated grassed slopes are estimated to be mid-way between rockfill slopes and smooth slopes

Levees at Wagga Wagga are likely to consist of either well or moderately well vegetated slopes or vertical walls. Calculated run-up values for these levee types at Wagga Wagga Levees are given in Table 3.5.

Table 3.5 Typical Wave Run-up Values

Levee	Levee Type	Slope	Wave Height Ho (m) (1)	Ho/T^2 (m/sec^2) (2)	R/Ho	R (m)
Main Levee	Earthfill, well vegetated	4:1	0.91	0.089	0.53	0.48
		3:1	0.91		0.62	0.56
	Earthfill, moderate veg.	4:1	0.91		0.75	0.68
	Rockfill	2:1	0.91		0.72	0.66
	Retaining wall	Vert.	0.91		0.5 (3)	0.46
North Wagga Levee (incl. Bank 2)	Earthfill, well vegetated	4:1	0.59	0.094	0.52	0.31
		3:1	0.59		0.60	0.35
	Earthfill, moderate veg.	4:1	0.59		0.72	0.42
	Rockfill	2:1	0.59		0.69	0.41
	Retaining wall	Vert.	0.59		0.5 (3)	0.30

(1) Maximum wave height from Table 3.3

(2) Wave period (T) corresponding to maximum wave height

(3) No wave run-up. Wave breaks against wall.

It can be seen from the wave run-up values in Table 3.5 that there can be considerable benefit in selecting levee types, at particular locations, which act to minimise wave run-up.

3.2 Local Water Surge

When water velocities and flow directions change locally, such as at a levee alignment which is oblique to the direction of flow or as a result of local blockages in the channel, local flood water levels can be higher than the general flood level. These changes can be difficult to predict under flood conditions, however flood modelling results can be used to assess likely surge heights.

The flood report (Ref 15) presents local velocity data for both design floods (100 yr ARI and 20 yr ARI) and surge heights can be determined from the relationship :-

$$\mathbf{h_s = v^2/2g}$$

where

$\mathbf{h_s}$ = surge height (m)

$\mathbf{v}$ = local velocity (m/sec)

Maximum surge heights, at selected oblique levee locations, are given in Table 3.6

Table 3.6 Local Surge Heights

Levee	Location	Velocity (m/sec)	Surge Height (m)
Main Levee (100yr ARI flood event)	Ch 8150-8880 Ch 5500-5800	0.7 1.3	0.025 0.086
North Wagga Levee (incl. Bank 2) (20yr ARI flood event)	Eastern face	0.6	0.018

Similar local surge effects could be expected due to blockages in the flood channel, adjacent to the levee (eg fallen trees).

A conservative 100mm local surge allowance is proposed. This surge allowance will allow not only for oblique levee alignments, but also isolated features and events that may act to promote local surge effects.

3.3 Uncertainties in Flood Levels

3.3.1 General

Uncertainties in the determination of flood levels typically consists of being unsure about the value of some of the parameters used in computation. Consequently these uncertainties can have localised or cumulative effects on the accuracy of hydrologic and hydraulic modelling. Confidence in the computed flood levels may be compromised due to the following:-

- How well the theoretical ARI-Discharge curve fits known flood levels;
- Availability of detailed survey and other topographic data;
- Reliability of the historical flood data;
- The calculation of the slope or flood profile along the length of the levee can be prone to error as the precise direction of flood flow in a wide flood plain can not always be predicted accurately; and
- Estimated parameters can contain some degree of uncertainty e.g. afflux, surface roughness, evapotranspiration loss, rainfall pattern etc.

3.3.2 100 year ARI Design Flood

The order of accuracy of the design flood levels was originally estimated to be ±0.5m in the 2004 flood study. This level of accuracy is based on two factors, the first being the lack of detailed topographic information and the second being the limited availability of historical flood information. The order of accuracy of design flood levels was increased to ±0.3 m in the 2009 flood study, as more detailed topographic information was made available for the study area.

3.3.3 20 year ARI Design Flood

The order of accuracy of the 20 year ARI design flood levels was suggested to be ±0.3 m in the 2009 flood study. However, long lengths of good quality flood height data are available for 20 year ARI flood event in contrast to 100 year ARI flood event. In areas where more detailed topographic information in addition to historical flood information are available, a better confidence level of the 20 year ARI flood level can be achieved.

It is proposed that the order of accuracy for the 20 year ARI flood event be adopted as ±0.25m

3.4 Levee Settlement

Levee type is an important element affecting freeboard requirements. The levee type may vary along the length of the levee according to land availability, ease of construction, construction resources and social considerations.

Some of the different types of levees likely to be used at Wagga Wagga, and typical estimates of settlement considerations include :-

- Earthfill Embankment – The structural integrity of an earthfill embankment depends on the age of the embankment, embankment design and material types, construction methods, and on-going maintenance program. In most cases settlement of earthfill embankments can be attributed to normal post construction settlement plus effects of drying, shrinkage and cracking etc.

  Well constructed embankment dams with a specified high degree of compaction and good construction quality control are expected to experience a post construction settlement of up to 0.5% of their constructed height. Levees are usually constructed with at least a reasonable degree of compaction and normal post construction settlement may be expected to be in the order of 1% of the height of the levee.

  Based on the above, settlement of the Wagga Wagga levee could be expected to be of the order of 0.02 – 0.05 metres, assuming that the entire levee section is re-constructed. In the case of the Wagga Wagga levees, where augmentation works could be expected to retain most of the existing levees which have been in place for many years, most post construction settlement will have finished. Settlement would therefore only be attributed to the newly constructed raised portion of the levee, plus some minor settlement of the existing levee due to the increased loading.

  A post construction settlement allowance for earthfill embankments for the raised Wagga Wagga Levee is therefore proposed as 0.025 metres. Should a new levee be required this settlement allowance should be revised.

- Retaining Walls – Correctly designed and constructed retaining walls (eg concrete cantilever walls, sheet pile walls, rockfill gabion baskets etc) are not expected to experience any significant settlement. No post construction settlement allowance is proposed.

3.5 Defects in Levee

3.5.1 Erosion

The degree of erosion depends on the condition of levee, level of compaction, type of materials, quality of protection (e.g. grass cover on batters, gravel crest etc) and quality control during construction. Some bare earth levees have been known to erode at a rate of 100mm/ year.

3.5.2 Holes

Holes can appear in levees due to burrowing animals, dispersion cavities etc. These holes may foster piping through the levee

Low points in the levee crest can result from concentrated traffic from animals, pedestrians and vehicular traffic.

Regular maintenance of the levee will address these problems.

3.5.3 Cracking

The extent of cracking of levee earthfill materials depends on the material used, the construction methods, subsequent maintenance and moisture content. Lateral cracks up to 2 metres depth can occur, leading to a risk of piping though the levee bank during a flood event.

3.5.4 Maintenance

Regular maintenance works will reduce or eliminate the risk of levee progressive failure from defects. Settlement of earthfill embankments can also be compensated by effective maintenance and follow up works.

3.5.5 Defect Allowance

The impact of defects in the levee can be mitigated by regular and effective maintenance. Levees which are neglected should allow a freeboard component of up to 0.5 metres to cater for defects. In the case of Wagga Wagga earthfill levees, which appear to be well maintained, a component freeboard allowance of 100mm is considered appropriate.

No defect allowance is considered necessary for a retaining wall type levee that is well maintained.

3.6 Climate Change

The Floodplain Development Manual indicates that climate change should be considered in developing and implementing Floodplain Risk Management plans. Climate science advises a range of trends in changes to the environment that will continue to impact on flood risk, irrespective of the effectiveness of climate change mitigation strategies.

Short to medium term climatic changes may influence the flood record. The impacts of climate change on sea levels and flood producing rainfall events will have a flow on effect on flood behaviour which may result in key flood levels being reached more frequently and floods of the same ARI, being of a larger magnitude. This is an emerging field that has the potential to have a significant bearing upon design flood estimation and its accuracy. The climate change factors influencing flood behaviour and their ramifications to the community will vary with the location.

The freeboard allowance required to cater for the climate change is greatly affected by the uncertainties in future model projections. The major constraints for correct projection are listed as follows :-

- Australian rainfall is highly variable on an annual timescale. The challenge is to separate climate variability from any longer term trends that relate to anthropogenic climate change;
- Historical data is insufficient to represent the full range of decadal scale variability in our climate;
- The decadal patterns of rainfall variability can be related to the Inter-decadal Pacific Oscillation, an ocean circulation operating over a longer time scale. Given the very high variability of rainfall in Australia it is harder to attribute recent rainfall patterns to human-induced climate change;

- One of the impediments to adaptation to climate change and reduced water availability has been the high uncertainty over future climate change. This uncertainty goes beyond scientific uncertainty in the global climate models to uncertainties in future greenhouse gas emissions; and
- Projections of climate change are based on global circulation models, which represent the atmospheric and oceanic processes across the globe. While the models are very detailed and advanced they do represent the globe and by necessity they only show conditions averaged over a large area. Individual runoff generating storms and hydrology operate at smaller scales and locally there can be much more extreme conditions than is suggested by the average.

Assignment of a freeboard allowance for the Wagga Wagga levee, to account for climate change, is therefore somewhat of an estimation. At the local level, such allowance may even be negative. We can expect that over time the impact of climate change will be reflected in flood records and climate data in general.

Notwithstanding the above, it is proposed that a climate change component be included in the total freeboard allowance for the Wagga Wagga Levees.

Current science suggests that whilst the region will become drier on average due to climate change, the frequency and intensity of the climate extremes such as storms, floods and droughts will increase (ie large storm events will occur more often and be greater in magnitude). The current science provides some guidance on the likely drying of the region by 2030 and 2070 however the guidance on the likely changes in extremes such as storms and resultant floods is limited.

The work of Hennessey et al suggests that for the region by 2030 there will be no significant increase in the 40 year ARI 24 hour and 72 hour rainfalls however there will be increases in both events of between 15% and 10% respectively, by 2070. Whilst it is more than likely that such increases in extreme rainfalls will translate to increased flood flows, it is currently difficult to quantify the likely nature and extent of these increases.

More recent work by the CSIRO suggests that the greatest increases in extreme rainfall intensities due to climate change will be for the shorter duration storm events (ie less than 6 hours) and that there will be a tendency for the rainfall to occur earlier in the storm event. The tendency will be for increases in storm intensities to decrease with increasing storm duration. This has more implications for small urban areas, where flash flooding is the dominant source of flooding, rather than say flooding in the Murrumbidgee River which results from longer duration storm events.

There is also uncertainty in how these changes in rainfall extremes due to climate change will translate to flood peaks. Little to no information has been provided on such factors as the wetness of the catchment prior to such storms (ie changes in rainfall losses) or the resultant catchment runoff and storage routing characteristics. A conservative worst case scenario of increased flooding from the Murrumbidgee River could be that by 2070 a 10% increase in extreme rainfall intensities (Ref 18) translates fully to an increase in flood peaks of 10%. The rating curve at Wagga Wagga reflects a 0.15 metre flood height increase (at Hampden Bridge) corresponding to this 10% increase in flood peak.

It is therefore proposed to include a 0.15 metre component in the flood freeboard allowance for the Wagga Wagga levees for both the 20yr ARI and 100 yr ARI flood events.

4. Freeboard Allowance

4.1 General

The freeboard allowance contributes to the overall Design Levee Levels (profile) for the entire length of the levees at Wagga Wagga (Main Levee) and North Wagga Wagga (North Wagga Levee). The Main Levee will be designed for the 100 year ARI flood event and North Wagga Levee for the 20 Year ARI flood event.

Levee Freeboard components, which are discussed in Section 3 of this report, are summarised in Table 4.1.

Table 4.1 Levee Freeboard Components

Freeboard Item	Maximum Height Allowance (m)	
	Main Levee	North Levee
Wave action		
• Run-up (including wave height (1))		
o Embankment (4:1, well grassed)	0.48	0.31
o Retaining wall	0.46	0.30
• Set-up	0.07	0.04
Local water surge (2)	0.1	0.1
Uncertainties in Flood Levels	0.30	0.25
Levee Settlement		
• Embankment	0.025	0.025
• Retaining walls	0	0
Defects in Levee		
• Embankment	0.10	0.10
• Retaining walls	0	0
Climate Change	0.15	0.15

(1) Wave height above still water flood level.
(2) Localised impact only.

4.2 Joint Probability Analysis

As a flood risk is rarely a function of just one source variable (e.g. waves, river velocity, wind speed etc), Joint Probability analyses is used to address the chance of two or more conditions occurring at the same time.

Joint Probability Analysis recognises that design flood characteristics could result from a variety of combinations of flood producing factors, rather than from a single combination. Thus, Joint Probability Analyses is used to take account of the dependence between input variables, as well as the distribution and extremes of the individual variables. It can increase the accuracy of failure probability estimation as it uses the input information more effectively. This approach, which considers the outcomes of events with all possible combinations of input values and their correlation structure, will lead to a better estimate of flood freeboard.

In general, and unless there is readily available alternative data, it is suggested that probability classification guidelines be adopted as set out in Table 4.2. These would be combined with freeboard component factors as relevant, to determine the design freeboard for the levee.

Table 4.2 Probability Classifications (Ref 13)

Description	Probability
Virtually certain	0.999
Very likely	0.99
Likely	0.9
Neutral	0.5
Unlikely	0.1
Very unlikely	0.01
Virtually impossible	0.001

4.3 Main Wagga Wagga Levee Freeboard Allowance

The required freeboard allowance for the Main Levee has been summarised in Table 4.3 and Table 4.4. The calculations have assumed that the levee consists of well grassed earthfill embankment levees and retaining wall levees respectively.

Table 4.3 Main Levee – Freeboard Allowance (Earthfill Embankment)

Freeboard Item	Allowance (m)	Probability (1)	Joint Probability Component (2)
Wave action			
• Run-up (incl. wave height)	0.48	0.5	0.24
• Set-up	0.07	0.5	0.035
Local water surge	0.1	1	0.1
Uncertainties in Flood Levels	0.30	1	0.30
Levee Settlement	0.025	0.5	0.012
Defects in Levee	0.10	0.5	0.05
Climate Change	0.15	1	0.15
Total			0.887
Freeboard Allowance			**0.90**

(1) Probability of the typical height occurring at location during flood.

(2) Probability weighted positive variation for this component

Table 4.4 Main Levee – Freeboard Allowance (Retaining Wall)

Freeboard Item	Allowance (m)	Probability (1)	Joint Probability Component (2)
Wave action			
• Run-up (incl. wave height)	0.46	0.5	0.23
• Set-up	0.07	0.5	0.035
Local water surge	0.1	1	0.1
Uncertainties in Flood Levels	0.30	1	0.30
Levee Settlement	0.0	0.5	0.0
Defects in Levee	0.0	0.5	0
Climate Change	0.15	1	0.15
Total			0.815
Freeboard Allowance			**0.80**

(1) Probability of the typical height occurring at location during flood.
(2) Probability weighted positive variation for this component

4.4 North Wagga Wagga Levee Freeboard Allowance

The required North Wagga Wagga freeboard allowance has been summarised in Table 4.5 and Table 4.6. The calculations have assumed that the levee consists of well grassed earthfill embankment levees and retaining wall levees respectively.

Table 4.5 North Wagga Wagga Levee – Freeboard Allowance (Earthfill Embankment)

Freeboard Item	Allowance (m)	Probability (1)	Joint Probability Component (2)
Wave action			
• Run-up (incl. wave height)	0.31	0.5	0.16
• Set-up	0.04	0.5	0.02
Local water surge	0.1	1	0.1
Uncertainties in Flood Levels	0.25	1	0.25
Levee Settlement	0.025	0.5	0.012
Defects in Levee	0.10	0.5	0.05
Climate Change	0.15	1	0.15
Total			0.742
Freeboard Allowance			**0.75**

(1) Probability of the typical height occurring at location during flood.
(2) Probability weighted positive variation for this component

Table 4.6 North Wagga Wagga Levee – Freeboard Allowance (Retaining Wall)

Freeboard Item	Allowance (m)	Probability (1)	Joint Probability Component (2)
Wave action			
• Run-up (incl. wave height)	0.30	0.5	0.15
• Set-up	0.04	0.5	0.02
Local water surge	0.1	1	0.1
Uncertainties in Flood Levels	0.25	1	0.25
Levee Settlement	0.0	0.5	0.0
Defects in Levee	0.0	0.5	0
Climate Change	0.15	1	0.15
Total			0.67
Freeboard Allowance			**0.70**

(1) Probability of the typical height occurring at location during flood.
(2) Probability weighted positive variation for this component

4.5 Application of Freeboard Allowance

The freeboard values calculated for the Wagga Wagga levees will be used to determine a general freeboard allowance rather than a variable freeboard to suit specific locations. For example, it could be argued that a section of levee which is protected by heavily timbered river banks could be provided with a reduced freeboard as a result of protection offered against wave action. Conversely, it could be argued that if these same trees are lost during a major flood, an inadequate freeboard would result at a critical time during the flood.

It is also important to note that the freeboard calculations are based on a continuation of the current maintenance regime at Wagga Wagga. Should maintenance be reduced and/or defects be not promptly repaired, an increased freeboard would be warranted.

Based on the freeboard assessment, it is therefore proposed that the levees be designed with freeboards as follows :-

- Main Levee 0.9 metres
- North Levee 0.75 metres

Although retaining wall type levees could have a lower freeboard, it is considered that for the short lengths of retaining walls present at Wagga Wagga, a variable freeboard would be inappropriate.

5. Conclusions

Conclusions arising from this freeboard study for the Wagga Wagga Levee system are:-

1. The levees at Wagga Wagga are to be designed to accommodate the following design floods :-
   - Main Levee – 100 yr ARI flood event
   - North Wagga Wagga Levee – 20 yr ARI flood event
2. Additional to these design flood levels, an appropriate freeboard allowance is to be added to provide the levee design crest levels. This freeboard will provide a reasonable certainty that the risk exposure associated with a particular design flood is actually provided.
3. Freeboard is calculated from a number of specific components, which include :-
   - Wave action
   - Local water surge
   - Uncertainties in design flood levels
   - Post construction settlement a defects in the levee
   - Climate change
4. There are no formal freeboard standards in Australia, and estimates of acceptable freeboard for the Wagga Wagga levees are made based on a Joint Probability Analysis basis.
5. Joint probability analysis is applied to the freeboard component values to address the chance of two or more conditions occurring at the same time.
6. Freeboard allowance for the Wagga Wagga main levee is calculated as :-
   - Embankment type levee – 0.90 metres
   - Retaining wall type levee – 0.80 metres
7. Freeboard allowance for the North Wagga Wagga Levee is calculated as :-
   - Embankment type levee – 0.75 metres
   - Retaining wall type levee – 0.70 metres
8. A consistent freeboard allowance is considered appropriate for the Wagga Wagga levees. The freeboard allowance is :-
   - Wagga Wagga Main Levee – 0.9 metres
   - North Wagga Wagga Levee – 0.75 metres.
9. Freeboard calculations are based on a continuation of the current levee maintenance regime at Wagga Wagga.

6. Recommendations

Recommendations arising from this freeboard study for the Wagga Wagga Levee system are:-

1. The design freeboard allowance for the Wagga Wagga levee system be :-
   - Wagga Wagga Main Levee – 0.9 metres
   - North Wagga Wagga Levee (including Bank Two) - 0.75 metres
2. That sound levee maintenance practices be continued, to ensure that the recommended levee freeboard remains appropriate for the levee..

7. References

1. Australian Commonwealth Scientific and Research Organization (CSIRO), *Hydrological Consequences of Climate Change*, 2007.
2. California Institute of Technology, "The Effect of Waves on Rubble-Mound Structures" W.M.Keck Laboratory of Hydraulics and Water Resources.
3. Chris Stanton, Stanton Associates, *Flood Levee Design Based on Progressive Failure Probability*.
4. Cooperative Research Centre for Catchment Hydrology, *Joint Probability Approaches to Design Flood Estimation: A Review*, 1998.
5. Duncan McLuckie et al, *Adapting for Climate Change Impacts on Flooding*, 2007.
6. NSW Department of Environment, climate Change and Water, Draft Flood Risk Management Guide, 2009.
7. NSW Department of Natural Resources, Floodplain Development Manual, 2005.
8. NSW Department of Natural Resources, Floodplain Risk Management Guideline No.15 Freeboard for Urban Levees.
9. Robin Fell, Geotechnical engineering of embankment dams. 2004.
10. SAVILLE Jr., T. *Wave run-up on shore structures*. Journal of the Waterways Division, 82, 925-1–925-14. 1956.
11. Sinclair Knight Merz, Deniliquin Flood Protection Levee Study, 1997.
12. Standards Australia, Australia/ New Zealand standard 1170.2:2002, Structural design action, Part 2 Wind Actions. 2002
13. USBR, *Dam Safety Risk Analysis Methodology, Version 3.3, Technical Service Centre*, September 1999).
14. U.S Department of the Interior, Freeboard criteria and Guidelines for Computing Freeboard Allowances for Storage Dam, 1981.
15. Webb, McKeown & Associates Pty, Ltd, *Murrumbidgee River Wagga Wagga Flood Study,* 2004
16. WMAWater, *Wagga Wagga Floodplain Risk Management Plan*, 2009.
17. WMAWater, *Wagga Wagga Floodplain Risk Management Study*, 2009.
18. Climate Change in New South Wales. Part 2. Projected Changes in Climate Extremes. CSIRO. 2004.

Narrabri Shire Section 7.11 Contributions Plan 2016

NARRABRI SHIRE
DISCOVER THE POTENTIAL

Narrabri Shire

Section 7.11 Contributions Plan 2016

Document history and status

This document was originally prepared by GLN Planning Pty Ltd Project No. 10486).
Amendments since 28 February 2017 have been made by Narrabri Shire Council.

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23/2017	21 February 2017	Adopted by Council

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1. Introduction

Section 7.11 of the Environmental Planning and Assessment Act 1979 (**EP&A Act**) authorises a Consent Authority to grant consent to a development subject to a condition requiring the applicant to make a monetary contribution to the local council for the purpose of providing public amenities and public services that are required or demanded by that development.

Such a condition can only be imposed if it is in accordance with a contributions plan adopted by the local council.

This plan is to enable Narrabri Shire Council (**Council**) and other Consent Authorities to require developers of land within Narrabri Shire to make contributions for the purpose of providing certain public amenities and public services in the Shire.

The types of developments and amenities covered by this plan are shown in **Table 1**.

Table 1 Contributions required under this plan

Development	Contribution required and the amenities to be provided
(a) Mines, extractive industries and other developments that result in increased numbers of laden heavy vehicles causing pavement damage on rural roads managed by the Council	A monetary contribution will be required to meet the cost of Council maintaining the haul routes
(b) Development on land shown in the **Schedule** fronting certain unformed roads in towns and villages	A monetary contribution will be required to meet the cost of Council upgrading the roads to an urban sealed standard

This contributions plan contains the following:

- Details of public amenities and services that will be provided by the Council.
- A schedule of contribution rates for various classes of development subject to the plan.
- Information on how the contribution rates were calculated.
- Council's policies on how and when developers can settle their contributions obligations, including opportunities for developers to provide land and works 'in kind'.
- Specific provisions on the role of accredited certifiers in imposing and collecting section 7.11 contributions.
- Various other provisions related to the fair and transparent administration of section 7.11 contributions involving development affected by the plan.

2. Plan summary

2.1 How to use this plan

This plan has been broken up into the following sections to allow easy navigation by Council staff, developers and private certifiers:

Section 2 – Plan Summary

This section identifies both the land and development that this plan applies to as well as the contribution rates that apply to development.

Section 3 – How are the contributions rates calculated?

This section explains how the contributions for development are calculated, and the nexus between the expected development and the infrastructure to be provided.

Section 4 – How and when will contributions be imposed on development?

This section explains how conditions of consent will be used to collect contributions levied under this plan and provisions to index the contributions payable to reflect changes in land acquisition and construction costs. It also describes accredited certifiers' obligations to address the requirements of this plan in the issuing of construction certificates and complying development certificates.

Section 5 – How and when a contribution requirement can be settled?

This section explains how consent conditions requiring the payment of contributions can be settled.

Section 6 – Other administration matters

This section outlines other administrative arrangements surrounding the operation of this plan, including a Dictionary of terms used in this plan.

Schedule

This section contains details and maps related to Urban Roads projects levied for under this plan.

Appendices

This section includes information supporting the body of the plan.

2.2 Name and commencement of plan

This plan is called Narrabri Shire Section 7.11 Contributions Plan 2016.

This plan commences on the date on which public notice was given under clause 31(2) of the EP&A Regulation or the date specified in that notice if it is a different date.

2.3 What is this plan's purpose?

The primary purpose of this plan is to authorise:

- the Council, when granting consent to an application to carry out development to which this plan applies; or
- an accredited certifier, when issuing a complying development certificate (**CDC**) for development to which this plan applies,

to require a section 7.11 contribution to be made towards the provision, extension or augmentation of public amenities and services that are required as a consequence of the development, or which were provided in anticipation of, or to facilitate, such development.

Other purposes of this plan are as follows:

- To provide a clear and transparent basis for levying contributions under the provisions of section 7.11 of the EP&A Act.
- To provide the framework for the efficient and equitable determination, collection and management of section 7.11 contributions.
- To establish the relationship between the expected development and the public amenities and services included in this plan, to demonstrate the required contributions are reasonable.
- To allow for the provision of the required public amenities and services by alternative means where this is acceptable to the developer and the Council (for example; through a planning agreement).
- To ensure that the broader Narrabri Shire community is not unreasonably burdened by the provision of public amenities and services required as a result of development affected by this plan.

2.4 What land and development does this plan apply to?

This plan applies to all land in the Narrabri Local Government Area.

This plan applies to the following developments:

(a) Mines, extractive industries and other development that result in increased numbers of laden heavy vehicles using Council's road network.

(b) Development on land fronting certain unformed roads in towns and villages shown in the contribution catchments maps in the **Schedule** to this plan.

2.5 What development is exempted?

This plan DOES NOT apply to the following types of developments:

- Development proposed by or on behalf of the Council.
- Development exempted from section 7.11 contributions by way of a direction made by the Minister for Planning under section 7.17 of the EP&A Act.

2.6 What public amenities and services will be provided under this plan?

The public amenities and services which are covered by this plan include the following:

- Pavement damage to rural roads caused by mines, extractive industries and other 'heavy haulage' developments
- Urban roads that were unformed or unsealed at the time this plan was made.

The costs of administering this plan will also be met by contributions imposed under this plan.

More details on the public amenities and services, and their relationship with the expected developments are included in **Part 3** of this plan.

2.7 What are the contribution rates?

Table 2 summarises the contribution rates for the various categories of public amenities and services in this plan.

Table 2 Contribution rates

Development	Contribution rate
(a) Mines, extractive industries and other developments that result in increased numbers of laden heavy vehicles using Council's road network	\$0.31 per Equivalent Standard Axle (ESA) per km of haul road or \$0.053 per tonne of hauled material per km of haul road
(b) Development on land shown in the **Schedule** fronting certain unsealed or unformed roads in towns and villages	Refer to **Schedule** at the back of this plan

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3. How are the contribution rates calculated?

This part of the plan describes the development that will demand the public amenities and services required under this plan and explains how each of the contribution rates were calculated.

3.1 Rural roads pavement damage

3.1.1 Overview

This plan authorises a contribution rate of either 5.3 cents / tonne / km of hauled material, or 31 cents / ESA / km.

This *contribution rate* enables the Consent Authority, in any particular case, to impose a *contribution amount* on a development relating to the length of local and regional roads that will be used by heavy vehicles for the haulage of material.

The consent condition will contain both a contribution rate and an assumed haul road length. The consent condition will require the development to make periodic payments to Council based on tonnage or ESA returns in the preceding quarter.

3.1.2 What is the nexus between the expected types of development and the demand for public amenities and services?

Roads have a design life after which they need reconstruction. Heavy vehicles can significantly reduce the life of a road. The heavy vehicles have a disproportionally greater impact on the life of roads compared to other light vehicles, notwithstanding their greater numbers.

Major roads and highways are generally designed and constructed to accommodate heavy vehicles and the damage associated with heavy trucks is recouped through registration and general taxation. Roads within the local road network managed by the local council conversely often have a lower design standard and are more susceptible to wear and tear associated with heavy vehicles resulting in the need for more frequent reconstruction work.

Council has the responsibility of maintaining most of the roads in the Narrabri Shire to an acceptable standard. The standard is to ensure the roads:

- are kept to an appropriate level of safety for the road user; and
- remain trafficable for the duration of their design life.

The additional heavy vehicle loadings on a road due to developments involving laden heavy vehicle movements will accelerate the deterioration of that road's pavement. The consequence is that in order for the roads authority to maintain the road pavement at its existing level of service, additional maintenance spending will be required sooner than would be the case without that development. In short, the use of a road by heavy vehicles will require the replacement of that road's pavement sooner.

From time to time Council receives development applications that involve the haulage of material and goods using heavy vehicles. These developments typically include quarries and other forms of extractive industry but can also include rural industries. These developments can be located anywhere within the LGA.

Concentrated heavy vehicle movements generated by these developments will accelerate the deterioration of road pavements that were designed to meet demands of rural rather than industrial or commercial developments.

Councils are not generally able to impose additional fees, charges or rates to meet the extra costs associated with accelerated deterioration of roads caused by heavy vehicle movements from these developments, except for section 7.11 contributions imposed under the EP&A Act.

Council considers that it is reasonable to expect that developments which generate unusually high truck movements or truck movements which have the effect to significantly reduce the life of the road construction and / or increase the cost of maintaining a road should make a monetary contribution. The amount should be based on the cost to Council of bringing forward the need for works or based on the increased cost to Council of maintaining the road.

This plan therefore authorises Consent Authorities to require contributions from developments that generate additional laden heavy vehicle movements to meet the additional cost burden of providing and maintaining roads caused by those developments.

Council shall allocate any monies received under this plan to the particular haul roads that developments have contributed towards. As heavy haulage developments can occur anywhere in the LGA, and this plan operates to respond to the impacts of yet-to-be-identified developments, it is not possible to identify those roads in this plan.

3.1.3 Calculation of the contribution rate

The contribution rates that will be applied to developments that cause pavement damage to rural roads are based on the methodologies applied by other northern NSW councils on such development.[1]

The methodology used is to determine the ratio of the cost to replace the asset to the design traffic loading, which gives a replacement cost per ESA. This ratio forms the basis of further calculations to determine loss of life in dollars per tonne of material hauled.

The following steps were followed for determining the contribution rates by these councils:

1. Determine design ESA
2. Estimate the cost to reconstruct / maintain 1 lane-km for the above ESA
3. Calculate the contribution rate in $ / ESA / km

At this point the ESA contribution rate is known. To determine the tonnage contribution, rate the following additional two steps were undertaken:

4. Calculate $ / typical vehicle ESA
5. Calculate $ / tonne / km

[1] Contributions levied by Ballina Shire Council under Ballina Shire Heavy Haulage Contributions Plan 2011, and by Lismore City Council under Lismore City Section 94 Contributions Plan 2014.

Table 3 summarises the calculations that were performed to determine the contribution rates for a sealed rural road with a medium level of traffic of 1,000 vehicles per day per lane. In Narrabri it is more likely that there would be lower levels of traffic on both sealed and unsealed roads. However, use of these road types in the methodology yielded higher contribution rates. The medium traffic sealed road contribution is more conservative and has been adopted by Narrabri Shire Council for the purposes of this plan.

Table 3 Summary of calculation of contribution rates for rural roads pavement damage

Step	Workings for sealed road with medium traffic[2]
Determine design ESA	Treat damage to pavement and damage to wearing course separately: • Design life of pavement: 873,743 ESAs over 30 years • Pavement spray-seal: 262,795 ESAs over 10 years
Estimate the cost to reconstruct / maintain 1 lane-km for the above ESA	Pavement reconstruction: $200,000 per lane per km Surfacing spray-seal: $20,000 per lane km
Calculate the contribution rate in $ / ESA / km	Pavement = $200,000 / 873,743 = $0.23 per ESA per km Spray-seal = $20,000 / 262,795 = $0.08 per ESA per km Total = $0.23 + $0.08 = **$0.31 per ESA per km**
Calculate $ / typical vehicle ESA	The typical vehicle assumed to be a 'class 4 + dog trailer' No. of ESAs per typical vehicle = 2.6 Contribution per typical vehicle = $0.31 x 2.6 = $0.80 per vehicle
Calculate $ / tonne / km	The typical load in a typical vehicle is assumed to be 15 tonnes Contribution = $0.80 / 15 = **$0.053 per tonne per km**

3.1.4 Calculation of the quarterly contribution payment

The process for calculating and collecting the contribution will generally be as follows:

1. Identify the length of local and regional roads (i.e. haul routes) that the development's laden heavy vehicles will utilise. Classified roads that are the sole maintenance responsibility of the NSW Government are excluded from consideration. The length of haul route(s) in kilometres will be determined from information submitted by the applicant with the development application. Any development application for mines, extractive industries or other

[2] 1,000 vehicles per day per lane with a growth rate of 1% per annum

developments involving the haulage of material or goods by heavy vehicles on any land in Narrabri LGA must include details of haul routes.

2. Consent Authority imposes a development consent condition requiring payment based on:

   (a) the $ rate per tonne per km, or the $ rate per ESA per km (from this plan);

   (b) the total length of all haul routes (from 1. above); and

   (c) the amount of material hauled (in tonnes), or the volume of vehicles accessing the site (in ESAs) over the preceding quarter.

3. No later than twenty-eight (28) days after the end of March, June, September and December over the life of the development, the operator of the development:

   (a) submits to Council independently verified tonnage (or ESA) returns for the development over the preceding quarter, and

   (b) pays the roads maintenance contribution to Council reflecting the $ rate per tonne (or per ESA) and total haul route length contained in the development consent.

Worked example

For example, where in a development application it is stated that a development's haul trucks will utilise 3.5 kilometres of public roads in the LGA, and that estimate of haul route use is considered by the Consent Authority to be a reasonable estimate, then the contribution amount that would be imposed on the development consent would be:

3.5 km X 5.3 cents per tonne per kilometre

= 18.55 cents per tonne of haulage material, calculated quarterly and indexed quarterly in accordance with the Producer Price Index described in **Section 6.3**

Then, after the first full quarter of operations, the operator submitted an independently verified statement showing that there had been 7,100 tonnes of extractive material transported from the development. The Council in response would issue to the operator a tax invoice showing the following details and payment amount:

18.55 centres per tonne X 7,100 tones

= $1,317.05

3.1.5 Application information to be relied on

There may be circumstances where the likely length or lengths of roads to be used by laden heavy vehicles in development vary, and therefore the contribution amount for that development, is difficult to quantify. In such cases, Council will determine the length or lengths of road to be levied based on the information submitted with the development application. It is the duty of the applicant to provide sufficient and accurate information on likely haul route use at the application stage.

3.1.6 Matters to be addressed during the operation of the development

The consent will identify the haul route length and the contribution rate applicable to the development. Council acknowledges that the haul routes used by a development may change over the life of the development. The consent will therefore include a condition that requires the proponent to prepare a statement of haulage routes at least every three years. The statement will identify the local and regional roads that are used by heavy vehicles transporting material and goods to / from the development, as well as the proportion of the development's total heavy vehicles using each road length.

The contribution rate in the consent will be automatically adjusted in accordance with annual movements in the Producer Price Index: Road and Bridge Construction New South Wales (Catalogue No. 6427.3101) as published by the Australian Bureau of Statistics.

Where an ESA-based contribution rate is imposed on the development, the following matters shall be addressed by way of conditions of consent to be implemented at the start of and throughout the development's life:

- A traffic classifier is to be installed (at the applicant's cost) at a suitable location to classify and count the number of loaded heavy vehicles that enter or exit the development site over each quarter. The purpose of the classifier is to record the number of ESAs that are subject to contributions.
- Responsibility for keeping the traffic classifier in good working order throughout the life of the development will rest with the operator.
- Council officers are to be provided access to the traffic classifier data on a regular (i.e. at least quarterly) basis.
- In the event of the traffic data being corrupted, then the Council at its discretion may determine the ESAs and therefore the contribution amount for the preceding period.

3.1.7 Roadworks may be required to be undertaken in addition to contributions required under this plan

The Shire's local and regional road network has been constructed and is maintained by Council as necessary to ensure an acceptable standard of service.

It is possible that some of these roads may not be able to accommodate additional heavy vehicle loading generated by mines and extractive industries without immediate upgrade. There may be upgrades to roads or traffic facilities that are directly required by a development and without which the development could not or should reasonably occur. New roads, or upgrades to sections of the existing road network, including ongoing maintenance, may be required to accommodate the additional heavy vehicle loading.

Where a development requires works to the road network to be undertaken, the requirement will be by way of a condition imposed on the development consent under section 4.17(1)(f) of the EP&A Act. This will be in addition to road maintenance contributions for haul routes imposed under this plan.

3.2 Urban roads

Most of the road network in the Shire's towns and villages is of a sealed standard.

There are however sections of road that have not been sealed.

Land fronting these sections has either been subdivided for urban purposes or is yet to be subdivided. Not all of the subdivided lots have been developed for urban (principally residential) purposes.

The local community generally expects that the roads directly servicing dwellings in towns and villages will be sealed.

This plan therefore authorises Consent Authorities to require monetary contributions from the first development of lots fronting unsealed roads in urban areas.

The particular urban road projects, their costs, their nexus with expected developments, and their contributions catchments and calculations of contribution rates are shown in the **Schedule** to this plan.

4. How and when will contributions be imposed on developments?

4.1 Monetary contributions

This plan authorises the Council or an accredited certifier, when determining an application for development or an application for a CDC, and subject to other provisions of this plan, to impose a condition requiring a contribution under section 7.11 of the EP&A Act on that approval for:

- the provision, extension or augmentation of public amenities and services to be provided by Council; and / or
- the recoupment of the previous costs incurred by Council in providing existing public amenities and services.

Accredited certifiers should also refer to **Section 4.4** of this plan as to their obligations in assessing and determining applications.

4.2 Cap on monetary section 7.11 contributions for residential development

The Minister for Planning has issued a Direction to Council that caps section 7.11 contributions for residential development.[3]

The Direction requires:

> *A council (or planning panel) must not grant development consent ... subject to a condition under section 7.11 (1) or (3) of the Environmental Planning and Assessment Act 1979 requiring the payment of a monetary contribution that:*
>
> *(a) in the case of a development consent that authorises one or more dwellings, exceeds $20,000 for each dwelling authorised by the consent, or*
>
> *(b) in the case of a development consent that authorises subdivision into residential lots, exceeds $20,000 for each residential lot authorised to be created by the development consent.*

This plan is consistent with the Minister's Direction in that it authorises section 7.11 contributions on residential development not to exceed the cap.

Where the sum of the contributions for a particular development calculated under this plan and any other contributions plan adopted by the Council exceeds $20,000 per residential lot or dwelling, the total amount included in the consent shall not exceed the cap.

[3] The most recent Direction issued by the Minister was dated 21 August 2012. A copy of the Direction is able to be viewed on the Department of Planning Environment website.

4.3 Latest rates to be used

The section 7.11 contribution imposed on a development will reflect the latest, indexed contributions rates authorised by this plan.

The monetary section 7.11 contribution rates shown in **Section 2.7** reflect the contribution rates at the date that this plan commenced. These rates are regularly adjusted for inflation (see **Section 6.3**).

Applicants and accredited certifiers should inquire at the Council for information on the latest contribution rates.

4.4 Obligations of accredited certifiers

4.4.1 Complying development certificates

This plan requires that, in relation to an application made to an accredited certifier for a CDC relating to development affected by this plan:

- the accredited certifier must, if a CDC is issued, impose a condition requiring a monetary contribution, if such a contribution is authorised by this plan
- the amount of the monetary contribution that the accredited certifier must so impose is the amount determined in accordance with this section
- the terms of the condition be in accordance with this section.

Procedure for determining the contribution amount

The procedure for an accredited certifier to determine the amount of the section 7.11 monetary contribution for complying development is as follows:

1. If, and only if specified in writing in the application for a CDC, the applicant has requested a credit under section 7.11(6) of the EP&A Act, or an exemption or part or the whole of the development under **Section 2.5** of this plan, the accredited certifier must:

   (a) make a request in writing to the Council for the Council's advice on whether the request is granted, or the extent to which it is granted; and

   (b) in calculating the monetary contribution, comply with the Council's written advice or if no such advice has been received prior to the granting of the CDC refuse the applicant's request.

2. Determine the unadjusted contributions in accordance with the rates included in **Section 2.7** of this plan taking into account any exempt development specified in **Section 2.5** and any advice issued by the Council under paragraph 1(b) above.

3. Adjust the calculated contribution in accordance with **Section 6.3** to reflect the indexed cost of the provision of the public amenities and services.

4. Subtract any infrastructure demand credit advised by the Council under paragraph 1(b) for any assumed demand relating to existing development.

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4.4.2 Construction certificates

It is the responsibility of an accredited certifier issuing a construction certificate for building work or subdivision work to ensure that each condition requiring the payment of a monetary contribution before work is carried out has been complied with in accordance with the CDC or development consent.

The accredited certifier must ensure that the applicant provides a receipt (or receipts) confirming that contributions have been fully paid and copies of such receipts must be included with copies of the certified plans provided to the Council in accordance with section 142(2) of the EP&A Regulation. Failure to follow this procedure may render such a certificate invalid and expose the certifier to legal action.

The only exceptions to the requirement are where a work in kind, material public benefit, dedication of land and/or deferred payment arrangement has been agreed by the Council. In such cases the Council will issue a letter confirming that an alternative payment method has been agreed with the applicant.

4.5 Variation to contributions authorised by this plan

The Council may, after considering a written application, reduce the section 7.11 contribution otherwise calculated in accordance with the provisions of this plan.

A developer's request for variation to a contribution calculated in accordance with this plan must be supported by written justification included with the development application. Such request will be considered as part of the assessment of the application.

An accredited certifier other than the Council cannot vary a section 7.11 contribution calculated in accordance with this plan, without Council's written approval.

5. How and when can a contribution requirement be settled?

5.1 Timing of payments

A monetary contribution required to be paid by a condition imposed on the development consent in accordance with this plan is to be paid at the time specified in the condition.

Generally, the condition will provide for payment as follows:

- For development where no further approvals are required – before the development consent is issued.
- For development involving subdivision – the contribution must be paid prior to the release of the subdivision certificate (linen plan).
- For development not involving subdivision, but where a construction certificate is required, the contribution must be paid prior to the release of the construction certificate for any works.
- For works authorised under a CDC, the contributions are to be paid prior to any work authorised by the certificate commences, as required by section 136L of the EP&A Regulation.

At the time of payment, it will be necessary for monetary contributions amounts to be updated in accordance with the relevant indexes (see **Section 6.3**).

5.2 Process for deferred payments

Council may accept the deferred or periodic payment of a monetary contribution required under this plan if the applicant, or any other person entitled to act upon the relevant consent, makes a written request and can satisfy the Council of non-compliance with the payment provisions.

Council must be satisfied that:

- there are valid reasons for the deferral or periodic payment;
- the granting of the request will not adversely impact on the administration, operation or cash flows of the plan;
- the granting of the request will not jeopardise the timely provision of works or land identified within the plan; and
- the proposed arrangement remains consistent with the purpose of the plan.

The decision to accept a deferred or periodic payment of a monetary contribution is at the sole discretion of Council. Any deferral will generally be limited to a period of no more than 24 months.

Where Council allows a deferral of contributions, an appropriate bank guarantee shall be secured for the amount of contributions to be deferred. The conditions under which the Council may accept deferred settlement by way of lodgement of a bank guarantee are that:

- the bank guarantee be by an Australian bank for the amount of the total contribution, or the amount of the outstanding contribution, plus an amount equal to thirteen (13) months interest;

- the bank unconditionally pays the guaranteed sum to the Council if the Council so demands in writing not earlier than twelve (12) months from the provision of the guarantee or completion of the work whichever occurs first;
- the bank must pay the guaranteed sum without reference to the applicant or landowner or other person who provided the guarantee, and without regard to any dispute, controversy, issue or other matter relating to the development consent or the carrying out of development in accordance with the development consent; and
- the bank's obligations are discharged when payment to the Council is made in accordance with this guarantee or when Council notifies the bank in writing that the guarantee is no longer required.

Any deferred or outstanding component of the monetary contribution will be adjusted in accordance with **Section 6.3** of this plan.

The applicant will be required to pay any charges associated with establishing or operating the bank guarantee. Council will not cancel the bank guarantee until the outstanding contribution as indexed and any accrued charges are paid.

Where Council agrees to a request for deferred or periodic payment, the applicant will be required to lodge, and pay for, a section 4.55 application to modify the development consent to specify the new payment arrangements.

5.3 Are there alternatives to paying the contribution?

5.3.1 Mines, extractive industries and other heavy haulage developments

Applicants may propose an alternative contribution rate that more accurately reflects the likely road impacts of the particular development. Any alternate contribution rate must be agreed to by Council prior to the due date for a contribution payment or the commencement of any works as part of that alternate payment method.

Applicants may also propose alternative arrangements to the payment of a periodic contribution to Council for excessive road wear and tear. This could include, for example, reconstruction of the road pavement up-front and no ongoing maintenance contribution.

Justification of any alternative must be addressed in a transport study on the proposed development. The study should address all of the relevant matters listed in **Appendix A**.

5.3.2 Other development

A person may make an offer to the Council to carry out works or provide another kind of material public benefit or dedicate land, in part or full satisfaction of a section 7.11 contribution required by a condition of consent imposed under this plan.

If a developer wishes to deliver infrastructure that is included in this plan instead of the Council delivering that infrastructure, then the developer can approach this either one of two ways:

(a) The developer may offer to enter into a planning agreement to undertake works, make monetary contributions, dedicate land, or provide some other material public benefit. Planning agreements are the most appropriate mechanism for offers made prior to the issue of a development consent for the development.

(b) If the developer has already received a development consent containing a condition requiring a section 7.11 contribution, the developer may offer to undertake works in kind through a works in kind agreement, or offer to dedicate land through a land dedication agreement.

Any offer for works in kind or other material public benefit shall be made in writing to the Council prior to the commencement of any works proposed as part of that offer. Retrospective works in kind agreements will not be accepted.

Works in kind or the dedication of land will be accepted by Council only under the following circumstances:

- Council will generally only accept offers of works or land that are the specific public amenities and services included in this plan; and
- Council determines that the works in kind are, or the land to be dedicated is, appropriate; and
- The value of the works to be undertaken or the land to be dedicated is at least equal to the value of the contribution assessed in accordance with this plan, or where the value of the proposed works in kind or the land to be dedicated is less than the monetary value of the contribution, the difference will be met by way of a monetary contribution.

Should an offer of works in kind or land dedication be accepted, Council will establish with the applicant the following as relevant:

The decision to accept the settlement of a contribution by way of works in kind or the dedication of land is at the sole discretion of Council and will be subject to any reasonable requirement of the Council in relation to the facility specification, program for delivery, and a suitable defects liability period.

6. Other administration matters

6.1 Relationship of this plan to other contributions plans

This plan does not affect any other contributions plan adopted by the Council.

6.2 Savings and transitional arrangements

This plan applies to a development application or application for a CDC submitted after the date on which this plan took effect.

A development application or application for a CDC that was submitted, but not yet determined, on or before the date on which this plan took effect, shall be assessed under the contributions plan or plans that applied at the date of submission of the application.

6.3 Adjustment of contributions to address the effects of inflation

To ensure that the value of contributions for the construction and delivery of infrastructure is not eroded over time by inflation or significant changes in land values, this plan authorises that contribution rates and the contribution amounts included in consents will be adjusted over time.

6.3.1 Contribution rates in this plan

Council will, without the necessity of preparing a new or amending contributions plan, make changes to the contribution rates set out in this plan to reflect annual movements in the value of land acquisition and works.

The Producer Price Index: Road and Bridge Construction New South Wales (Catalogue No. 6427.3101), as published by the Australian Bureau of Statistics, will be used to update the contribution rates in this plan.

6.3.2 Contribution amounts in consents

A monetary contribution amount required by a condition of development consent imposed in accordance with this plan will be indexed between the date of the grant of the consent and the date on which the contribution is paid in accordance with annual movements in the Producer Price Index: Road and Bridge Construction New South Wales (Catalogue No. 6427.3101) as published by the Australian Bureau of Statistics.

6.4 Pooling of contributions funds

This plan authorises monetary contributions paid for different purposes in accordance with development consent conditions authorised by this plan and any other contributions plan approved by the Council to be pooled and applied progressively for those purposes.

6.5 Accountability and access to information

In accordance with the EP&A Act and EP&A Regulation a contributions register will be maintained by Council and may be inspected upon request.

The register will be maintained at regular intervals and will include the following:

- Particulars sufficient to identify each development consent for which contributions have been sought
- Nature and extent of the contribution required by the relevant condition of consent
- Name of the contributions plan under which the condition of consent was imposed
- Date the contribution was received, for what purpose and the amount.

Separate accounting records will be maintained for each contribution type in this plan and published every year in Council's financial accounts. They will contain details concerning contributions received and expended, including interest for each service or amenity to be provided. The records are held at Council's Administration Office and may be inspected upon request.

6.6 Dictionary

Words and phrases used in this plan have the same meaning as the terms defined in Narrabri Local Environmental Plan 2012 or the EP&A Act, except as provided for below.

In this plan, the following words and phrases have the following meanings:

CDC means complying development certificate.

Consent Authority has the same meaning as in the EP&A Act but also includes an accredited certifier responsible for issuing a CDC.

Council means Narrabri Shire Council.

EP&A Act means the Environmental Planning and Assessment Act 1979.

EP&A Regulation means the Environmental Planning and Assessment Regulation 2000.

ESA means equivalent standard axle.

LGA means local government area.

Schedule means the schedule that appears at the back of this plan.

SCHEDULE

Urban Roads Contributions Projects

SCHEDULE

URBAN ROADS CONTRIBUTIONS PROJECTS

Lynn Street, Boggabri

Urban roads project number	**B1-2016**
Affected land	Refer to contributions catchment map
Development on affected land that may be levied a contribution	• Subdivision to create additional allotments with a dwelling right; and • all new dwellings on existing allotments where a contribution has not previously been levied in accordance with this schedule of the plan.
Public amenities and services required to meet the development of the land	Construction and sealing of Lynn Street between Clare Street and Kamilaroi Highway, Boggabri
Cost of the public amenities and services	$309,000
Contribution rates	$20,000 per dwelling/lot
Staging / timing of the public amenities and services	To be determined – dependent on the rate of development in the contributions catchment
Works location map	Refer to works map

Background

Lynn Street is unsealed between Clare Street and Kamilaroi Highway.

Land on the western side of this section of road is zoned R1 General Residential under Narrabri Local Environmental Plan 2012. This land contains residential dwellings and has the potential to be developed for more residential dwellings in the future. The total expected development potential is 12 dwelling house lots, assuming an average allotment size of 800 square metres.

Safe and convenient access to this development would require the sealing of the subject section of Lynn Street. Council has estimate the cost of this work at $309,000.

The contribution rate formula is as follows:

Contribution rate per lot = $309,000 / 12 lots

= $25,750 per lot or dwelling

Regardless of this amount, the contribution rate that will be imposed on residential development shall be $20,000 per residential lot or dwelling, reflecting the cap imposed by the Minister under the section 7.17 direction issued on 21 August 2012.

SCHEDULE

URBAN ROADS CONTRIBUTIONS PROJECTS

Contributions catchment map for B1-2016

SCHEDULE

URBAN ROADS CONTRIBUTIONS PROJECTS

Works map for B1-2016

SCHEDULE

URBAN ROADS CONTRIBUTIONS PROJECTS

Derby, Oakham and Merton Streets, Boggabri

Urban roads project number	**B2-2016**
Affected land	Refer to contributions catchment map
Development on affected land that may be levied a contribution	• Subdivision to create additional allotments with a dwelling right; and • all new dwellings on existing allotments where a contribution has not previously been levied in accordance with this schedule of the plan.
Public amenities and services required to meet the development of the land	Construction and sealing of Derby, Oakham and Merton Streets, Boggabri
Cost of the public amenities and services	$803,000
Contribution rates	$5,695.04 per dwelling/lot
Staging / timing of the public amenities and services	To be determined – dependent on the rate of development in the contributions catchment
Works location map	Refer to works map

Background

Derby Street and the southernmost sections of Oakham Street and Merton Streets are unsealed roads.

Certain land fronting these roads is zoned R1 General Residential under Narrabri Local Environmental Plan 2012. This land contains residential dwellings and has the potential to be developed for more residential dwellings in the future. The total expected development potential is 141 dwelling house lots, assuming an average allotment size of 800 square metres.

Safe and convenient access to this development would require the sealing of the subject section of Lynn Street. Council has estimate the cost of this work at $803,000.

The contribution rate formula is as follows:

Contribution rate per lot = $803,000 / 141 lots

= $5,695.04 per lot or dwelling

SCHEDULE

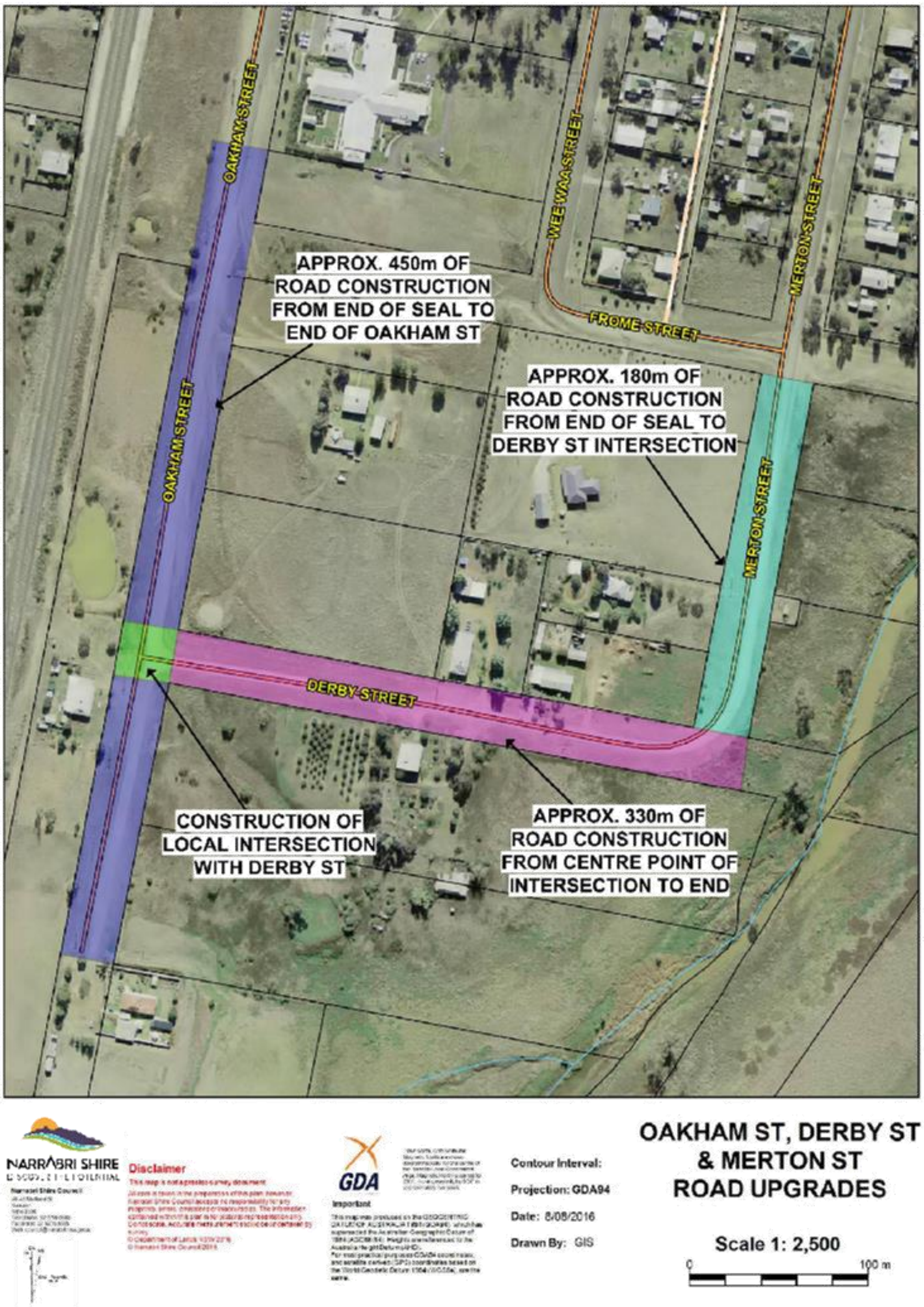
URBAN ROADS CONTRIBUTIONS PROJECTS

Contributions catchment map for B2-2016

SCHEDULE

URBAN ROADS CONTRIBUTIONS PROJECTS

Works map for B2-2016



APPENDIX A

Alternative to Roads Maintenance Contribution - Transport Study Requirements

Justification of any alternative to paying the Roads Maintenance Contribution

Transport Study Requirements

1. Identify the route over which haulage is proposed.

2. Identify the type and number of vehicles used to haul material.

3. An engineering assessment of the road condition and alignment over the entire length that haulage is proposed, including:

    a. existing pavement condition, and seal widths

    b. existing shoulder conditions

    c. existing pavement composition and structural capacity

    d. existing alignment, specifically detailing those areas which fail to meet current standards

    e. the number of overtaking opportunities and climbing lanes and the impact that increased truck traffic will have on existing travel times and accident rates

    f. an analysis in accordance with AUSTROADS principles of the existing road length showing current levels of service, and any assumptions made in their calculation.

4. The impact that road haulage will have on the existing road condition, including:

    a. the expected rate of pavement deterioration over each year that haulage is proposed, assessed in conjunction with the expected number of heavy vehicle movements (expressed as Equivalent Standard Axles)

    b. the reduction in pavement life which may be expected from the haulage

    c. the cost to the community to repair the pavement damage resulting from the haulage, and to maintain the pavement in an acceptable condition

    d. the cost to the community of the reduced pavement life resulting from the haulage.

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NARRABRI SHIRE
DISCOVER THE POTENTIAL

Narrabri Shire Section 7.12 - Fixed Development Consent Levies Contributions Plan 2011

NARRABRI SHIRE
DISCOVER THE POTENTIAL

Narrabri Shire
Section 7.12 Fixed Development Consent Levies Contributions Plan 2011

Document history and status

This document was originally prepared by Hill PDA (Job Ref No: C11092).

Amendments since have been made by Narrabri Shire Council.

Version	Issued To	Date	Prepared by:	Reviewed by:
Draft	Narrabri Shire Council	01/07/2011	DB	SH
Revised Draft	N/A	10/07/2019	MH	DB

MINUTE NUMBER	MEETING DATE	DESCRIPTION OF CHANGE
669/2011	18 October 2011	Adopted by Council

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LIST OF APPENDICES

LIST OF TABLES

1. Introduction

1.1 Legislative Context

Section 7.12 - Fixed Development Consent Levies, of the Environmental Planning and Assessment Act 1979 provides as follows:

(1) A consent authority may impose, as a condition of development consent, a requirement that the applicant pay a levy of the percentage, authorised by a contributions plan, of the proposed cost of carrying out the development.

(2) A consent authority cannot impose as a condition of the same development consent a condition under this section as well as a condition under section 7.11.

(2A) A consent authority cannot impose a condition under this section in relation to development on land within a special contributions area without the approval of:

(a) the Minister, or

(b) a development corporation designated by the Minister to give approvals under this subsection.

(3) Money required to be paid by a condition imposed under this section is to be applied towards the provision, extension or augmentation of public amenities or public services (or towards recouping the cost of their provision, extension or augmentation). The application of the money is subject to any relevant provisions of the contributions plan.

(4) A condition imposed under this section is not invalid by reason only that there is no connection between the development the subject of the development consent and the object of expenditure of any money required to be paid by the condition.

(5) The regulations may make provision for or with respect to levies under this section, including:

(a) the means by which the proposed cost of carrying out development is to be estimated or determined, and

(b) the maximum percentage of a levy.

1.2 The Purpose of the Plan

In accordance with the above this Section 7.12 Contributions Plan (the Plan) has been prepared by Narrabri Shire Council (from here on referred to as the Council) to:

- Authorise the imposition of a condition on certain development consents and complying development certificates requiring the payment of a contribution pursuant to Section 7.12 of the Environmental Planning and Assessment Act 1979;
- require a certifying authority to impose, as a condition of issuing a complying development

certificate or a construction certificate, a requirement that the applicant pay to Council a levy determined in accordance with this Plan;

- assist Council to provide the appropriate public facilities which are required to maintain and enhance amenity and service delivery within the area; and
- To publicly identify the purposes for which the levies are required.

1.3 References and Definitions

In this plan, unless the context or subject matter otherwise indicates or requires the following definitions apply:

- **ABS** means the Australian Bureau of Statistics;
- **EP&A Act** means the Environmental Planning and Assessment Act 1979;
- **EP&A Regulation or Regulation** means the Environmental Planning and Assessment Regulation 2000;
- **Council** means Narrabri Shire Council;
- **Development contributions** means a development contribution required to be paid by a condition of development consent imposed pursuant to Section 7.12 of the Act;
- **Levy** means a levy under Section 7.12 of the Act authorised by this Plan; and
- **Public Facility** and **Public Infrastructure** means a public amenity or public service.

2. Summary Schedules

The following schedules are included in this plan:

1. Schedule of Works; and
2. Summary of Levies.

2.1 Schedule of Works

The detailed schedule of works is provided at Appendix 2 and identifies the public facilities for which Section 7.12 levies will be required together with a summary of the anticipated expenditure on the respective items and priority for delivery.

2.2 Summary of the Levies

Levies paid to Council under this Plan will be applied towards meeting the costs of provision, or augmentation, of new public facilities as summarised in the Schedule of Works.

The Plan will be reviewed on an annual basis to ensure income from the levy is able to match proposed expenditure.

Table 1 - Summary of Section 7.12 Levies for Narrabri Shire

Type of Development	Estimated Cost of Development	Levy (%)
Residential accommodation, commercial development, business and retail development, tourist and visitor accommodation, industrial and storage premises development, primary production, any project declared to be a project to which Part 3A of the EP & A Act applies, extractive industries, utility installations, subdivisions and all other forms of development not specifically exempted under this plan.	$0 - $100,000	Nil
	$100,001 - $200,000	0.5%
	More than $200,000	1.0%

3. ADMINISTRATION OF THE PLAN

3.1 What is the Name of this Plan?

This development contributions plan is called the Narrabri Shire Council Section 7.12 Fixed Development Consent Levies 2011.

3.2 Application of this Plan

This Plan applies to all land within the Narrabri Shire Local Government Area (LGA).

The Plan applies to all applications for development consent and complying development certificates required to be made by or under Part 4 of the Environmental Planning and Assessment Act 1979 with respect to development on land to which this Plan applies.

In determining a development application, Council may impose a condition of consent requiring the payment of a levy, or dedication of land, in accordance with the provisions of this Plan.

The contribution rates for different types of development are provided in Table 1 (above).

3.3 When does this Plan Commence?

This plan came into effect when adopted by minute number 669/2011 at the Ordinary Council meeting conducted on the 18 October 2011.

4. OPERATION OF THE PLAN

4.1 Are There Any Exemptions to the Levy?

The levy will not be imposed in respect of development:

- where the proposed cost of carrying out the development is $100,000 or less;
- for the purposes of disabled access;
- for the sole purpose of providing affordable housing;
- for the purpose of reducing consumption of mains supplied potable water, or reducing the energy consumption of a building;
- for the sole purpose of the adaptive reuse of an item of environmental heritage;
- Other than the subdivision of land, where a condition under section 7.11 of the Act has been imposed under a previous development consent relating to the subdivision of the land on which the development is proposed to be carried out;
- Seniors housing, as defined in the State Environmental Planning Policy (Seniors Living) 2004, which is undertaken by a social housing provider;
- School developments that are a Federal Building the Education Revolution Project; or
- Any other Ministerial Direction released following the adoption of this plan.

There are no additional exemptions at the time of commencement of this Plan, however, Council may consider exempting other categories of developments, or components of developments from the requirement for a levy, but only by resolution of Council.

Consideration will be given to requests for exemption for the following types of development:

- works undertaken for charitable purposes or by a registered charity (as defined by the ATO);
- places of worship;
- public infrastructure for or on behalf of the NSW Government including but not limited to hospitals, public transport, police and fire stations and education facilities;
- public community infrastructure such as but not limited to libraries, community facilities, child care facilities, recreational areas, recreational facilities or car parks;
- privately funded community infrastructure, such as but not limited to education facilities, universities, and private hospitals;
- industrial, retail or commercial development, where there is no increase in floor space within an existing building;
- the continued operation of a coal mine, where rail transport is used for the transportation of coal; or
- Demolition (where there is no replacement building or development).

For an exemption to be considered any such development will need to submit a written request making the case for exemption and including details of:

- Under which point in Section 4.1 of this Plan the exemption claimed is to be considered;
- The mechanism ensuring that such development will remain in the form proposed in the future (i.e. not to increase future demand on public amenities and services); and
- Other items if applicable such as: How the development will incorporate the maintenance of the item of heritage significance? How the development will contribute to the public benefit of the community? Works in the public domain included in the development? How the residents/users will utilise existing private facilities attached to the development that replicate those types provided by Council?

4.2 Pooling of Levies

This Plan expressly authorises Section 7.12 levies be paid for different purposes to be pooled and applied (progressively or otherwise) for those purposes. The priorities for the expenditure of the levies are shown in the works schedule (refer to Appendix 2).

4.3 Construction Certificates and the Obligation of Accredited Certifiers

In accordance with Clause 146 of the Environmental Planning and Assessment (EP&A) Regulation 2000, a certifying authority must not issue a construction certificate for building work or subdivision work under a development consent unless it has verified that each condition requiring the payment of levies has been satisfied.

In particular, the certifier must ensure that the applicant provides a receipt(s) confirming that levies have been fully paid and copies of such receipts must be included with copies of the certified plans provided to Council in accordance with Clause 142(2) of the of the EP&A Regulation. Failure to follow this procedure may render such a certificate invalid.

The only exceptions to the requirement are where a works in kind, material public benefit, dedication of land or deferred payment arrangement has been agreed by the Council. In such cases, Council will issue a letter confirming that an alternative payment method has been agreed with the applicant.

4.4 How will the Levy be Calculated?

The levy will be determined based on the rate as set out in the Summary Schedule (refer to Table 2).

The levy will be calculated as follows:

Levy	**=**	**%C**	**x**	**$C**
Where:				
- %C is the levy rate applicable;				
- $C is the proposed cost of carrying out the				

The proposed cost of carrying out the development will be determined in accordance with Clause 25J of the EP&A Regulations 2000. The procedure set out in Appendix 1 to this Plan must be followed to enable Council to determine the amount of the levy to be paid.

The value of the works must be provided by the applicant at the time of the request and if appropriate must be independently certified by a quantity surveyor, who is registered with the Australian Institute of Quantity Surveyors, or a person who can demonstrate equivalent qualifications.

Without limitation to the above, Council may review the valuation of works and may seek the services of an independent person to verify the costs. If the result of a review indicates the value of the works differ from that provided, Council may determine the value of the works to be applied as the basis for any levy payable.

Contribution amounts payable can be checked with Council by contacting (02) 6799 6866 during office hours.

4.5 When is the Levy Payable?

A levy must be paid to Council at the time specified in the condition that imposes the levy. If no such time is specified, the levy must be paid prior to the issue of a construction certificate or complying development certificate.

4.6 How will the Levy be Adjusted?

Contributions required as a condition of consent under the provisions of this Plan will be adjusted at the time of payment of the contribution in accordance with the following formula:

Contribution = $Co + A at time of payment

Where:

- $ Co is the original contribution as set out in the consent; and

- A is the adjustment amount which is:

$$\$Co \times \frac{[\text{Current Index}^{5} - \text{Base Index}^{6}]}{[\text{Base Index}]}$$

Note: *In the event that the Current Index is less than the Base Index the Current Index shall be taken as not less than the Base Index.*

[5] Current Index (6401.0 - Consumer Price Index Australia) is the Consumer Price Index, Australia CPI: Groups, Weighted Average of Eight Capital Cities, Index Numbers and Percentage Changes as published for the last quarter by the Australian Bureau of Statistics available at the time of review of the contribution rate.

[6] Base Index (6401.0 - Consumer Price Index Australia) is Consumer Price Index, Australia CPI: Groups, Weighted Average of Eight Capital Cities, Index Numbers and Percentage Changes as published by the Australian Bureau of Statistics published at the date of adoption of this plan which is July 2011.

4.7 Can Deferred or Periodic Payments be Made?

Deferred or periodic payments may be permitted in the following circumstances:

- When the deferred or periodic payment of the contribution will not prejudice the timing or the manner of the provision of public facilities included in the works program; and
- In other circumstances considered reasonable by Council.

If Council agrees to accept deferred or periodic payment, Council may require the applicant to provide a bank guarantee for the full amount of the contribution or the outstanding balance on condition that:

- the bank guarantee be for the amount of the total contribution, or the amount of the outstanding contribution, plus an amount equal to thirteen (13) months interest plus any charges associated with establishing or operating the bank security;
- the bank unconditionally pays the guaranteed sum to the Council if the Council so demands in writing not earlier than 12 months from the provision of the guarantee or completion of the work;
- the bank must pay the guaranteed sum without reference to the applicant or landowner or other person who provided the guarantee, and without regard to any dispute, controversy, issue or other matter relating to the development consent or the carrying out of development;
- the bank's obligations are discharged when payment to the Council is made in accordance with this guarantee or when Council notifies the bank in writing that the guarantee is no longer required; and

- Where a bank guarantee has been deposited with Council, the guarantee shall not be cancelled until such time as the original contribution and accrued interest are paid.

4.8 Accountability

Financial management and accountability are important components of a Section 7.12 Development Contributions Plan. Council is responsible for the maintenance of an accurate and up to date register of all contributions. Monetary contributions received under this Plan are kept in a separate account specifically for this plan. Accounting records show the contributions received and expended, including any interest earned on invested funds for each account. These records are updated on a monthly basis.

Separate accounting records are maintained for all Council's Contributions Plans. Information on Section 7.12 accounts and funds relating to this Plan will be provided in a condensed format within Narrabri Shire Council's Annual Reports in accordance with the requirements of the EP&A Regulations 2000. Information is also available from Council's contribution register relating to this Plan, which can be inspected at Council during ordinary office hours.

4.9 Offer to Enter into a Voluntary Planning Agreement

An applicant may offer to enter into a voluntary planning agreement (VPA) with Council under Section 7.4 of the EP&A Act in connection with the making of a development application, rather than pay a contribution in relation to a development. Under the planning agreement, the applicant may offer to:

- pay money;
- dedicate land;
- carry out works; or
- provide other material public benefits for public purposes.

The applicant's provision under a VPA may be additional to, or instead of, paying a contribution in accordance with a condition of development consent authorised by this Plan. This will be a matter for negotiation with Council. An approach should be made to Council at an early stage in the project, prior to lodgement of any development application, to finalise any negotiations required to avoid delays as part of the development assessment process.The offer to enter into the VPA together with a copy of the draft agreement should accompany the relevant development application.

Council will publicly notify the draft VPA and an explanatory note relating to the draft agreement along with the development application and will consider the VPA as part of its assessment of that application. If Council agrees to enter into the VPA, it may impose a condition of development consent under Section 7.7(3) of the EP&A Act 1979 requiring the agreement to be entered into and performed.

If Council does not agree to enter into the VPA, it may grant consent subject to a condition authorised by this Plan requiring the payment of a contribution.

Appendix 1 - PROCEDURE FOR COUNCIL TO DETERMINE THE LEVY AMOUNT

Procedure

A cost summary report is required to be submitted to allow Council to determine the contribution that will be required. The following should be provided:

- Minor works that are demonstrated to comprise works less than $50,000 in value do not require a cost report to be completed;
- A cost summary report must be completed for works with a value between $50,000 and $500,000 (refer to template over page); or
- A quantity surveyor's Detailed Cost Report must be completed by a registered quantity surveyor for works with a value greater than $500,000 (refer to template over page).

To avoid doubt, Section 25J of the Environmental Planning and Assessment Regulation 2000 states that the proposed cost of carrying out development is to be determined by adding up all of the costs and expenses that have been or are to be incurred by the applicant in carrying out the development, including the following:

- the development involves the erection of a building, or the carrying out of engineering or construction work—the costs of, or incidental to, erecting the building, or carrying out the work, including the costs (if any) of, and incidental to, demolition, excavation and site preparation, decontamination or remediation;
- the development involves a change of use of land—the costs of or incidental to doing anything necessary to enable the use of the land to be changed; and
- The development involves the subdivision of land—the costs of or incidental to preparing, executing and registering the plan of subdivision and any related covenants, easements or other rights.

The Regulation makes clear that the following costs and expenses are not to be included in any estimate or determination of the proposed cost of carrying out development:

- the cost of the land on which the development is to be carried out;
- the costs of any repairs to any building or works on the land that are to be retained in connection with the development;
- the costs associated with marketing or financing the development (including interest on any loans);
- the costs associated with legal work carried out or to be carried out in connection with the development;
- project management costs associated with the development;
- the cost of building insurance in respect of the development;
- the costs of fittings and furnishings, including any refitting or refurbishing, associated with the development (except where the development involves an enlargement, expansion or intensification of a current use of land);

- the costs of commercial stock inventory;
- any taxes, levies or charges (other than GST) paid or payable in connection with the development by or under any law;
- the costs of enabling access by disabled persons in respect of the development;
- the costs of energy and water efficiency measures associated with the development;
- the cost of any development that is provided as affordable housing; and
- the costs of any development that is the adaptive reuse of a heritage item.

Sample Cost Summary Report (Development Cost No Greater than $500,000)

Council References		
Development Application No:		
Reference:		
Complying Development Certificate Application No:		
Construction Certificate No:	Date**:**	
Applicants Details		
Applicant's Name:	Applicant's Address:	
Development Details		
Development Name:	Development Address:	
Description of Development Cost	**Cost Estimate ($)**	
Demolition and alterations		
Hydraulic services		
Structure		
Mechanical services		
External walls, windows and doors		
Fire services		
Internal walls, screens and doors		
Lift services		
Wall finishes		
External works		
Floor finishes		
External services		

Ceiling finishes	
Other related work	
Fittings and equipment	
Sub-total	

Sub-total above carried forward	
Preliminaries and margin	
Sub-total	
Consultant Fees	
Other related development costs	
Sub-total	
Goods and Services Tax	
Total Development Cost	

I certify that I have:

- Inspected the plans the subject of the application for development consent or construction certificate.
- Calculated the development costs in accordance with the definition of development costs in clause 25J of the Environmental Planning and Assessment Regulation 2000 at current prices.
- Included GST in the calculation of development cost.

Signed:
Name:
Position and Qualifications:
Date:

Sample Cost Summary Report (Development Cost more than $500,000)

This report must be completed by a Registered Quantity Surveyor (A member of the Australian Institute of Quantity Surveyors)

Council References		
Development Application No:		
Reference:		
Complying Development Certificate Application No:		
Construction Certificate No:	Date:	
Applicants Details		
Applicant's Name:	Applicant's Address:	
Development Details		
Development Name:		
Development Address:		
Gross Floor Area – Commercial	sqm	
Gross Floor Area – Residential	sqm	
Gross Floor Area – Retail	sqm	
Gross Floor Area – Other	sqm	
Gross Floor Area – Car Parking	sqm	
Total Gross Floor Area	sqm	
Total Site Area	sqm	
Total Number of Car Parking Spaces		
Total Development Cost	$	
Total Construction Cost	$	
Total GST	$	
Estimate Details:		
Professional Fees	$	
% Of Development Cost		

% Of Construction Cost	
Excavation	$
Cost per sqm of Site Area	$
Car Park	$
Cost per sqm of site area	$
Cost Per Space	$
Demolition and Site Preparation	$
Cost per sqm of site area	$
Construction – Commercial	$
Cost per sqm of commercial area	$
Fit-Out – Commercial	$
Cost per sqm of commercial area	$
Construction – Residential	$
Cost per sqm of Residential area	$
Fit-Out – Residential	$
Cost per sqm of Residential area	$
Construction – Retail	$
Cost per sqm of Retail area	$
Fit-Out – Retail	$
Cost per sqm of Retail area	$

I certify that I have:

- inspected the plans the subject of the application for development consent or construction certificate;
- prepared and attached an elemental estimate generally prepared in accordance with the Australian Cost Management Manuals from the Australian Institute of Quantity Surveyors;
- calculated the development costs in accordance with the definition of development costs in the S7.12 Development Contributions Plan of the council of [insert] at current prices;
- included GST in the calculation of development cost; and
- Measured gross floor areas in accordance with the Method of Measurement of Building Area in the AIQS Cost Management Manual Volume 1, Appendix A2.

Signed:
Name:
Position and Qualifications:
Date:

Appendix 2 - SCHEDULE OF WORKS

Fixed Development Consent Levies Contributions Plan
Schedule of Works

Priority	Description
Low (L)	Capital Works prioritised and expected to be needed from 7 – 10 years
Medium (M)	Capital Works prioritised and expected to be needed from 3 – 7 years
High (H)	Capital Works prioritised and expected to be needed from 1 – 3 years

Item	Infrastructure	Location	Priority	Estimate ($)
1	Community Facilities Upgrades	Narrabri - Cooma Oval - playground area additional seating	H	5,000
2	Community Facilities Upgrades	Narrabri - Cooma oval shelters - Covered seating areas on the edge of field	H	45,000
3	Community Facilities Upgrades	Narrabri - Collins Park - four new seating structures for the riverbank area	H	15,000
4	Community Facilities Upgrades	Narrabri - Pirate Playground - additional shelter & BBQ area	H	45,000
5	Community Facilities Upgrades	Narrabri - Pirate Playground - shade shelter over playground	H	30,000
6	Community Facilities Upgrades	Narrabri – Cooma Oval – widen access area to Ugoa Street Carpark	H	5,000
7	Community Facilities Upgrades	Narrabri - Narrabri creek accessible jetty - All accessible concrete jetty next to boat ramp	H	90,000
8	Communities Facilities Upgrade	Narrabri - Gately field - Covered seating areas on the edge of field	H	45,000
9	Community Facilities Upgrades	Narrabri - leash free park - Construct a leash free dog park	H	50,000
10	Community Facilities Upgrades	Boggabri – Middle Park – install additional picnic table and shelter	H	20,000
11	Community Facilities Upgrades	Boggabri - Vickery Park Gym equipment - Two cover gym stations and connecting pathway	H	85,000
12	Community Facilities Upgrades	Boggabri - New fence and gate and pathway to link equipment and park furniture	H	60,000
13	Community Facilities Upgrades	Narrabri Shared Cycle/Pedestrian Pathway Project	H	235,000
14	Community Facilities Upgrades	Wee Waa - Ludowici Park - install BBQ into sheltered area	H	8,000
15	Community Facilities Upgrades	Wee Waa - Ludowici Park - install pathway to link new shelter to playground	H	25,000
16	Community Facilities Upgrades	Wee Waa - Ludowici Park - install shade shelter	H	35,000
17	Community Facilities Upgrades	Wee Waa - Ludowici Park - replace swing set	H	8,000
18	Community Facilities Upgrades	Gwabegar - Anzac Park - renew playground equipment	H	60,000

19	Community Facilities Upgrades	Gwabegar - Anzac Park - install shade shelter	H	25,000
20	Community Facilities Upgrades	Pilliga - Anzac Park - install new playground equipment	H	50,000
21	Community Facilities Upgrades	Pilliga - Anzac Park - install shade shelter	H	25,000
22	Community Facilities Upgrades	Pilliga - Rural Transaction Centre - replace amenities	H	60,000
23	Community Facilities Upgrades	Baan Baa – Hall – new playground and shade	H	60,000
24	Community Facilities Upgrades	Bellata – Public Toilet - toilet installed at playground or camping site	H	100,000
25	Community Facilities Upgrades	Bellata – Picnic Shelter and seat	H	40,000
26	Footpath	Killarney Street from Tibbereena Street to Barwan Street	H	51,000
27	Footpath	Barwan Street from Bowen Street to Denison Street	H	51,000
28	Footpath	Gibbons Street from Wandi Place to Existing Footpath	H	28,000
29	Footpath	Boheena Street Wukawa Street to Cooma Road	H	73,000
30	Footpath	Wee Waa Street from Brent Street to Caxton Street	H	64,000
31	Pools Boggabri	Pools - Boggabri Pool - Tables & Chairs for BBQ Area	H	5,000
32	Pools Narrabri	Pools - Narrabri Aquatic Centre - Outdoor Tables & Chairs for Canteen Area	H	10,000
33	Pools Wee Waa	Pools - Wee Waa Pool - Tables & Chairs for BBQ Area	H	5,000
34	Footpath	Narrabri Jetty Area pathway to link arterial pathway	H	35,000
35	Community Facilities Upgrades	Narrabri Lake additional seating	H	15,000
36	Community Facilities Upgrades	Boggabri Vickery Park flying fox	H	30,000

For the purposes of section 7.12 (3) of the Act, the cost of providing public amenities or public services is to be indexed annually (as specified in the relevant contributions plan) in accordance with movements in the Consumer Price Index (All Groups Index) for Sydney issued by the Australian Statistician.

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NARRABRI SHIRE
DISCOVER THE POTENTIAL

DEVELOPMENT APPLICATION ASSESSMENT

1 Preliminary Scoping

1.1 Application Details

DA No.	77/2019
Lot/DP	Lot 38 DP 1040539
Street Address	1 Guest Street, Narrabri
Area	1,793m²
Applicant	Ross Gleeson/ Gleeson Surveying
Land Owner(s)	William James McInnes
Proposed Development	2 lot subdivision
Land Use Description	Subdivision
Date	7 August 2019
Officer	Erika Dawson

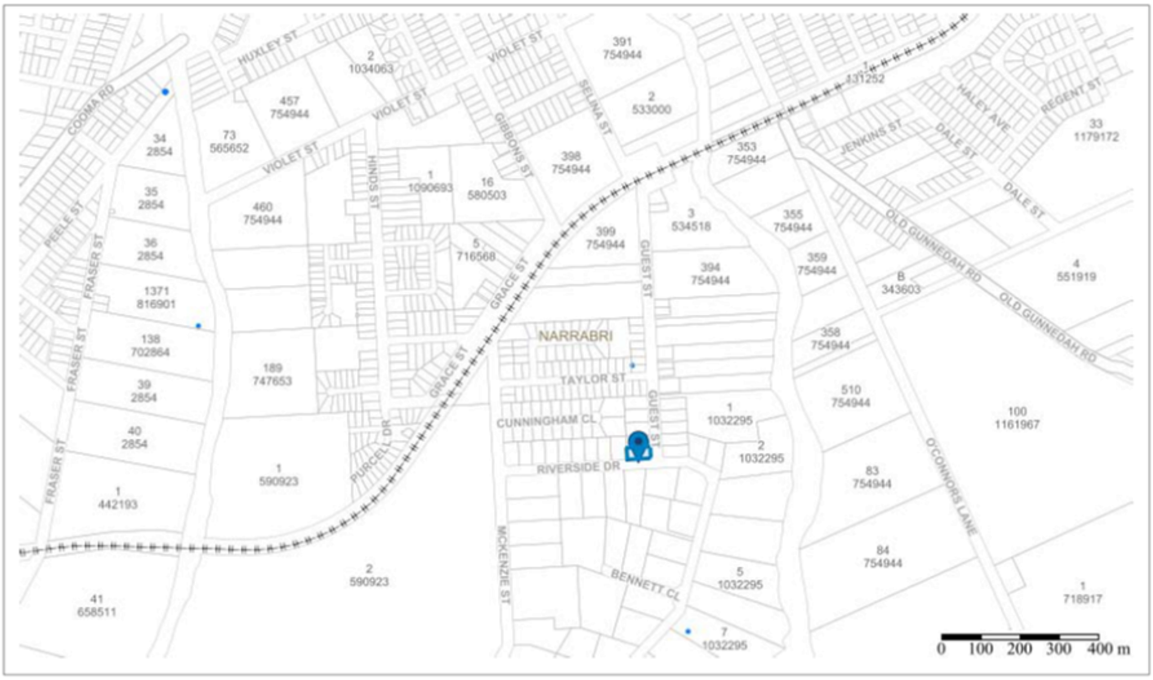

Figure 1 – Site Location Plan

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Figure 2 – Site Aerial Photograph

1.2 History

No history known to be relevant.

1.3 Constraints

Issue	Yes	No	Issue	Yes	No
Bushfire Prone	☐	☒	Heritage (State Heritage Register)	☐	☒
Flood Prone	☒	☐	Heritage (LEP)	☐	☒
Flora & Fauna/Native vegetation	☐	☒	Indigenous Heritage	☐	☒
Any easements other applicable restrictions on use etc?	☐	☒			

Comments:

- AHIMS Search – no items/areas listed as being recorded on site.
- BioNet Search – no records on site or in immediate vicinity.

1.4 Applicable Environmental Planning Instruments

1.4.1 Local Environmental Plan (LEP)

LEP Name:	Narrabri LEP
Map Sheet No.:	4B
Zoning:	R1 General Residential
Proposed Land Use/Development	Subdivision
Minimum Lot Size *(relevant to the development, i.e.*	K = 550m²

might relate to MDH or dual occ MLS)					
Check LEP maps for the following:					
Issue	**Yes**	**No**	**Issue**	**Yes**	**No**
LEP Heritage Conservation Area	☐	☒	Obstacle Limitation Surface	☐	☒
LEP Heritage Item	☐	☒	Active Street Frontages	☐	☒
Flood Planning Area	☒	☐	Additional permitted uses	☐	☒
Land Reservation Acquisition	☐	☒			
List other LEP clauses needing to be addressed:	1.9A Suspension of covenants, agreements and instruments 2.3 Zone Objectives & Land Use Table 2.6 Subdivision – Consent Requirements Land use table 4.1 MLS 6.1 Earthworks 6.2 Flood planning 6.5 Essential services				

Figure 3 – LEP Zoning Map

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Figure 4 – LEP Minimum Lot Size Map

Figure 5 – LEP Flood Planning Area Map

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1.4.2 State Environmental Planning Policies (SEPPs)

The following outlines the SEPPs that are applicable to the development.

SEPP	Yes	No	SEPP	Yes	No
SEPP 1- Development Standards	☐	☒	SEPP 19 – Bushland in Urban Areas	☐	☒
SEPP 21 – Caravan Parks	☐	☒	SEPP 33 – Hazardous & Offensive Development	☐	☒
SEPP 36 – Manufactured Home Estates	☐	☒	SEPP 44 – Koala Habitat Protection	☐	☒
SEPP 47 – Moore Park Showground	☐	☒	SEPP 50 – Canal Estate Development	☐	☒
SEPP 55 – Remediation of Land	☒	☐	SEPP 64 – Advertising & Signage	☐	☒
SEPP 65 – Design Quality of Residential Apartment Development	☐	☒	SEPP 70 – Affordable Housing (Revised Schemes)	☐	☒
SEPP Aboriginal Land 2019	☐	☒	SEPP Affordable Rental Housing 2009	☐	☒
SEPP BASIX 2004	☐	☒	SEPP Coastal Management 2018	☐	☒
SEPP Concurrences 2018	☐	☒	SEPP Educational Establishments & CC Facilities 2017	☐	☒
SEPP Exempt & Complying Development Codes 2008	☐	☒	SEPP Gosford City Centre 2018	☐	☒
SEPP Housing for Seniors & People with a Disability 2004	☐	☒	SEPP Infrastructure 2007	☐	☒
SEPP Kosciuszko – Alpine Resorts 2007	☐	☒	SEPP Kurnell Peninsula 1989	☐	☒
SEPP Mining, Petroleum Production & Extractive Industries 2007	☐	☒	SEPP Miscellaneous Consent Provision 2007	☐	☒
SEPP Penrith Lakes Scheme 1989	☐	☒	SEPP Primary Production & Rural Development 2019	☐	☒
SEPP State & Regional Development 2011	☐	☒	SEPP State Significant Precincts 2005	☐	☒
SEPP Sydney Drinking Water Catchment 2011	☐	☒	SEPP Sydney Region Growth Centres 2006	☐	☒
SEPP Three Ports 2013	☐	☒	SEPP Urban Renewal 2010	☐	☒
SEPP Vegetation in Non-Rural Areas 2017	☐	☒	SEPP Western Sydney Employment Area 2009	☐	☒
SEPP Western Sydney Parklands 2009	☐	☒			

1.5 Integrated Development

The following outlines which other approvals are required which would constitute "integrated development" for the purpose of Section 4.46 of the EP&A Act.

Issue	Yes	No	Issue	Yes	No
Coal Mine Subsidence Compensation Act 2017	☐	☒	Petroleum (Onshore) Act 1991	☐	☒
Fisheries Management Act 1994	☐	☒	POEO Act 1997	☐	☒
Heritage Act 1977	☐	☒	Roads Act 1993	☐	☒
Mining Act 1992	☐	☒	Rural Fires Act 1997	☐	☒
NPWS Act 1974	☐	☒	Water Management Act 2000	☐	☒

1.6 Other Matters for consideration

Issue	Yes	No
Is the development Designated Development (check schedule3 of EP&A Regs)?	☐	☒
Is the development Crown Development (check Division 4.6 EP&A Act)?	☐	☒
Is the development for a Concept DA (check Division 4.4 EP&A Act)?	☐	☒
Is the development Regional Development (check SRD SEPP)?	☐	☒
Is the development State Significant Development (check SRD SEPP)?	☐	☒
Is the development for an existing use (check Division 4.11 EP&A Act)?	☐	☒

1.7 Permissibility

Permissible pursuant to clause 2.6 and the MLS requirements of clause 4.1.

1.8 DA Documentation

This section determines whether sufficient information been provided with the DA to enable assessment. Checklist in **Appendix A** to cover items in Schedule 1 Part 1 of EP&A Regs.

Comments:

Ok.

1.9 Internal Referrals

1.9.1 Infrastructure Delivery

1.9.1.1 Sewer

- Lot 381 has an existing sewer connection.
- Lot 382 will require connection to the Council sewer system. The SEE indicates that an available sewer main is located within Riverside Drive (front of the property).

Conditions

- Therefore, the developer will be required to submit a 'Water Supply and Sewerage Service Connection Enquiry application to connect to the existing sewer main.

1.9.1.2 Water

- Lot 381 has an existing potable water connection.
- Lot 382 will require connection to the Council potable water system. An available water main is located within Riverside Drive (front of the property).

Conditions

- Therefore, the developer will be required to submit a 'Water Supply and Sewerage Service Connection Enquiry application to connect to the existing water main.

1.9.1.3 Stormwater

- N/A - roof drainage to be assessed by Development & Economic Growth Department when an application to construct a dwelling has been lodged.

1.9.1.4 Vehicle Access

- The property currently does not have a formal vehicle access for either proposed Lot 381 or 382.

Conditions

- Therefore a vehicle access shall be constructed in accordance with Council specifications (i.e. full width concrete driveway) from the Riverside Drive kerb alignment to the property boundary (for both Lot 381 & 382). A 'Request for Urban Driveway Inspection' form is required to be completed by the developer prior to construction.
- The access for each lot will need to be constructed prior to the construction of a dwelling on the lot.

1.10 External Referrals

Nil required.

2 DA Assessment (s.4.15 EP&A Act)

2.1 Environmental Planning Instruments (EPI)

The following provides an assessment of the applicable EPIs as identified in **Section 1.4.2**.

2.1.1 SEPP 55 – Remediation of Land

Table 1 – SEPP 55 Assessment

Provision	Comment/Response	Compliance
7 Contamination and remediation to be considered in determining development application		
(1) A consent authority must not consent to the carrying out of any development on land unless: (a) it has considered whether the land is contaminated, and (b) if the land is contaminated, it is satisfied that the land is suitable in its contaminated state (or will be suitable, after remediation) for the purpose for which the development is proposed to be carried out, and (c) if the land requires remediation to be made suitable for the purpose for which the development is proposed to be carried out, it is satisfied that the land will be remediated before the land is used for that purpose.	The land is not known to be contaminated by virtue of the known previous land uses.	✓
(2) Before determining an application for consent to carry out development that would involve a change of use on any of the land specified in subclause (4), the consent authority must consider a report specifying the findings of a preliminary investigation of the land concerned carried out in accordance with the contaminated land planning guidelines.	No change of use. Land zoned for residential development.	N/A

2.1.2 LEP

The relevant LEP clauses identified in **Section 1.4.1** are addressed below.

Table 2 – Narrabri LEP 2012

Provision	Comment/Response	Compliance
1.9A Suspension of covenants, agreements and instruments		
(1) For the purpose of enabling development on land in any zone to be carried out in accordance with this Plan or with a consent granted under the Act, any agreement, covenant or other similar instrument that restricts the carrying out of that development does not apply to the extent necessary to serve that purpose.	88B restrictions on the title are not applicable for the purposes of this assessment.	N/A
2.3 Zone objectives and Land Use Table		
(1) The Land Use Table at the end of this Part specifies for each zone: (a) the objectives for development, and (b) development that may be carried out without development consent, and (c) development that may be carried out only with development consent, and (d) development that is prohibited.	The objectives of the R1 zone are: • To provide for the housing needs of the community. • To provide for a variety of housing types and densities. • To enable other land uses that provide facilities or services to meet the day to day needs of residents. The proposed subdivision is considered to be consistent with the zone objectives.	✓
(2) The consent authority must have regard to the objectives for development in a zone when determining a development application in respect of land within the zone.		
2.6 Subdivision – Consent Requirements		
(1) Land to which this Plan applies may be subdivided, but only with development consent.	This DA forms the application.	✓
4.1 Minimum subdivision lot size		
(2) This clause applies to a subdivision of any land shown on the Lot Size Map that requires development consent and that is carried out after the commencement of this Plan. (3) The size of any lot resulting from a subdivision of land to which this clause applies is not to be less than the minimum size shown on the Lot Size Map in relation to that land	The MLS = 550m². Proposed Lot 381 = 896m² Proposed Lot 392 = 897.2m²	✓

Table 2 – Narrabri LEP 2012

Provision	Comment/Response	Compliance
6.1 Earthworks		
(3) Before granting development consent for earthworks (or for development involving ancillary earthworks), the consent authority must consider the following matters:		
(a) the likely disruption of, or any detrimental effect on, drainage patterns and soil stability in the locality of the development,	The development is not expected to disrupt or detrimentally effect any drainage patterns or soil stability in the locality.	✓
(b) the effect of the development on the likely future use or redevelopment of the land,	The development is consistent with the future use of the land.	✓
(c) the quality of the fill or the soil to be excavated, or both,	No significant excavation or fill required. Any fill to be clean.	✓
(d) the effect of the development on the existing and likely amenity of adjoining properties,	No adverse impacts anticipated.	✓
(e) the source of any fill material and the destination of any excavated material,	No significant excavation or fill required.	✓
(f) the likelihood of disturbing relics,	Not likely, however, unexpected finds condition to be imposed.	✓
(g) the proximity to, and potential for adverse impacts on, any waterway, drinking water catchment or environmentally sensitive area,	No expected impacts on waterway, drinking water catchment or environmentally sensitive area.	✓
(h) any appropriate measures proposed to avoid, minimise or mitigate the impacts of the development.	Outlined above.	✓
6.2 Flood planning		
(2) This clause applies to: (a) land identified as "Flood planning area" on the Flood Planning Map, and (b) other land at or below the flood planning level.	The site is mapped as being within the Flood Planning Area.	✓
(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development: (a) is compatible with the flood hazard of the land, and (b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and	Hydraulic Categorisation (Figure 6) • The site is not within a flood way • The site is within a flood storage area. Hazard Category (Figure 7 & Figure 8) • The site is predominately within the H3 category, which is acceptable (being ≤ H4).	✓

Table 2 – Narrabri LEP 2012

Provision	Comment/Response	Compliance
(c) incorporates appropriate measures to manage risk to life from flood, and (d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and (e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.	Risk to Future Buildings • Hazard category is considered acceptable for future dwellings. Construction elements of future dwellings would be required to be designed to withstand velocities. Risk to Life • The site is located within an area subject to an acceptable level of risk. • Egress routes are generally located with an acceptable level of risk. Flood Behaviour Impacts • The flood modelling undertaken assumes full development of R1 zoned land. • The proposed development would not impact on flood behaviour.	
6.5 Essential services		
Development consent must not be granted to development unless the consent authority is satisfied that any of the following services that are essential for the development are available or that adequate arrangements have been made to make them available when required:		
(a) the supply of water,	Proposed Lot 381 has an existing water supply connection. A new connection would be required for proposed Lot 382.	✓
(b) the supply of electricity,	Underground electricity is available within the Riverside Drive road reserve.	✓
(c) the disposal and management of sewage,	Proposed Lot 381 has an existing sewerage connection. A new connection would be required for proposed Lot 382.	✓
(d) stormwater drainage or on-site conservation,	The site drains can drain to the street.	✓
(e) suitable vehicular access.	Both proposed lots have access to the street.	✓

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Figure 6 – Hydraulic Categorisation

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Figure 7 – Hazard Category

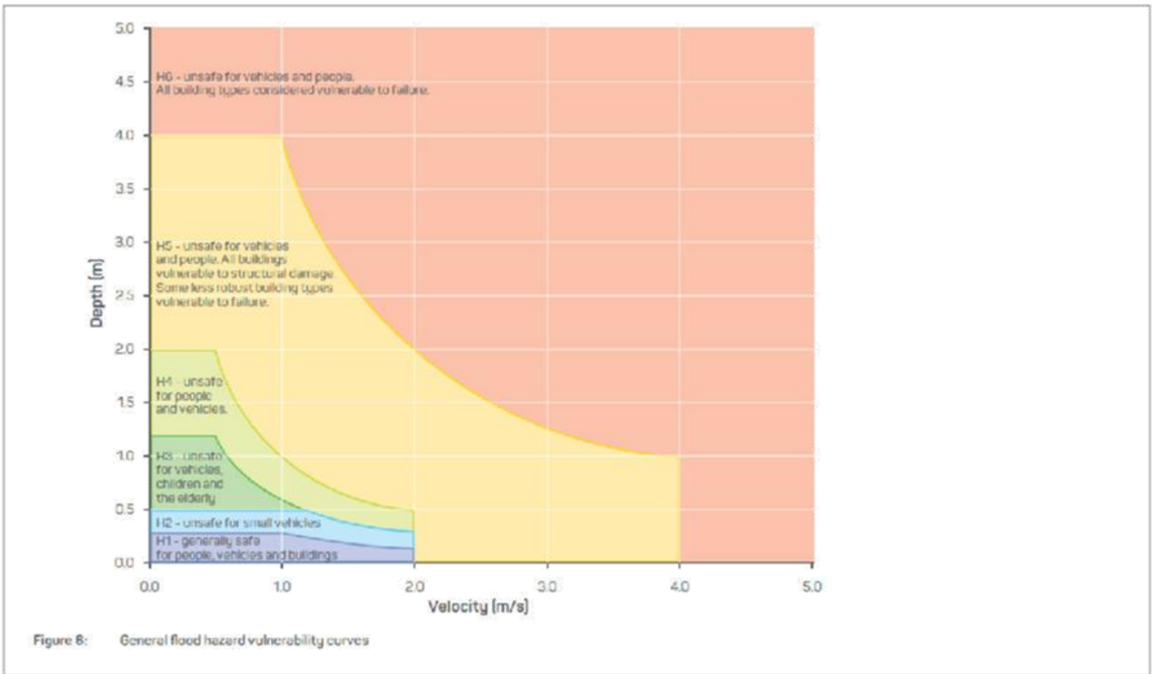

Figure 8 – Hazard Category Graph

2.2 Proposed EPIs

Nil known to be applicable.

2.3 DCPs

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2.3.1 DCP Notification Policy

Table 3 – DCP Notification Policy

Required	Provided	Compliance
Infill Subdivision = Category B Notification Category A Notification requires: • Letter to adjoining property owners Required to be notified for minimum ten (10) working days.	The DA was notified in accordance with the requirements from 10 April 2019 to 29 April 2019 (> 10 working days). Two (2) submissions received, which have been addressed in **Section 2.8**.	

2.3.2 DCP Subdivision Code

Access to Urban Properties

Required

- Kerb and gutter, and vehicle laybacks are to be provided at the applicant's expense where the subdivision is to take place on a street that does not have kerb and gutter.

Provided

- Existing kerb and gutter provided. Laybacks not considered necessary as it is mountable kerb.

Building Envelope

Required

- All residential allotments, and all other allotments (except where the applicant can prove to Council in writing that compliance is unnecessary), are required to have an area of 15m x 18m behind the Council's adopted building line on which construction of a building is possible.

Provided

- Both proposed lots would achieve the required building envelopes.

Street Frontages

Required

- Street trees required for urban subdivisions.

Provided

- This would have been addressed as part of the original subdivision.

2.3.2.1 Provision of Services

Essential Services

Required

- Water and sewer connections to be provided to all lots
- Consultation required with electricity provider for requirements.

Provided

- Condition water and sewer connections.
- Condition consultation with electricity provider

Community Services

Required

- Payment of s94 contributions
- Payment of headworks charges

Provided

- Condition payment s94 contributions
- Condition payment of headworks charges

Natural Hazards

Flooding

Required:

- For urban areas, applicant to provide 1 in 100 year flood level.

Provided:

- The Flood Level Certificate for the site indicates:
    - The existing ground level on this property ranges from 214.62 m AHD to 214.92 m AHD.
    - The peak 1 in 100 year flood level ranges from 215.58 m AHD to 215.60 m AHD on this property.
    - The depth occurring on this property during a 1 in 100 year flood ranges from 0.67 m AHD to 0.97 m AHD.
    - The velocity occurring on this property during a 1 in 100 year flood ranges from 0.10 m/sec to 0.40 m/sec.
    - The Minimum Floor Level of all habitable areas of any residential building on this property is required to be constructed a minimum of 500mm above the 1 in 100 year flood level.
    - The Flood Planning Level (known as the Minimum Floor Level), on this property ranges from 216.08 m AHD to 216.10 m AHD.

2.4 Planning Agreements Entered into

Nil know to be in existence.

2.5 The Regulations

No provisions relevant to the proposed development.

2.6 Likely Impacts of the Development

2.6.1 Context & Setting

The development will provide for two lots smaller than those in the surrounding area. However, the lots are to be larger than the minimum permissible lot size. The development is considered that it will provide for a variety in housing density which is consistent with the zone objectives. The development is considered that it is consistent with the context and setting for the area.

2.6.2 Access, Transport & Traffic

The development is expected to potentially generate one (1) additional dwelling's worth of traffic. The local road network is suitable to accommodate this additional traffic without any required upgrades. Sufficient sight distance exists for driveways for both lots. The proposed development is not expected to have any adverse impact on access, transport and traffic.

2.6.3 Public Domain

The development is not expected to adversely impact on the public domain.

2.6.4 Utilities

The development would require connection to existing water and sewerage services in the adjacent road reserves. There are no known issues with capacity.

Conditions

- Condition connection to water and sewerage infrastructure.

2.6.5 Heritage

Aboriginal Heritage

A search of the AHIMS register has not identified that any:

- Aboriginal sites have recorded in or near the searched location; or
- Aboriginal places have been declared in or near the searched location.

European Heritage

The site is not listed as being a local heritage item under the LEP or listed on the state heritage register.

Conditions

- It is however recommended that a condition be imposed requiring works to cease and OEH to be contacted should any items suspected of being Aboriginal in origin discovered during works.

2.6.6 Water

Stormwater

Stormwater is to be disposed of on to the street drainage system.

Conditions

Nil required.

2.6.7 Flora & Fauna

Not expected to significantly adversely affect any flora, fauna or their habitats.

2.6.8 Natural Hazards

2.6.8.1 Bushfire

The site is not mapped as being bushfire prone.

2.6.8.2 Flooding

The site is mapped as being within the Flood Planning Area of the LEP maps.

Hydraulic Categorisation

The site is not mapped as being within a Floodway. It is mapped as being with the Flood Storage Area.

Hazard Category

The site is mapped as Hazard Category H3, which is within the acceptable hazard level (i.e. ≤ H4) for residential development. Construction elements of future dwellings would be required to be designed to withstand velocities.

Risk to Life

The site is located within an area subject to an acceptable level of risk.

Egress routes are generally located with an acceptable level of risk.

Flood Behaviour Impacts

The flood modelling undertaken assumes full development of R1 zoned land.

The proposed development would not impact on flood behaviour.

Conclusion

It is considered that the site is suitable for subdivision and can each lot can support a future dwelling without unreasonable risk to or from flooding.

2.6.9 Safety, Security & Crime Prevention

The proposed development is not expected to have an adverse impact on safety, security or crime prevention.

2.6.10 Social Impacts in the Locality

No adverse social impacts expected in the locality

2.6.11 Economic Impacts in the Locality

No adverse economic impacts expected in the locality.

2.6.12 Construction

Conditions

Appropriate standard conditions to imposed on the approval to manage any potential adverse impacts from construction of the associated infrastructure.

2.6.13 Cumulative Impacts

The proposed development is not expected to result in any adverse cumulative impacts.

2.7 Suitability of the Site for the Development

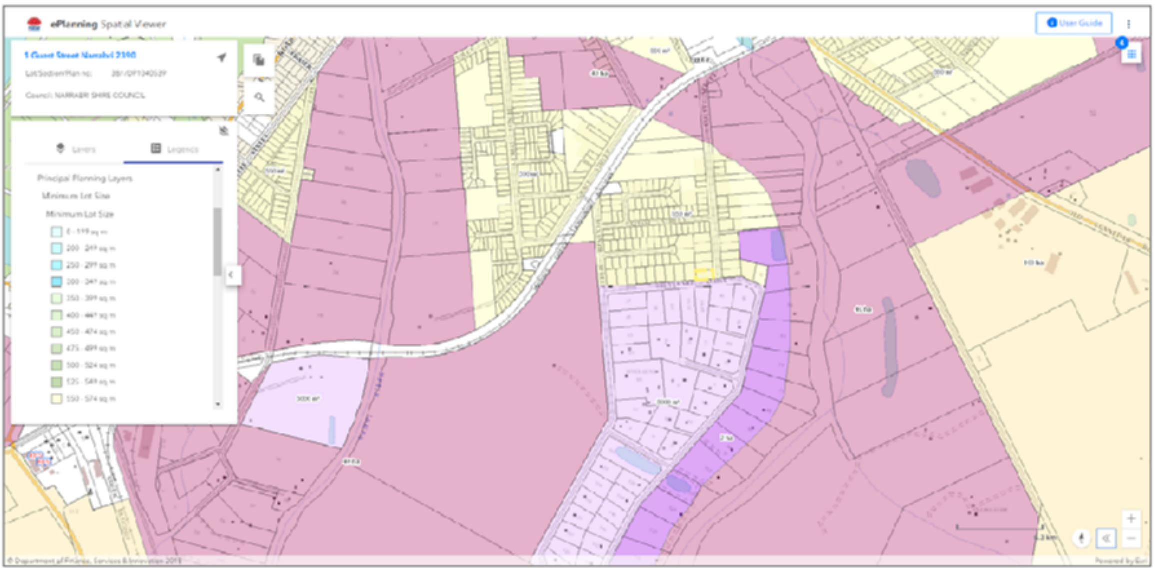
The site is considered suitable for the proposed development.

2.8 Submissions

Two (2) submissions have been received in response to the notification of the development. Both submissions raised the following issues. The applicant has provided a response to the issue which Council has reviewed. Considering both, Council provides the following response to each issue:

1. Dividing of this block is not in keeping with the amenity of the estate which "Riverbend" was designed; being that land lots at Riverbend were larger to allow for distance and room between neighbours and keeping a country feel with ease of living.

Response: Council's planning framework consisting of the Local Environmental Plan (**LEP**) and Development Control Plans (**DCP**) establishes the controls which development within an area must adhere to. These controls guide the development density of an area. There are lots to the south of the site that are larger (i.e. 5,000m²), however the site and the land to the north have a minimum lot size of 550m² (refer **Figure 9**). The proposed development is consistent with the planning controls for the site.



Source: (NSW Government)

Figure 9: LEP Minimum Lot Size

2 Almost all lots in this area are already built on under the understanding that lots would not be reduced and houses not be built close to other neighbours.

Response: The proposed development is consistent with the planning controls for the site which permits lots of $500m^2$ or greater in size. The proposed lots are quite a bit larger (approximately $346m^2$ or 62%) than the minimum required.

3. Houses in the estate on both street frontages for this area (Riverside Drive & Guest Street), are already set back from the roadside to a standard and consistent setback. Dividing this lot will mean that there will not be the required allowable room for dwellings to build; without being right on the boundary; if the dwellings are set back to the same required distance as other dwellings in the street to keep the attractiveness of the street appeal. This then means that these blocks will have dwellings built closer to the road, detracting from the designed look and amenity of the estate.

should council resolve to approve the application for the subdivision of the land into two lots, as a means of ensuring a consistent streetscape and maintaining the existing building line in Riverside Drive (north side) and Guest Street (western side); I request that council consider imposing a condition on the developer in the form of a Section S8B/covenant requiring that building envelopes be imposed on each allotment to ensure the consistency of the building line, and hence the streetscape and amenity is maintained.

Response: Any future development on the lots will be required to comply with the applicable planning controls, including setbacks. It is considered that sufficient area will exist on each proposed lot to accommodate a future dwelling that will comply with the planning controls, including setback requirements. The smaller lots will actually assist in achieving the objectives of the zone, by providing for a variety of housing types and densities.

4. The sewage system design for this estate is not designed for the division of lots and was only has an allowable tolerance for oversupply. This oversupply may have already been used due to the division of other blocks, in the later stages of the south of the estate, outbound of this development application. Have been made aware by the developer, that there were limited lots that were allowable to have multiple dwellings on them and this is not one of those lots.

Response: Council's Engineers have advised that the sewerage system is not at capacity and can handle the additional volume. In fact it will actually provide a benefit by assisting with the pressure in the line and moving the waste before it turns septic.

5. This development will directly affect the safety of all other landowners in the estate, on the grounds that the extra footprint of the extra dwelling for the second lot, will change the effectiveness of the current flood study and place further potential risk of flooding on existing landowners.

Response: The flood study has considered full development of all residential zoned lots. It is not considered that the subdivision would result in future development that will change the effectiveness of the current flood study or place additional risk of flooding on existing land owners.

6. As there will be limited room for a dwelling to be built on lot 382, my driveway will be impacted by any potential driveway on the riverside drive frontage of this block.

Response: Any future driveway will require approval from Council (as the roads authority) to ensure its location is appropriate.

2.9 The Public Interest

The development is considered to be in the public interest.

3 Other Matters for Consideration

3.1 Biodiversity Conservation Act 2016

3.1.1 Introduction

The *Biodiversity Conservation Act 2016* (BC) contains a number of matters that are required to be considered as part of a DA. These are outlined below.

3.1.2 Likely to significantly affect threatened species

The first consideration is whether the development is likely to significantly affect threatened species (s7.2 BC Act). There are three considerations to determine this:

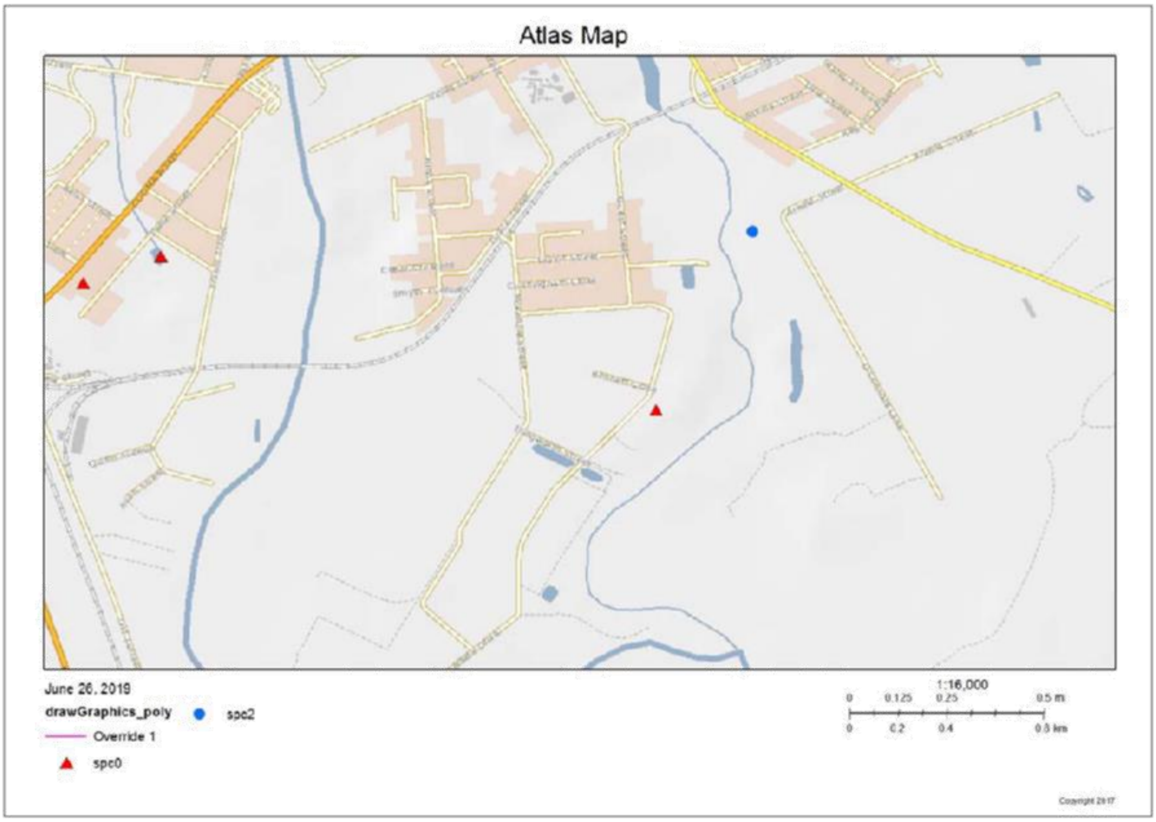
1. Is the development likely to significantly affect threatened species or ecological communities, or their habitats, according to the test in section 7.3?
2. Does the development exceed the biodiversity offsets scheme threshold if the biodiversity offsets scheme applies to the impacts of the development on biodiversity values?
3. Is the development to be carried out in a declared area of outstanding biodiversity value?

Each of these considerations are addressed below.

Likely to significantly affect threatened species or ecological communities, or their habitats (7.3 Test)

A search of BioNet Public Report of all Valid Records of Threatened (listed on TSC Act 1995) or Commonwealth listed Entities in selected area [North: -30.29 West: 149.73 East: 149.83 South: -30.39] returned a total of 26 records of 15 species. **Figure 10** provides a map of the search results. No records are located on the site or immediately surrounding the site.

Given the highly disturbed nature of the site, it is not expected that the development would significantly affect threatened species or ecological communities, or their habitats.



Source: (NSW Environment & Heritage)

Figure 10: BioNet Atlas Search

Biodiversity Offsets Scheme (BOS) Threshold

A proposed development exceeds the BOS threshold for the purposes of Part 7 of the BC Act if it is or involves:

- the clearing of native vegetation of an area declared by clause 7.2 as exceeding the threshold, or
- the clearing of native vegetation, or other action prescribed by clause 6.1, on land included on the Biodiversity Values Map published under clause 7.3.

Clearing Threshold

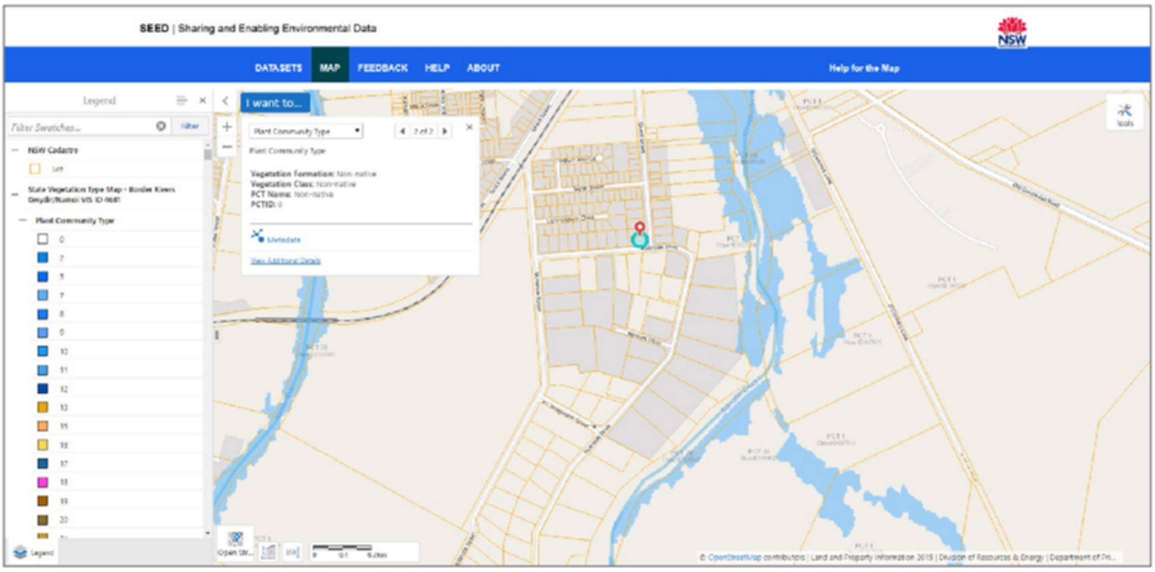
The site has a minimum lot size (MLS) of 550m² under the Narrabri LEP.

Table 4: Clearing Thresholds

Minimum lot size of land	Area of clearing
Less than 1 hectare	0.25 hectare or more
Less than 40 hectares but not less than 1 hectare	0.5 hectare or more
Less than 1,000 hectares but not less than 40 hectares	1 hectare or more
1,000 hectares or more	2 hectares or more

Source: Clause 7.2 of BC Regulation 2017

Based on the MLS, the applicable clearing threshold for the development site is 0.25 hectares.



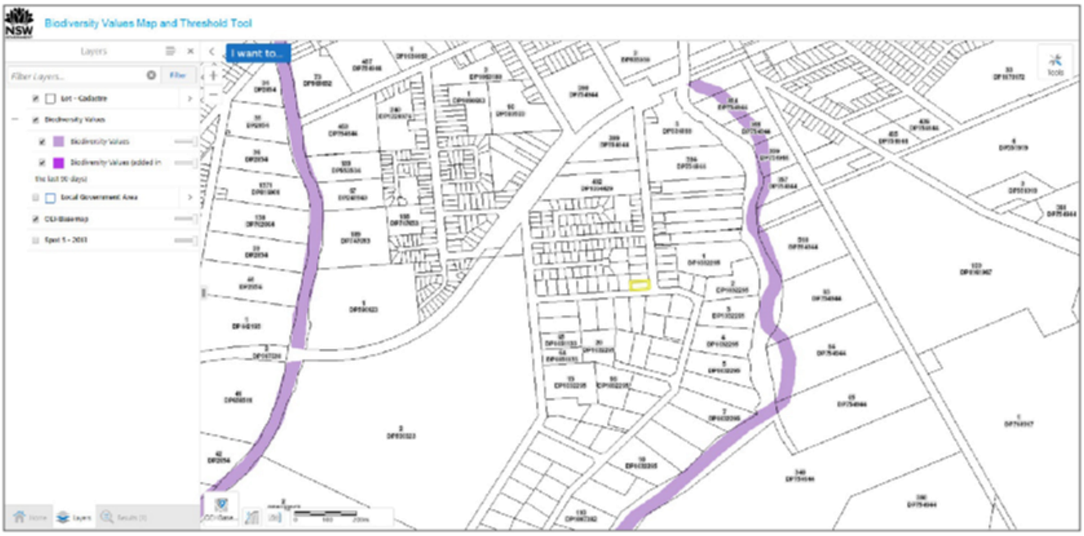
Source: (NSW Government)

Figure 11: Plant Community Types – State Vegetation Map

The site affected by the development footprint is mapped as non-native (refer **Figure 11**). Based on this, the assessment concluded that the proposal would not trigger the area threshold of ≥ 1.0ha.

Biodiversity Values Map

As shown in **Figure 12**, the site is not mapped as being on the Biodiversity Values Map.



Source: (NSW Department of Planning and Environment)

Figure 12: Biodiversity Values Map

Declared Area of Outstanding Biodiversity Value (AOBV)

Areas of declared critical habitat under the Threatened Species Conservation Act 1995 have become the first AOBVs in NSW with the commencement of the Biodiversity Conservation Act. The Critical habitat declarations in NSW are (NSW Office of Environment & Heritage):

- • Gould's Petrel - critical habitat declaration (PDF 1.45MB)

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- • Little penguin population in Sydney's North Harbour - critical habitat declaration
- • Mitchell's Rainforest Snail in Stotts Island Nature Reserve - critical habitat declaration
- • Wollemi Pine - critical habitat declaration (PDF 2.21MB)

The site is not known to be an AOBV.

3.1.3 Biodiversity Development Assessment Report (BDAR)

A BDAR is to be submitted with all DAs that are likely to significantly affect threatened species. As outlined in **Section 3.1.2**, the development is **not** likely to significantly affect threatened species. Therefore a BDAR is not required for this DA.

4 Conclusion

4.1 Recommendation

It is recommended that DA 2019/46 be approved subject to the draft conditions contained in Attachment 2.

Erika Dawson

Signature of Assessing Officer

Erika Dawson

Name of Assessing Officer

7 August 2019

Date assessment completed

4.2 Peer Review

I, the undersigned, have sighted and reviewed the Section 79c Assessment Report, Site Inspection Report, Draft Development Consent and File and the following comments have been made:

Consent may only be granted once the peer review officer has signed below.

Planning Officer (approval sighted, conditions checked)	**Building Officer** (approval sighted, conditions checked)
______________________________ (Name)	______________________________ (Name)

Appendix A – DA Document Requirements

Requirement			Yes	No	N/A
1	**Information to be included in development application**				
(1)	A development application must contain the following information:				
	(a)	the name and address of the applicant,	☒	☐	☐
	(b)	a description of the development to be carried out,	☒	☐	☐
	(c)	the address, and formal particulars of title, of the land on which the development is to be carried out,	☒	☐	☐
	(d)	an indication as to whether the land is, or is part of, critical habitat,	☐	☒	☐
	(e)	an indication as to whether the development is likely to significantly affect threatened species, populations or ecological communities, or their habitats, unless the development is taken to be development that is not likely to have such an effect because it is biodiversity compliant development,	☐	☒	☐
	(ea)	for biodiversity compliant development, an indication of the reason why the development is biodiversity compliant development,	☐	☐	☒
	(f)	a list of any authorities from which concurrence must be obtained before the development may lawfully be carried out or from which concurrence would have been required but for section 4.13 (2A) or 4.41,	☐	☒	☐
	(f1)	in the case of an application that is accompanied by a biodiversity development assessment report, the reasonable steps taken to obtain the like-for-like biodiversity credits required to be retired under the report to offset the residual impacts on biodiversity values if different biodiversity credits are proposed to be used as offsets in accordance with the variation rules under the Biodiversity Conservation Act 2016,	☐	☐	☒
	(f2)	if the land is subject to a private land conservation agreement under the Biodiversity Conservation Act 2016, a description of the kind of agreement and the area to which it applies,	☐	☐	☒
	(g)	a list of any approvals of the kind referred to in section 4.46 (1) of the Act that must be obtained before the development may lawfully be carried out,	☐	☐	☒
	(g1)	in the case of State significant development, a list of any authorisations that must be provided under section 4.42 of the Act in relation to the development,	☐	☐	☒
	(h)	the estimated cost of the development,	☒	☐	☐
	(h1)	in the case of State significant development, the capital investment value of the development,	☐	☐	☐
	(i)	evidence that the owner of the land on which the development is to be carried out consents to the application, but only if the application is made by a person other than the owner and the owner's consent is required by this Regulation,	☒	☐	☐
	(j)	a list of the documents accompanying the application.	☒	☐	☐
2	**Documents to accompany development application**				
(1)	A development application must be accompanied by the following documents:				
	(a)	a site plan of the land,	☒	☐	☐
	(b)	a sketch of the development,	☒	☐	☐
	(c)	a statement of environmental effects (in the case of development other than designated development or State significant development),	☒	☐	☐
	(d)	in the case of development that involves the erection of a building, an A4 plan of the building that indicates its height and external configuration, as erected, in relation to its site (as referred to in clause 56 of this Regulation),	☐	☐	☐

Requirement		Yes	No	N/A
(e)	an environmental impact statement (in the case of designated development or State significant development),	☐	☐	☒
(f)	a species impact statement (in the case of land that is, or is part of, critical habitat or development that is likely to significantly affect threatened species, populations or ecological communities, or their habitats), but not if the development application is for State significant development,	☐	☐	☒
(g)	if the development involves any subdivision work, preliminary engineering drawings of the work to be carried out,	☐	☐	☒
(h)	if an environmental planning instrument requires arrangements for any matter to have been made before development consent may be granted (such as arrangements for the provision of utility services), documentary evidence that such arrangements have been made,	☐	☐	☒
(i)	if the development involves a change of use of a building (other than a dwelling-house or a building or structure that is ancillary to a dwelling-house and other than a temporary structure): (i) a list of the Category 1 fire safety provisions that currently apply to the existing building, and (ii) a list of the Category 1 fire safety provisions that are to apply to the building following its change of use,	☐	☐	☒
(j)	if the development involves building work to alter, expand or rebuild an existing building, a scaled plan of the existing building,	☐	☐	☒
(k)	if the land is within a wilderness area and is the subject of a wilderness protection agreement or conservation agreement within the meaning of the Wilderness Act 1987, a copy of the consent of the Minister for the Environment to the carrying out of the development,	☐	☐	☒
(k1)	in the case of development comprising mining for coal (within the meaning of section 380AA of the Mining Act 1992)—documentary evidence that the applicant holds an authority under the Mining Act 1992 in respect of coal and the land concerned or has the written consent of the holder of such an authority to make the development application,	☐	☐	☒
(l)	in the case of development to which clause 2A applies, such other documents as any BASIX certificate for the development requires to accompany the application,	☐	☐	☒
(m)	in the case of BASIX optional development—if the development application is accompanied by a BASIX certificate or BASIX certificates (despite there being no obligation under clause 2A for it to be so accompanied), such other documents as any BASIX certificate for the development requires to accompany the application,	☐	☐	☒
(n)	if the development involves the erection of a temporary structure, the following documents: (i) documentation that specifies the live and dead loads the temporary structure is designed to meet, (ii) a list of any proposed fire safety measures to be provided in connection with the use of the temporary structure, (iii) in the case of a temporary structure proposed to be used as an entertainment venue—a statement as to how the performance requirements of Part B1 and NSW Part H102 of Volume One of the Building Code of Australia are to be complied with (if an alternative solution, to meet the performance requirements, is to be used), (iv) documentation describing any accredited building product or system sought to be relied on for the purposes of section 4.15 (4) of the Act, (v) copies of any compliance certificates to be relied on,	☐	☐	☒

Requirement	Yes	No	N/A
(o) in the case of a development involving the use of a building as an entertainment venue or a function centre, pub, registered club or restaurant—a statement that specifies the maximum number of persons proposed to occupy, at any one time, that part of the building to which the use applies.	☐	☐	☐
(2) The site plan referred to in subclause (1) (a) must indicate the following matters: (a) the location, boundary dimensions, site area and north point of the land, (b) existing vegetation and trees on the land, (c) the location and uses of existing buildings on the land, (d) existing levels of the land in relation to buildings and roads, (e) the location and uses of buildings on sites adjoining the land.	☒	☐	☐
(3) The sketch referred to in subclause (1) (b) must indicate the following matters: (a) the location of any proposed buildings or works (including extensions or additions to existing buildings or works) in relation to the land's boundaries and adjoining development, (b) floor plans of any proposed buildings showing layout, partitioning, room sizes and intended uses of each part of the building, (c) elevations and sections showing proposed external finishes and heights of any proposed buildings (other than temporary structures), (c1) elevations and sections showing heights of any proposed temporary structures and the materials of which any such structures are proposed to be made (using the abbreviations set out in clause 7 of this Schedule), (d) proposed finished levels of the land in relation to existing and proposed buildings and roads, (e) proposed parking arrangements, entry and exit points for vehicles, and provision for movement of vehicles within the site (including dimensions where appropriate), (f) proposed landscaping and treatment of the land (indicating plant types and their height and maturity), (g) proposed methods of draining the land, (h) in the case of development to which clause 2A applies, such other matters as any BASIX certificate for the development requires to be included on the sketch, (i) in the case of BASIX optional development—if the development application is accompanied by a BASIX certificate or BASIX certificates (despite there being no obligation under clause 2A for it to be so accompanied), such other matters as any BASIX certificate for the development requires to be included on the sketch.	☒	☐	☐
(4) A statement of environmental effects referred to in subclause (1) (c) must indicate the following matters: (a) the environmental impacts of the development, (b) how the environmental impacts of the development have been identified, (c) the steps to be taken to protect the environment or to lessen the expected harm to the environment, (d) any matters required to be indicated by any guidelines issued by the Planning Secretary for the purposes of this clause.	☒	☐	☐
(5) In addition, a statement of environmental effects referred to in subclause (1) (c) or an environmental impact statement in respect of State significant development must include the following, if the development application relates to residential apartment development to which State Environmental Planning Policy No 65—Design Quality of Residential Apartment Development applies: (a) an explanation of how: (i) the design quality principles are addressed in the development, and (ii) in terms of the Apartment Design Guide, the objectives of that guide have been achieved in the development,	☐	☐	☒

Requirement	Yes	No	N/A
(b) drawings of the proposed development in the context of surrounding development, including the streetscape, (c) development compliance with building heights, building height planes, setbacks and building envelope controls (if applicable) marked on plans, sections and elevations, (d) drawings of the proposed landscape area, including species selected and materials to be used, presented in the context of the proposed building or buildings, and the surrounding development and its context, (e) if the proposed development is within an area in which the built form is changing, statements of the existing and likely future contexts, (f) photomontages of the proposed development in the context of surrounding development, (g) a sample board of the proposed materials and colours of the facade, (h) detailed sections of proposed facades, (i) if appropriate, a model that includes the context.			
(5A) The species impact statement referred to in subclause (1) (f) is not required in relation to the effect of the development on any threatened species, populations or ecological communities, or their habitats, if the development is taken to be development that is not likely to significantly affect those threatened species, populations or ecological communities, or their habitats, because it is biodiversity compliant development.	☐	☐	☒
(6) In the case of development to which clause 2A applies, the explanation referred to in subclause (5) (a) need not deal with the design quality principles referred to in that paragraph to the extent to which they aim: (a) to reduce consumption of mains-supplied potable water, or reduce emissions of greenhouse gases, in the use of the building or in the use of the land on which the building is situated, or (b) to improve the thermal performance of the building.	☐	☐	☒
2A BASIX certificate required for certain development			
(1) In addition to the documents required by clause 2, a development application for any BASIX affected development must also be accompanied by a BASIX certificate or BASIX certificates for the development, being a BASIX certificate or BASIX certificates that has or have been issued no earlier than 3 months before the date on which the application is made. (2) If the proposed development involves the alteration, enlargement or extension of a BASIX affected building that contains more than one dwelling, a separate BASIX certificate is required for each dwelling concerned.	☐	☐	☒

Appendix 2 – Draft Conditions

Appendix 3 – Local Development Performance Monitoring Checklist

(To be filled out by Assessing Officer at time of Approval)

DA Number: DA77/2019
Assessing Officer: Erika Dawson

1.	**Concurrence:**	☐ Yes ☒ No
2.	**Section 4.55 Category (modification):**	☒ Not Relevant ☐ Other Section 96 ☐ Minor Error or Misdescription ☐ Minimal Environmental impact ☐ Other Modification
3.	**Private Assessment:**	☒ Yes ☐ No
4.	**Use of Independent Hearing and Assessment Panel (IHAP):**	☐ Yes ☒ No
5.	**Pre DA Meeting Held:**	☐ Yes ☒ No
6.	**Change of Use:**	☐ Yes ☒ No
7.	**Number of Submissions:**	Two (2)
8.	**Integrated/Designated/Local:**	☐ Designated ☐ Integrated/Designated ☐ Integrated ☒ Local
9.	**Appeal Arbitrator Decision:** ***if No, go to Q.13***	☐ Yes ☒ No
10.	**Date Planning Arbitrator Appointed:**	
11.	**Date Determined by Planning Arbitrator:**	
12.	**Planning Arbitrator Decision:**	☐ Approved ☐ Refused ☐ Withdrawn/Cancelled
13.	**Codes SEPP for CDC:**	☐ SEPP ☐ Council Control