

OURIMBAH CREEK FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN -

EXECUTIVE SUMMARY



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STUDY OBJECTIVE

The main objective of this report is to identify floodplain risk, analyse floodplain strategies for the management of risk and to put forward priorities and approximate costed recommendations in regards to flood risk mitigation in the catchment.

CATCHMENT DESCRIPTION

The Ourimbah Creek catchment is located on the Central Coast of NSW, approximately 90km north of Sydney. Covering a total area of 160 km², the majority of the catchment is contained in the Wyong Shire Local Government Area (LGA), with 8 km² of the catchment contained in the Gosford City LGA to the south. In 2016 the two councils were combined into the Central Coast Council.

Ourimbah Creek generally flows in an easterly direction through state forest and rural properties before passing beneath the Pacific Motorway and Pacific Highway near Palmdale. It continues to flow in a northern and then easterly direction before passing beneath the Main Northern Railway Line and Wyong Road and eventually discharging into Tuggerah Lake at Chittaway Point. The catchment also incorporates a number of significant tributaries that are typically situated east of the Pacific Motorway and Pacific Highway. These include Bangalow Creek, Cut Rock Creek, Chittaway Creek, Dog Trap Gully, Canada Drop Down Creek and Kangy Angy Creek.

The Ourimbah Creek catchment west of the Pacific Motorway is typically characterised by state forest and rural land uses. The catchment area on the eastern side of the Pacific Motorway is significantly more developed and incorporates a range of residential, commercial, industrial and rural land uses. A number of major transportation links also extend across the eastern section of the catchment including the Main Northern Railway, Pacific Highway and Motorway, Wyong Road, Enterprise Drive and Chittaway Road.

FLOODING DOWNSTREAM OF WYONG ROAD

Downstream of Wyong Road the predominant cause of flooding is due to elevated levels in Tuggerah Lakes (as occurred in February 1990 and June 2007). Management measures for this area have previously been investigated in the 2014 Tuggerah Lakes Floodplain Risk Management Study and Plan and have not been considered further in this report.

PAST STUDIES

A number of past studies have looked at flooding in Ourimbah Creek. The latest being the 2013 Ourimbah Creek Flood Study. Possible management measures have also been examined in some of these past studies.

STAKEHOLDER AND COMMUNITY CONSULTATION

Throughout this study there has been consultation with the key stakeholders as well as with the community through the floodplain management committee, newsletters, questionnaires and

workshops.

EXISTING FLOOD PROBLEM

Flooding has been experienced in the catchment since prior to the 1970's and the more recent February 1990 and June 2007 events typify the nature of the problem. Whilst few urban areas are affected and general less than 10 residential floors inundated (note for the area upstream of Wyong Road and thus not affected by elevated levels in Tuggerah Lakes) the key issues are inconvenience and road access issues. The latter is significant as cars being washed away in floods are one of the main rescue activities undertaken by the SES and in Australia results in the main cause of death in floods. In a 10% AEP event 13 house floors are inundated and in the 1% AEP 34. However in the PMF over 500 houses will be inundated above floor.

Recent developments on the fringe of the floodplain have placed further pressure on the flood problem and in particular at the University of Newcastle, Ourimbah campus where inundation of student vehicles has occurred as well as raising risk to life issues with student access.

PREVIOUS FLOOD MITIGATION MEASURES UNDERTAKEN

The most significant works undertaken by the then Gosford City Council was creek re-alignment and stabilisation in the reach from the Pacific Highway to Teralba Street at Lisarow. Retarding basins were also constructed in the upper catchment to minimise the effects of urbanisation.

Both the former Wyong and Gosford Councils also adopted many property and response modification measures to address the issue.

POSSIBLE FLOODPLAIN MANAGEMENT MEASURES

Management measures can be subdivided into flood modification (changes the nature of flooding), property modification (change to the property) or response modification (changes the response of people) measures as summarised below.

Flood Modification	Property Modification	Response Modification
Levees	Land zoning	Community awareness
Temporary defences	Voluntary purchase	Flood warning
Channel construction	Building & development controls	Evacuation planning
Channel modification	Flood proofing	Evacuation access
Major structure modification	House raising	Flood plan / recovery plan
Drainage network modification	Flood access	
Drainage maintenance		
Retarding basins		

Each possible measure has to be investigated considering the positive and negative social, economic, hydraulic and environmental effects (refer Figure 1 (a to j)). As a result many measures are eliminated.

All flood modification measures investigated in detail are listed below:

- Option FM1 – East Chittaway Point Levee (Section 9.2.1.1);
- Option FM2 – Bangalow Creek Levees (Section 9.2.1.2);

- Option FM3 – Mill Street Industrial Area Levee (Section 9.2.1.3);
- Option FM4 – University Lower Carpark Levee (Section 9.2.1.4);
- Option FM5 – University Lower Carpark Filling (Section 9.2.1.5);
- Option FM6 – Canntree Road Levee (Section 9.2.1.6);
- Option FM7 – Tuggerah Business Park Levee and Railway Levee Survey and Maintenance (Section 9.2.1.7);
- Option FM8 – Baileys Road Diversion Channel (Section 9.2.3.1);
- Option FM9 – Lees Bridge Widening (Section 9.2.5.1);
- Option FM10 – Footts Road Weir Removal (Section 9.2.5.2);
- Option FM11 – Upstream Pacific Motorway Vegetation Management Area (Section 9.2.6.1);
- Option FM12 – Sohier Park Vegetation Management Area (Section 9.2.6.2);
- Option FM13 – Cut Rock Creek Basin (Section 9.2.7.1);
- Option FM14 – Combined Channel and Basin (Section 9.2.8).

The following roads have been investigated for flood access improvements:

- Option RM1 – Tuggerah Street at the Pacific Highway (Section 9.3.1.1);
- Option RM2 – Tuggerah Street and Cutrock Road near Plum Park (Section 9.3.1.2);
- Option RM3 – Coachwood Drive North of Mahogany Close (Section 9.3.1.3);
- Option RM4 – The Boulevard at the University of Newcastle Ourimbah Campus (Section 9.3.1.4);
- Option RM5 – Chittaway Road near Burns Road (Section 9.3.1.5);
- Option RM6 – Howes Road, Link Road (Section 9.3.1.6);
- Option RM7 – Orchard Road, Link Road (Section 9.3.1.7);
- Option RM8 – Tall Timbers, Link Road (Section 9.3.1.8);
- Option RM9 – Burns Road Bridge (Section 9.3.1.9);
- Option RM10 – Burns Road Raising and Culvert Upgrades (Section 9.3.1.10);
- Option RM11 – Elmo Street near Footts Road (Section 9.3.1.11);
- Option RM12 – Tapley Road (Section 9.3.1.12);
- Option RM13 – Macdonalds Road near Indigo Place (Section 9.3.1.13);
- Option RM14 – Pacific Highway at Dog Trap Gully (Section 9.3.1.14).

In addition the following other response modification measures have been evaluated:

- Automatic Road Closures and Boom Gates (Option RM15) (Section 9.3.2.1);
- Warning Signs (Option RM16 and RM17) (Section 9.3.2.2);
- Camera Fines (Option RM18) (Section 9.3.2.3);
- Potential Gauges for Flood Warning (Options RM19 and RM20) (Section 9.3.3.2);
- Opportunities for Increasing Available Warning Time (Options RM21 and RM22) (Section 9.3.3.6);
- Opportunities for Reducing Required Warning Time (Options RM23 and RM24) (Section 9.3.3.7);
- Shelter-in-place Feasibility Assessment (Option RM25) (Section 9.3.3.8);
- Flood Emergency Management Planning (Options RM26, RM27, RM28) (Section 9.3.4);
- Create a SES Flood Intelligence Card for Lees Bridge (Option RM29) (Section 9.3.4.3);

- Emergency Response Plans (Options RM30 and RM31) (Section 9.3.4.4);
- Community Flood Education (Option RM32) (Section 9.3.5).

The following specific property measures have been assessed:

- House Raising (Option PM1) (Section 9.4.1);
- Voluntary Purchase (Option PM2) (Section 9.4.2);
- Land Use Zoning (Option PM3) (Section 9.4.4);
- Changes to Planning Policy (Option PM4) (Section 9.4.7).

In addition Council requested the following specific objectives for flood prone areas, identified as part of the Flood Study to be investigated in this report (these are labelled as Brief Specific Objectives on Figure 1a to Figure 1j):

1. Cut Rock Creek between Pacific Highway and Teralba Street (Option FM14, see Section 9.2.8);
2. Pluim Park (improved flood access, see Section 9.3.1.1);
3. Tall Timbers Estate (improved flood access, see Section 9.3.1.8);
4. Sohier Park (improved flood access, see Section 9.3.1);
5. Turpentine, Ourimbah and Orchard Roads Kangy Angy (improved flood access, see Section 9.3.1.7);
6. Howes Road (improved flood access, see Section 9.3.1.6);
7. Chittaway Point (house raising, see Section 9.4.1);
8. University of Newcastle Ourimbah Campus. Issues include; access and evacuation (improved flood access, see Section 9.3.1), possible early flood warning system (see Section 9.3.3.3), flooding of lower car parking areas (see Option FM4 and FM5, Section 9.2.1.4 and 9.2.1.5);
9. Burns Road (improved flood access and road closures, see Section 9.3.1 and 9.3.2);
10. Assessment of existing levees (see Section 6.5).

1. OURIMBAH CREEK FLOODPLAIN RISK MANAGEMENT PLAN

1.1. Introduction

The Ourimbah Creek Floodplain Risk Management Plan has been prepared for the Central Coast Council in accordance with the NSW Government's *Floodplain Development Manual* 2005 (Reference 1) and:

- *Is based on a comprehensive and detailed evaluation of factors that affect and are affected by the use of flood prone land;*
- *Represents the considered opinion of the local community on how to best manage its flood risk and its flood prone land; and*
- *Provides a long-term path for the future development of the community.*

The Ourimbah Creek catchment is located on the Central Coast of NSW, approximately 90km north of Sydney. Covering a total area of 160 km², the majority of the catchment is contained in the Wyong Shire Local Government Area (LGA), with 8 km² of the catchment contained in the Gosford City LGA to the south. In 2016 the two councils were combined into the Central Coast Council.

Flooding has been recorded periodically since the 1930's but there are many more recorded instances of flooding in Tuggerah Lakes. It is possible that the incidence of flooding has historically been under reported along Ourimbah Creek and its tributaries. In recent times there have been two significant events, in February 1990 and June 2007. In both these events there was extensive flooding in the Newcastle, Lake Macquarie and Wyong/Gosford regions. Flooding causes significant hardship, including both tangible and intangible damages, to the community and for this reason the Central Coast Council has undertaken a program of studies to address the management of the flood problem in accordance with the NSW Government's *Floodplain Development Manual* 2005 (Reference 1).

1.2. Risk Management Measures Considered

A matrix of possible management measures was prepared and evaluated in this Floodplain Risk Management Study taking into account a range of parameters. This process eliminated a number of flood risk management measures (refer Section 9) including flood mitigation dams, additional retarding basins and voluntary purchase of all flood liable buildings. The use of on-site stormwater detention as a flood mitigation measure, as opposed to its use for mitigating the effects of urbanisation was also eliminated.

The full range of measures was evaluated and the outcomes are summarised in Table 1. Table 2 details the matrix scoring system and Table 3 provides the matrix results which ranks the management measures considered.

Community opinion on the full range of options has been canvassed during the public exhibition period. However, it should be noted that these outcomes may change in the future if climate change induced rainfall increases become significant.

Table 1: Summary of Management Measures Investigated in Study

MEASURE	PURPOSE	COMMENT
FLOOD MODIFICATION:		
ON-SITE DETENTION (Section 9.1)	Decrease effects of increased urbanisation.	<ul style="list-style-type: none"> On-site detention or retarding basins are suitable measures to mitigate the potential increase in peak flow on downstream reaches as rural areas become urbanised. Smaller on-site detention can help water quality and local drainage, but has little impact along the main tributaries.
LEVEES AND FILLING (Section 9.2.1)	Prevent or reduce the frequency of flooding of protected areas.	<ul style="list-style-type: none"> Levees are suitable on large river systems where they can protect a number of buildings. May cause local drainage problems and be unacceptable to the community due to restriction of waterfront access and views. Levees will still be overtopped in major flood events and for this reason flood planning controls will still apply to areas protected by levees. Specific sites have been investigated.
CHANNEL CONSTRUCTION / FLOODWAYS (Section 9.2.3)	To channel floodwaters away from affected areas and so reduce flood levels.	<ul style="list-style-type: none"> The creation of floodways can provide an effective means of diverting floodwaters away from affected areas and thus reducing flood levels. There are no practical areas where a floodway could be created due to existing development.
CHANNEL MODIFICATIONS (Section 9.2.4)	To increase the capacity of the channel and so reduce flood levels upstream.	<ul style="list-style-type: none"> The hydraulic capacity of the channel and floodplain can be increased by straightening of the channel, widening or removal of vegetation along the banks. However, such measures can often increase flood risk downstream. These measures are costly to undertake and generally require on going maintenance, have significant environmental impacts, are not an ecologically sustainable measure and are thus rarely used.
REMOVAL OF HYDRAULIC RESTRICTIONS (Section 9.2.5)	To increase the capacity of the channel and so reduce flood levels upstream.	<ul style="list-style-type: none"> The hydraulic capacity of the channel and floodplain can be increased by removal of significant hydraulic restrictions such as narrow culverts or low level bridges or even minimising the potential for blockage. However, such measures can often increase flood risk downstream. The larger measures (widen culverts or replace a bridge) are generally costly to undertake. Reducing the potential for blockage through regular maintenance is supported. No location was identified which would provide a significant reduction in above floor inundation

MEASURE	PURPOSE	COMMENT
		upstream.
DRAINAGE MAINTENANCE (9.2.6)	Maintenance of the drainage network is important to ensure it is operating with maximum efficiency and to reduce the risk of blockage or failure and may involve removing unwanted vegetation and other debris.	<ul style="list-style-type: none"> Is an on going issue for Council. Is not an environmentally sustainable management measures. May have significant environmental implications.
FLOOD MITIGATION DAMS, RETARDING BASINS (Section 9.2.7)	Reduce the peak flow from the catchment into Ourimbah Creek and its tributaries by increasing the volume of flood storage in the catchment.	<ul style="list-style-type: none"> The size of storages required to make a difference to large creeks such as Ourimbah Creek are very large, making them impractical on environmental, social and economic grounds.
RESPONSE MODIFICATION:		
IMPROVED FLOOD ACCESS (Section 9.3.1)	To ensure safe and reliable access during times of flood.	<ul style="list-style-type: none"> There is a significant existing problem and 14 locations were investigated. Elimination of the flood hazard cannot be eliminated. Measures have been proposed to reduce the hazard at a number of locations.
ROAD CLOSURES AND NOTIFICATIONS (Section 9.3.2)	To reduce the risk to life of vehicles entering flood waters.	<ul style="list-style-type: none"> A number of measures are possible. Further investigation and liaison with RMS is required to determine the most appropriate and viable measures.
FLOOD WARNING (Section 9.3.3)	Enable people to prepare and evacuate, to reduce damages to property and injury to persons.	<ul style="list-style-type: none"> Relatively short warning time makes it impossible to provide a fail safe warning system. Any system will provide some additional warning. Installation of water level gauges is supported.
FLOOD EMERGENCY PLANNING (Section 9.3.4)	Effective planning for emergency response is a vital way of reducing risk to life and property.	<ul style="list-style-type: none"> The cost to undertake this measure is small and will provide a high benefit/cost ratio. A range of measures are provided and supported.
COMMUNITY FLOOD EDUCATION (Section 9.3.5)	Educate people to prepare themselves and their properties for floods, to minimise flood damages and reduce the risk.	<ul style="list-style-type: none"> A cheap and effective method but requires continued effort. Possible approaches are provided.
PROPERTY MODIFICATION:		
VOLUNTARY HOUSE RAISING	Prevent flooding of existing buildings by raising the floor	<ul style="list-style-type: none"> All flood damages will not be prevented and only suitable for non-brick buildings on piers.

MEASURE	PURPOSE	COMMENT
(Section 9.4.1)	level above the floodwaters.	<ul style="list-style-type: none"> Costs approximately \$80,000 per house but can vary considerably. Only suitable for a small number of houses (generally with floor levels first inundated in the 10% AEP (1 in 10 year)) or smaller events and not attractive to all residents. Should be investigated further for applicable properties.
VOLUNTARY PURCHASE OF INDIVIDUAL BUILDINGS (Section 9.4.2)	Purchase and removal of the most hazardous flood liable buildings to reduce risk to property and people.	<ul style="list-style-type: none"> High cost per property. Applicable for isolated, high hazard properties in flood liable areas. Progress applications for 6 existing properties on Mannings Road. Investigate scheme for Tall Timbers Estate.
FLOOD PROOFING (Section 9.4.3)	Prevent flooding of existing buildings by sealing all the entry points.	<ul style="list-style-type: none"> Generally only suitable for brick, slab on ground buildings. Less viable for residential buildings but should be considered for non residential buildings of slab on ground construction.
LAND USE ZONING (Section 9.4.4)	Reduce potential hazard and losses from flooding by appropriate land use planning.	<ul style="list-style-type: none"> Well-established processes are in place for dealing with land-use in flood hazard areas. Ourimbah Masterplan must address flooding.
FLOOD PLANNING LEVELS (Section 9.4.5)	Provides a development control measure for managing future flood risk and is derived from a combination of a flood event and a freeboard.	<ul style="list-style-type: none"> Recommended as the 1% AEP + 0.5m freeboard.
FLOOD PLANNING AREA (Section 9.4.6)	It is important to define the boundaries of the FPA to ensure flood related planning controls are applied where necessary and not to those lots unaffected by flood risk.	<ul style="list-style-type: none"> Review undertaken and consistent with best practice.
CHANGES TO PLANNING POLICY (Section 9.4.7)	Appropriate planning restrictions which ensure that development is compatible with flood risk can significantly reduce flood damages.	<ul style="list-style-type: none"> Council should apply further controls in some areas. Flood mapping should take into consideration the findings of the Flood Study and this FRMS&P.
MODIFICATION TO THE S10.7 CERTIFICATE (Section 9.4.8)	S10.7 certificates should clearly inform owners and purchasers of risks, planning controls and policies that apply to the subject land.	<ul style="list-style-type: none"> Council should continue to review flood related information on the Section 10.7 Certificate to bring it in line with the findings of the Flood Study and this FRMS&P.

MEASURE	PURPOSE	COMMENT
OTHER MANAGEMENT MEASURES		
FLOOD INSURANCE (Section 9.5)	To spread the risk of individual financial loss across the whole community through insuring against flood damage.	<ul style="list-style-type: none"> Does not reduce damage, but spreads the cost. These issues are outside the scope of this present study. Flood insurance at an individual property level is encouraged for affected land owners, but is not an appropriate risk management measure as it does not reduce flood damages.. Insurance against storm surge, tidal inundation, and permanent inundation from sea level rise is not available.

1.2.1. Relative Merits of Management Measures

A number of methods are available for judging the relative merits of competing measures. The benefit/cost (B/C) approach has long been used to quantify the economic worth of each option enabling the ranking against similar projects in other areas. The benefit/cost ratio is the ratio of the net present worth (the total present value of a time series of cash flows) of the project over its life. It is a standard method for using the time value of money to compare the reduction in flood damages (benefit) with the capital and on going cost of the works. Generally the ratio expresses only the reduction in tangible damages as it is difficult to accurately include intangibles (such as anxiety, risk to life, ill health and other social and environmental effects).

The potential environmental or social impacts of any proposed flood mitigation measure must be considered in the assessment of any management measure and these cannot be evaluated using the classical B/C approach. For this reason a matrix type assessment has been used which enables a value (including non-economic worth) to be assigned to each measure. A multi-variate decision matrix was developed for the Ourimbah Creek area, allowing B/C estimates, community involvement in determining social and other intangible values, and assessment of environmental impacts.

1.2.2. Management Matrix

The criteria assigned a value in the management matrix are:

- impact on flood behaviour (reduction in flood level, hazard or hydraulic categorisation) over the range of flood events;
- number of properties benefited by measure;
- technical feasibility (design considerations, construction constraints, long-term performance);
- community acceptance and social impacts;
- economic merits (capital and recurring costs versus reduction in flood damages);
- financial feasibility to fund the measure;
- environmental and ecological benefits;
- impacts on the State Emergency Services;
- political and/or administrative issues;

- long-term performance given the likely impacts of climate change,
- risk to life.

The colour coded scoring system for the above criteria is provided in Table 2 and largely relates to the impacts in a 1% AEP event. Table 3 indicates the weighting assigned to each measure, however these may be adjusted in the light of community consultations and local conditions.

Table 2: Colour Coded Matrix Scoring System

	-3	-2	-1	0	1	2	3
Impact on Flood Behaviour	>100mm increase	50 to 100mm increase	<50mm increase	no change	<50mm decrease	50 to 100mm decrease	>100mm decrease
Number of Properties Benefitted	>5 adversely affected	2-5 adversely affected	<2 adversely affected	none	<2	2 to 5	>5
Technical Feasibility	major issues	moderate issues	minor issues	neutral	moderately straight forward	straight forward	no issues
Community Acceptance	majority against	most against	some against	neutral	minor	most	majority
Economic Merits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Financial Feasibility	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Environmental and Ecological Benefits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Impacts on SES	major disbenefit	moderate disbenefit	minor disbenefit	neutral	minor benefit	moderate benefit	major benefit
Political/administrative Issues	major negative	moderate negative	minor negative	neutral	few	very few	none
Long Term Performance	major disbenefit	moderate disbenefit	minor disbenefit	neutral	positive	good	excellent
Risk to Life	major increase	moderate increase	minor increase	neutral	minor benefit	moderate benefit	major benefit

Table 3: Matrix of Management Measures Investigated in Study

Ref	Option	Section in Study	Impact on Flood Behaviour	Number of Properties Benefited	Technical Feasibility	Community Acceptance	Economic Merits	Financial Feasibility	Environmental / Ecological Benefits	Impact on SES	Political / Admin Issues	Long Term Performance	Risk to Life	Total Score	Rank (Total)	Recommended
FM1	East Chittaway Point Levee	9.2.1.1	3	3	-3	1	-3	-3	0	2	1	3	3	7	29	
FM2	Bangalow Creek Levees	9.2.1.2	3	3	-2	-2	-3	-3	0	1	1	2	2	2	38	
FM3	Mill Street Industrial Area Levee	9.2.1.3	3	2	1	0	-2	-2	0	1	1	2	1	7	29	
FM4	University Lower Carpark Levee	9.2.1.4	3	0	-2	0	-3	-2	0	1	0	2	2	1	41	
FM5	University Lower Carpark Filling	9.2.1.5	3	0	1	0	-3	-1	-1	1	0	3	2	5	35	Yes
FM6	Canntree Road Levee	9.2.1.6	3	2	2	-1	-3	-3	0	1	-1	2	2	4	36	
FM7	Existing Levee Survey and Maintenance	9.2.1.7	0	0	3	3	3	3	0	2	3	3	3	23	4	Yes
FM8	Baileys Road Diversion Channel	9.2.3.1	1	2	-2	2	-3	-2	-1	0	-2	-1	0	-6	48	
FM9	Lees Bridge Widening	9.2.5.1	1	2	-2	0	-3	-2	0	0	-2	3	0	-3	44	
FM10	Footts Road Weir Removal	9.2.5.2	0	0	1	1	-3	-3	0	0	-1	3	0	-2	42	
FM11	Upstream Pacific Highway Vegetation Management	9.2.6.1	1	1	-2	2	-3	-3	-3	0	-2	-3	0	-12	49	
FM12	Sohier Park Vegetation Management	9.2.6.2	1	1	-2	2	-3	-3	-3	0	-2	-3	0	-12	49	
FM13	Cut Rock Creek Basin	9.2.7.1	1	1	-2	-1	-3	-3	1	0	0	2	0	-4	46	
FM14	Combination of Options FM8 and FM13	9.2.8	2	1	-2	-1	-3	-3	0	0	0	2	0	-4	46	
RM1	Improved access -Tuggerah Street at the Pacific Highway	9.3.1.1	0	3	3	3	0	1	0	3	0	3	3	19	11	Yes
RM2	Improved access -Tuggerah Street and Cutrock Road near Plum Park	9.3.1.2	0	3	-3	3	-3	-3	0	3	0	3	3	6	31	Yes
RM3	Improved access -Coachwood Drive North of Mahogany Close	9.3.1.3	0	3	1	3	-2	-3	0	3	0	3	3	11	25	Yes
RM4	Improved access -The Boulevard at the University of Newcastle Ourimbah Campus	9.3.1.4	0	1	-1	1	-3	-3	0	2	0	3	3	3	37	Yes
RM5	Improved access -Chittaway Road near Burns Road	9.3.1.5	0	3	-2	2	-3	-3	0	3	0	3	3	6	31	Yes
RM6	Improved access -Howes Road, Link Road	9.3.1.6	0	2	-2	3	0	1	0	3	0	3	3	13	24	Yes
RM7	Improved access -Orchard Road, Link Road	9.3.1.7	0	3	3	3	0	3	0	3	0	3	3	21	6	Yes
RM8	Improved access -Tall Timbers, Link Road	9.3.1.8	-1	3	0	3	-3	1	0	3	-2	3	3	10	26	Yes
RM9	Improved access -Burns Road Bridge	9.3.1.9	0	3	-3	3	-3	-3	0	3	0	3	3	6	31	Yes
RM10	Improved access -Burns Road Raising and Culvert Upgrades	9.3.1.10	0	3	-2	3	0	1	0	3	0	3	3	14	21	Yes
RM11	Improved access -Elmo Street near Footts Road	9.3.1.11	0	3	3	3	0	1	0	3	0	3	3	19	11	Yes
RM12	Improved access -Tapley Road	9.3.1.12	0	3	3	3	0	1	0	3	0	3	3	19	11	Yes
RM13	Improved access -Macdonalds Road near Indigo Place	9.3.1.13	0	3	3	3	0	1	0	3	0	3	3	19	11	Yes
RM14	Improved access -Pacific Highway at Dog Trap Gully	9.3.1.14	0	3	3	3	0	1	0	3	0	3	3	19	11	Yes
RM15	Automatic Road Closures and Boom Gates	9.3.2.1	0	3	3	2	1	1	0	2	1	1	2	16	19	Yes
RM16	Automatic Warning Signs and Depth Indicators	9.3.2.2	0	3	2	3	1	1	0	1	1	1	1	14	21	Yes
RM17	Early Notification and Road Closures	9.3.2.2	0	3	2	3	2	2	0	3	1	1	1	18	18	Yes
RM18	Camera Fines	9.3.2.3	0	3	-2	-1	-2	-1	0	0	-1	1	1	-2	42	Yes

Ref	Option	Section in Study	Impact on Flood Behaviour	Number of Properties Benefited	Technical Feasibility	Community Acceptance	Economic Merits	Financial Feasibility	Environmental / Ecological Benefits	Impact on SES	Political / Admin Issues	Long Term Performance	Risk to Life	Total Score	Rank (Total)	Recommended
RM19	Assessment of Feasibility of Gauge Use	9.3.3.2	0	3	2	3	2	2	0	0	2	1	1	16	19	Yes
RM20	Additional Gauges Recommended for Installation	9.3.3.2	0	3	3	3	2	2	0	3	2	1	0	19	11	Yes
RM21	Increasing Mobile Phone Reception	9.3.3.6	0	3	1	3	1	-2	0	2	2	3	1	14	21	
RM22	Provide Accessible Real-time Flood Information	9.3.3.6	0	3	2	2	2	3	0	1	2	3	1	19	11	
RM23	Flood Warning Messages	9.3.3.7	0	3	3	3	3	3	0	2	2	3	2	24	2	Yes
RM24	Telephone Dial-out System	9.3.3.7	0	3	3	3	3	3	0	3	2	3	2	25	1	Yes
RM25	Shelter-in-place Feasibility Assessment	9.3.3.8	0	3	1	2	0	3	0	0	-2	3	0	10	26	Yes
RM26	Updating of Wyong and Gosford LFPs	9.3.4	0	3	3	3	3	3	0	1	1	3	1	21	6	Yes
RM27	Relocation of Wyong Evacuation Centre	9.3.4.1	0	0	1	3	-3	-2	0	3	1	3	0	6	31	Yes
RM28	Resourcing of Wyong and Gosford SES units	9.3.4	0	0	3	3	3	3	0	3	2	3	0	20	9	Yes
RM29	Create SES Flood Intelligence Card for Lees Bridge	9.3.4.3	0	3	3	3	3	3	0	3	3	3	0	24	2	Yes
RM30	Assist Key Floodplain Exposures to Create Emergency Response Plan	9.3.4.4	0	3	3	1	3	3	0	3	3	2	0	21	6	Yes
RM31	Assist Flood Affected Residents to Create Emergency Response Plan	9.3.4.4	0	3	3	2	3	3	0	2	2	1	1	20	9	Yes
RM32	Prepare Flood Education Program	9.3.5	0	3	3	3	3	3	0	3	3	1	1	23	4	Yes
PM1	House Raising	9.4.1	0	1	-1	2	-1	-2	0	0	1	1	1	2	38	Yes
PM2	Voluntary Purchase	9.4.2	0	1	-3	-1	-3	-3	0	3	-3	3	3	-3	44	Yes
PM3	Land Use Zoning	9.4.4	0	3	-2	-1	1	0	0	0	-2	3	0	2	38	Yes
PM4	Changes to Planning Policy	9.4.7	0	3	-1	0	2	1	0	0	-1	3	3	10	26	Yes

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1.3. Floodplain Risk Management Measures in Plan

The recommended measures are described in Table 4 according to the ranking in Table 3. However a high rank in Table 3 may not necessarily be a high priority measure for implementation as for example, funds may not be available and it will depend upon the ease of implementation (agreement between agencies, responsibility etc.).

Table 4: Recommended Management Measures in Plan

Option	Priority	Responsibility	Costing	Timeframe	Rank (Total)
Telephone Dial-out System	High	Council / SES	Low	Short Term	1
Flood Warning Messages	High	Council / SES	Low	Short Term	2
Create SES Flood Intelligence Card for Lees Bridge	High	SES	Low	Short Term	2
Existing Levee Survey and Maintenance	High	Council	Low	Short Term	4
Prepare Flood Education Program	High	Council / SES	Low	Short Term	4
Improved access -Orchard Road, Link Road	Low	Council / RMS	High	Long Term	6
Updating of Wyong and Gosford LFPs	High	Council	Low	Short Term	6
Assist Key Floodplain Exposures to Create Emergency Response Plan	High	Council / SES	Low	Short Term	6
Resourcing of Wyong and Gosford SES units	High	SES	Low	Short Term	9
Assist Flood Affected Residents to Create Emergency Response Plan	High	Council / SES	Low	Short Term	9
Improved access -Tuggerah Street at the Pacific Highway	Low	Council / RMS	High	Long Term	11
Improved access -Elmo Street near Footts Road	Low	Council / RMS	High	Long Term	11
Improved access -Tapley Road	Low	Council / RMS	High	Long Term	11
Improved access -Macdonalds Road near Indigo Place	Low	Council / RMS	High	Long Term	11
Improved access -Pacific Highway at Dog Trap Gully	Low	Council / RMS	High	Long Term	11
Additional Gauges Recommended for Installation	High	Council	Low	Short Term	11
Early Notification and Road Closures	High	Council / RMS	Low	Short Term	18
Automatic Road Closures and Boom Gates	High	Council / RMS	Medium	Short Term	19
Assessment of Feasibility of Gauge Use	High	Council	Low	Short Term	19
Improved access -Burns Road Raising and Culvert Upgrades	Low	Council / RMS	High	Long Term	21
Automatic Warning Signs and Depth Indicators	High	Council / RMS	Medium	Short Term	21
Improved access -Howes Road, Link Road	Low	Council / RMS	High	Long Term	24
Improved access -Coachwood Drive North of Mahogany Close	Low	Council / RMS	High	Long Term	25
Improved access -Tall Timbers, Link Road	Low	Council / RMS	High	Long Term	26
Shelter-in-place Feasibility Assessment	Medium	Council / SES	Low	Short Term	26
Changes to Planning Policy	High	Council	Low	Short Term	26
Improved access -Tuggerah Street and Cutrock Road near Plum Park	Low	Council / RMS	High	Long Term	31
Improved access -Chittaway Road near Burns Road	Low	Council / RMS	High	Long Term	31

Option	Priority	Responsibility	Costing	Timeframe	Rank (Total)
Improved access -Burns Road Bridge	Low	Council / RMS	High	Long Term	31
Relocation of Wyong Evacuation Centre	Medium	Council / SES	Medium	Short Term	31
University Lower Carpark Filling	High	Council /Univ	High	Short Term	35
Improved access -The Boulevard at the University of Newcastle Ourimbah Campus	Medium	Council / RMS	High	Long Term	37
House Raising	Medium	Council / OEH	Medium	Long Term	38
Land Use Zoning	High	Council	Low	Short Term	38
Camera Fines	High	Council	Low	Short Term	42
Voluntary Purchase	Medium	Council / OEH	High	Long Term	44

Notes:

Costing: Low < \$40K, Medium \$40K to \$100K, High > \$100K

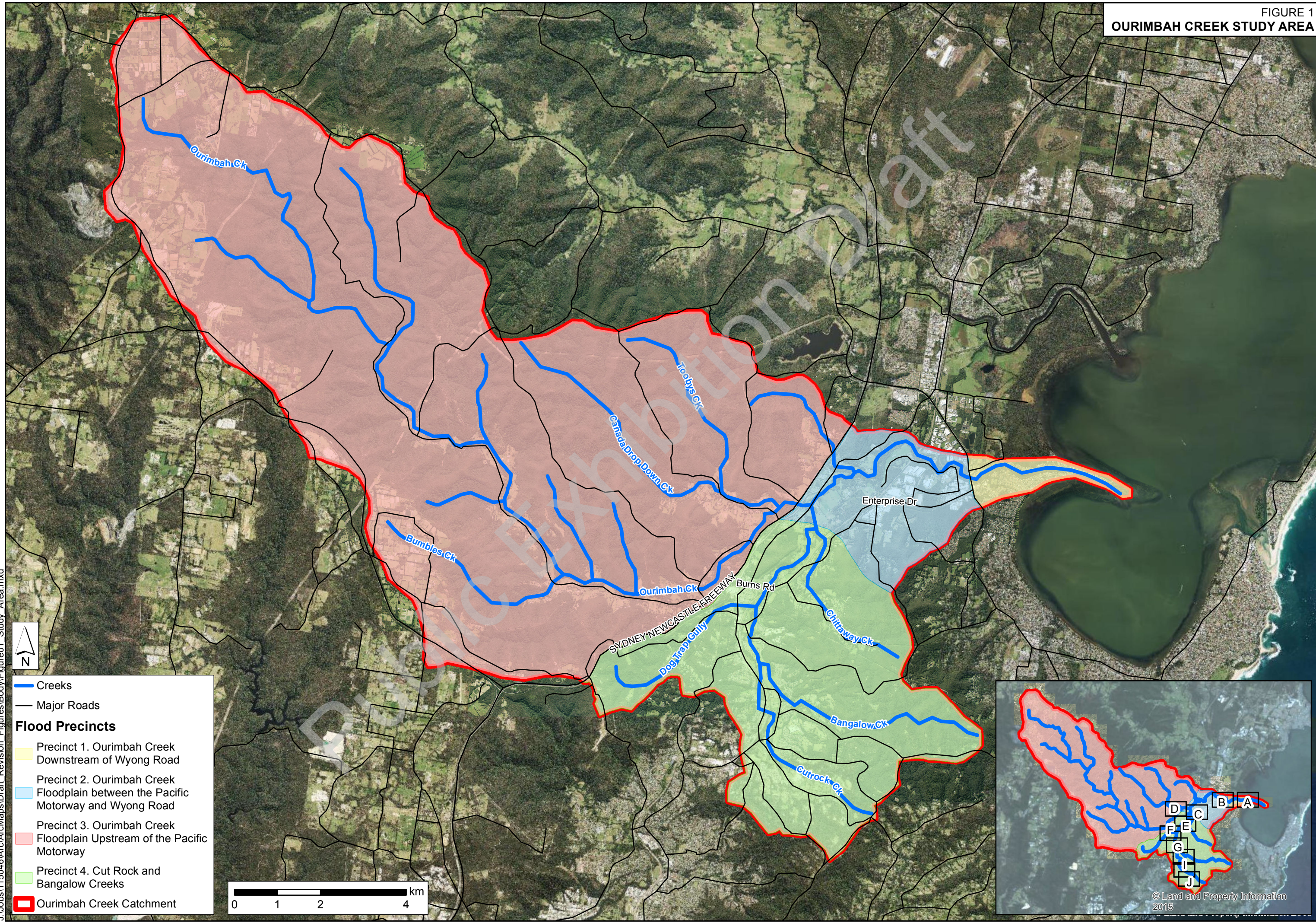
Timeframe: Short < 2 years, Long > 2 years

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Figures

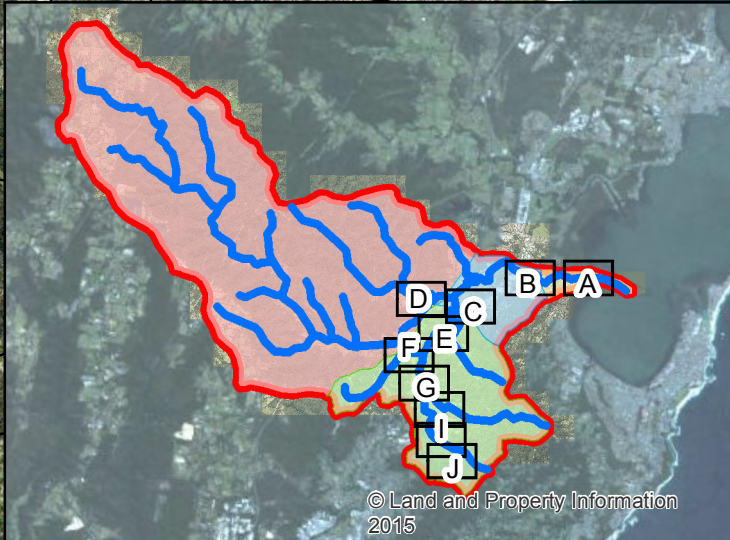
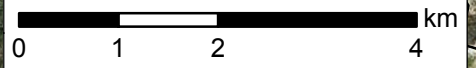
FIGURE 1
OURIMBAH CREEK STUDY AREA



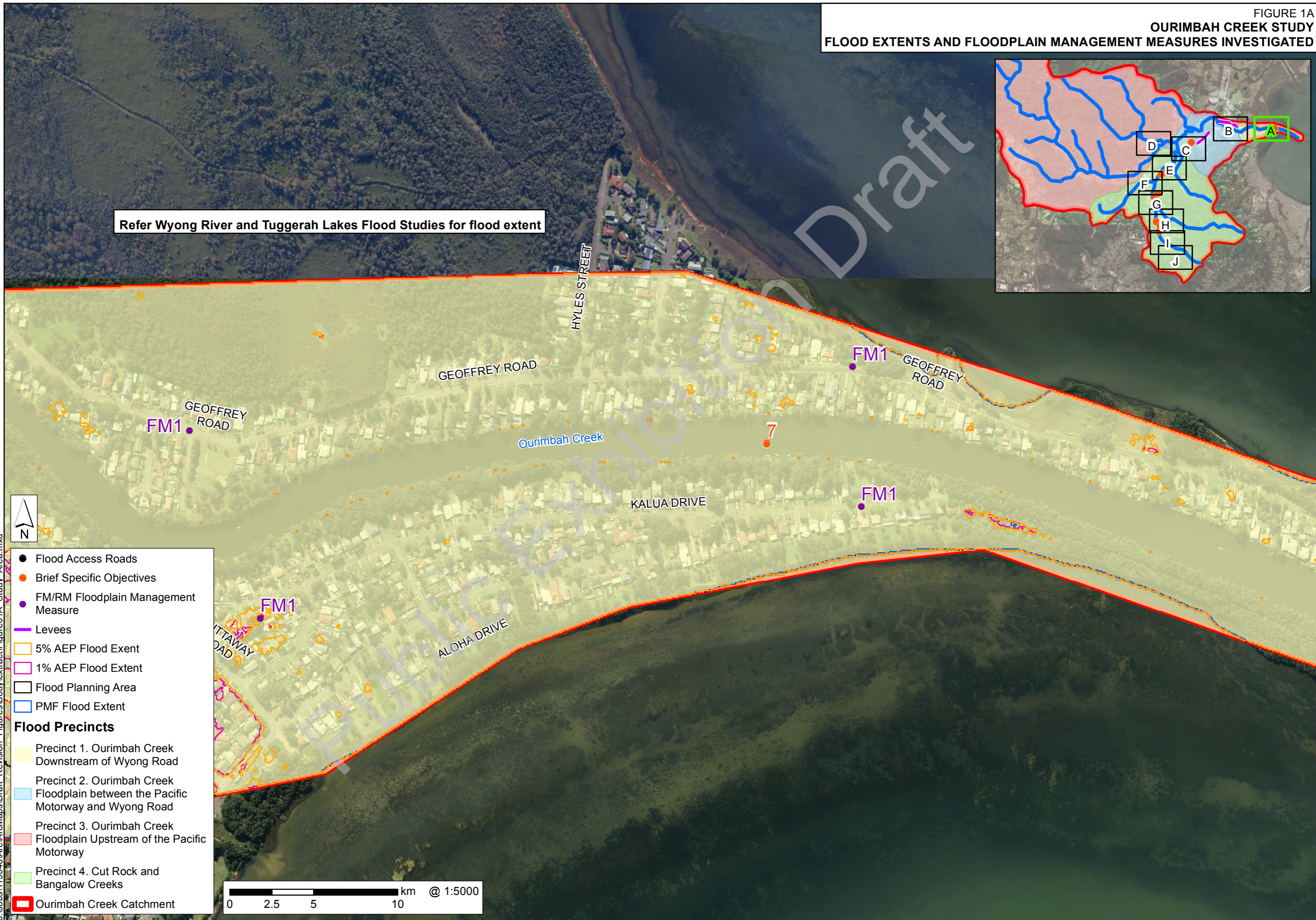
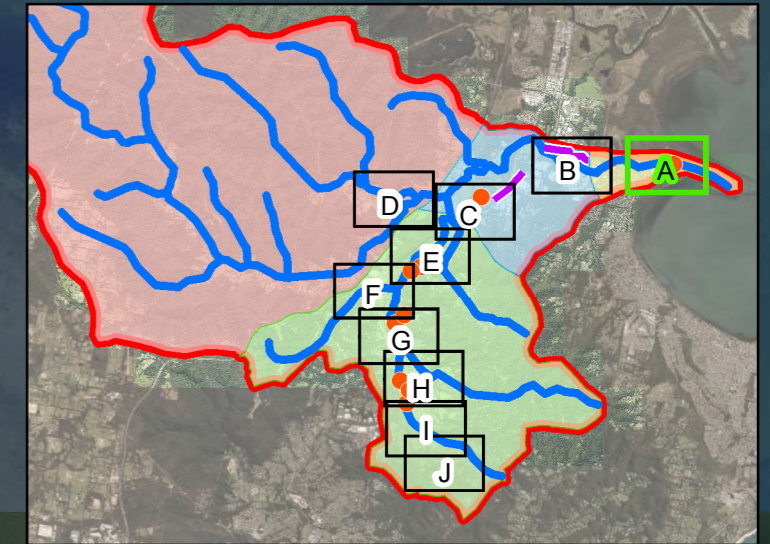
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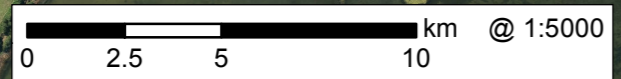
- Creeks
- Major Roads
- Flood Precincts**
- Precinct 1. Ourimbah Creek Downstream of Wyong Road
- Precinct 2. Ourimbah Creek Floodplain between the Pacific Motorway and Wyong Road
- Precinct 3. Ourimbah Creek Floodplain Upstream of the Pacific Motorway
- Precinct 4. Cut Rock and Bangalow Creeks
- Ourimbah Creek Catchment



Refer Wyong River and Tuggerah Lakes Flood Studies for flood extent

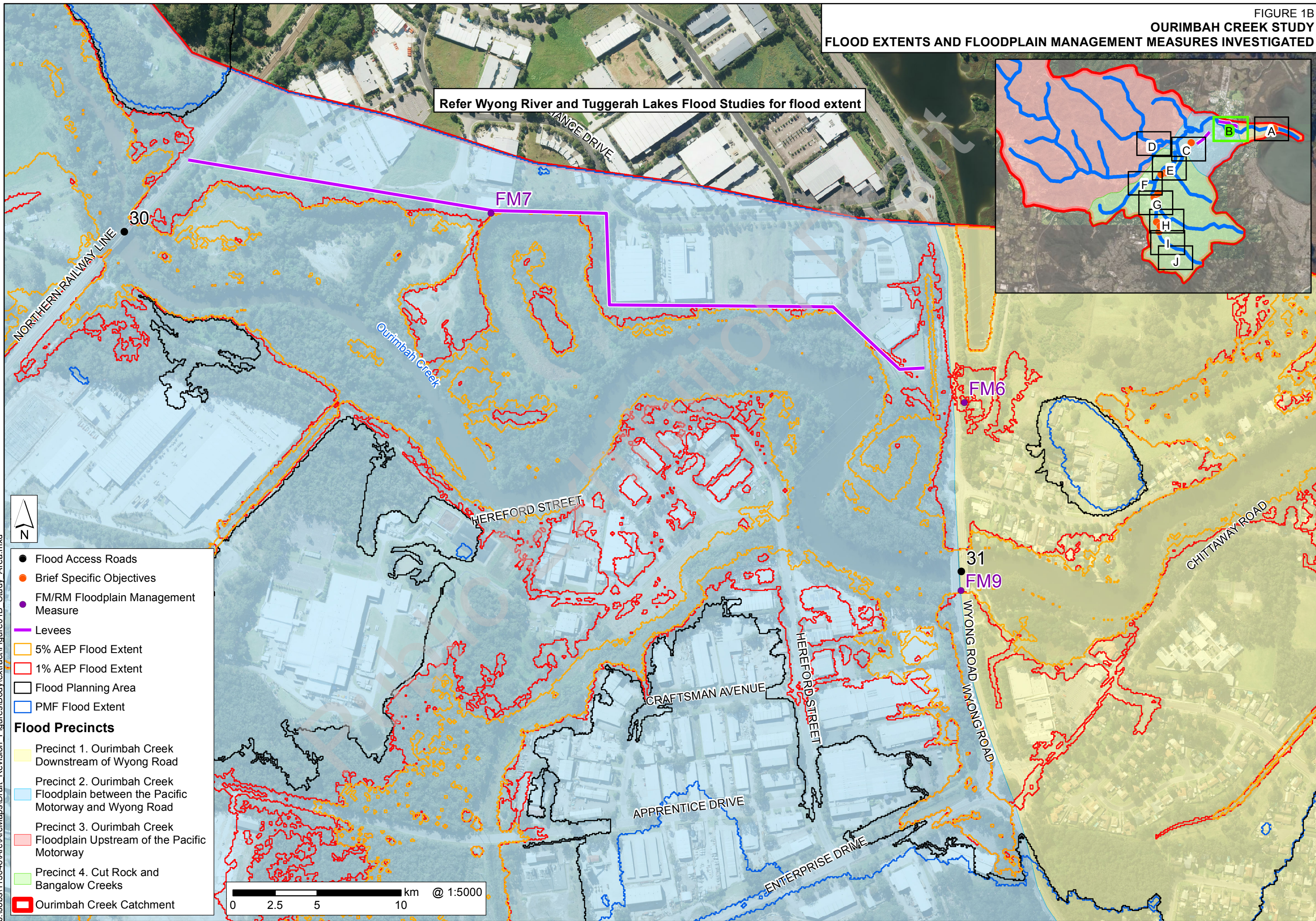
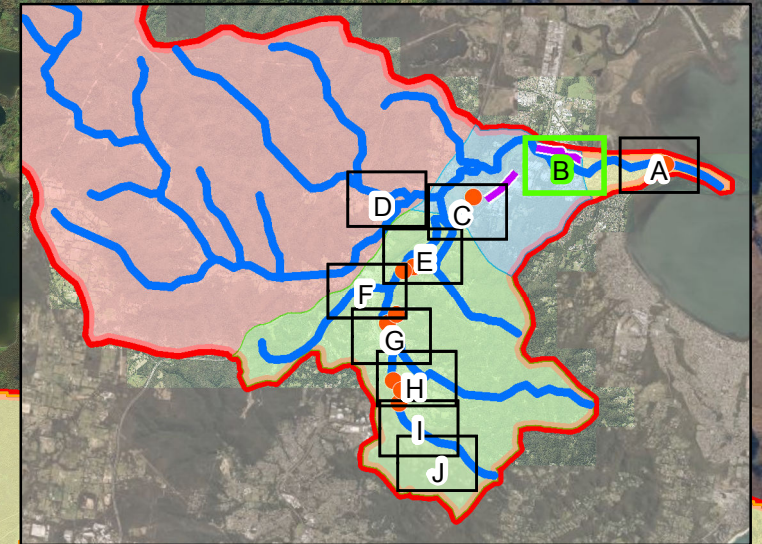


- Flood Access Roads
 - Brief Specific Objectives
 - FM/RM Floodplain Management Measure
 - Levees
 - 5% AEP Flood Extent
 - 1% AEP Flood Extent
 - Flood Planning Area
 - PMF Flood Extent
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 - Ourimbah Creek Catchment



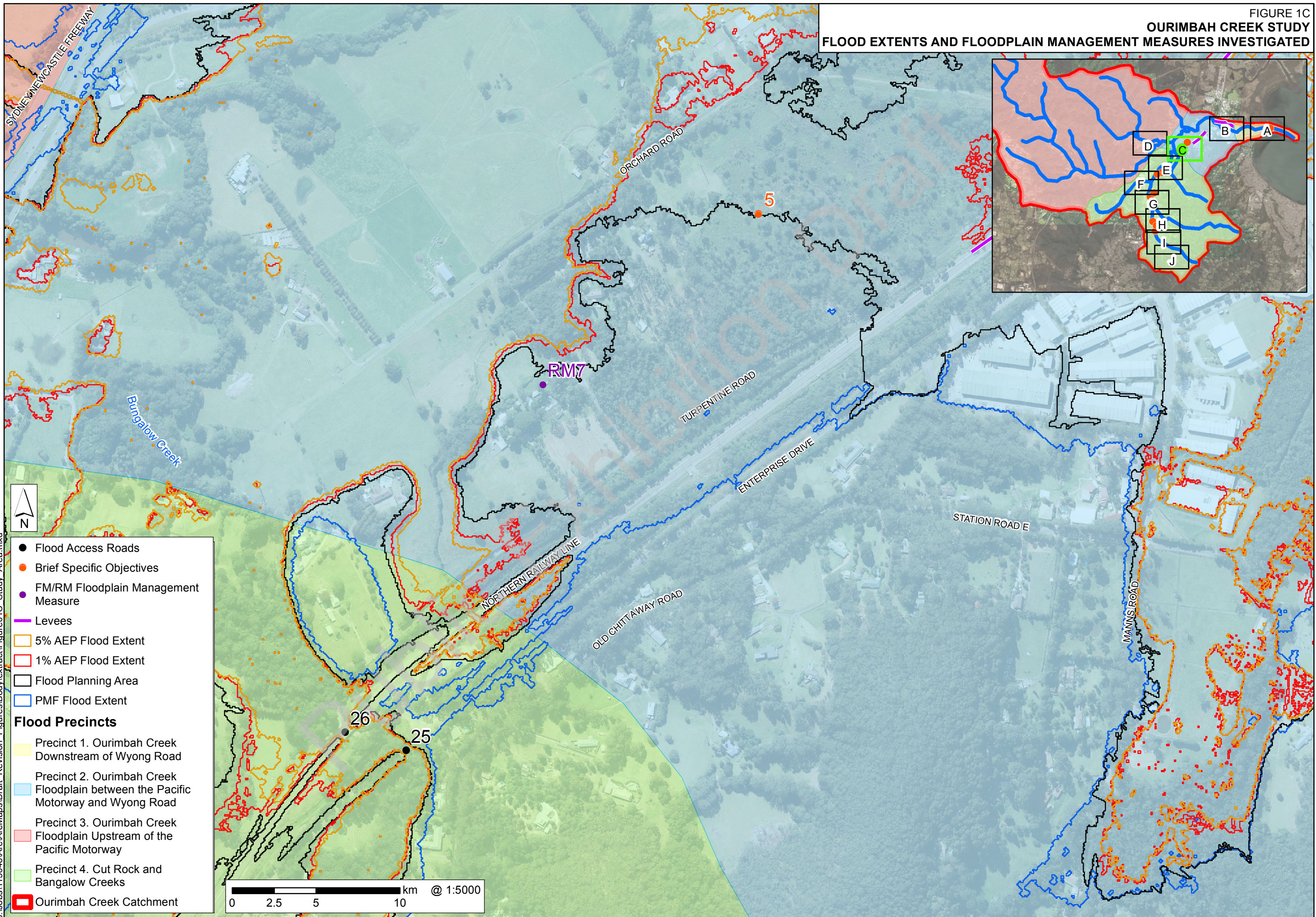
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Refer Wyong River and Tuggerah Lakes Flood Studies for flood extent

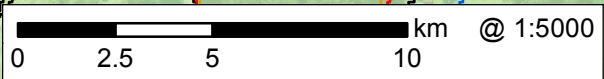


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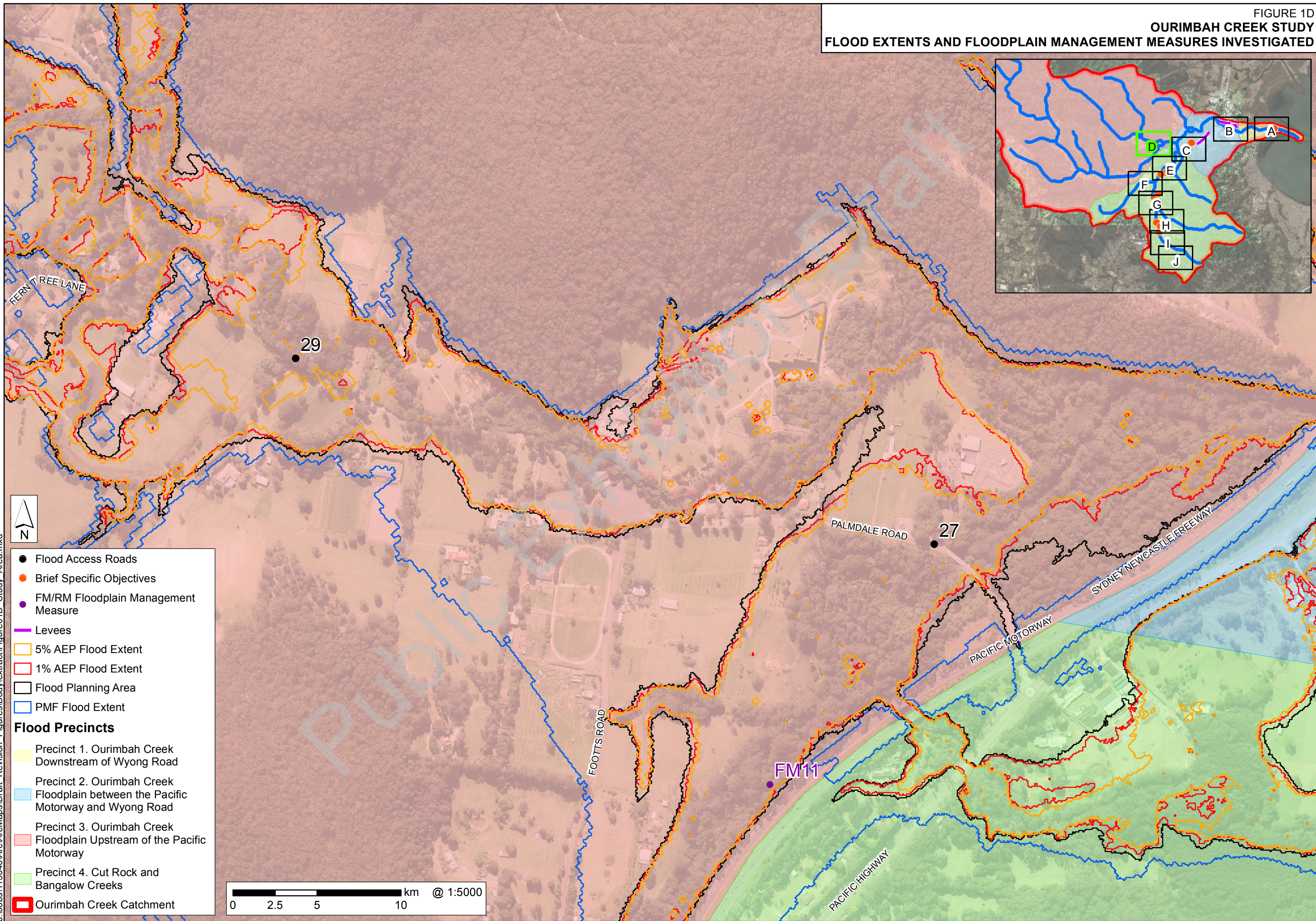
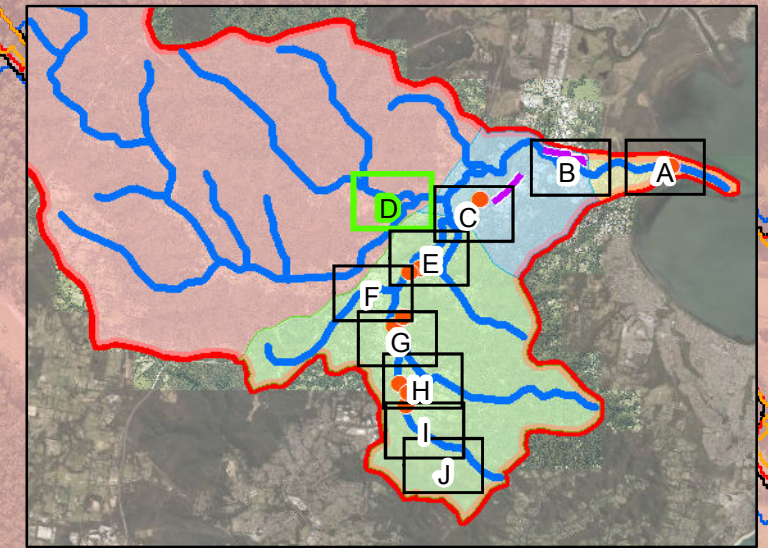




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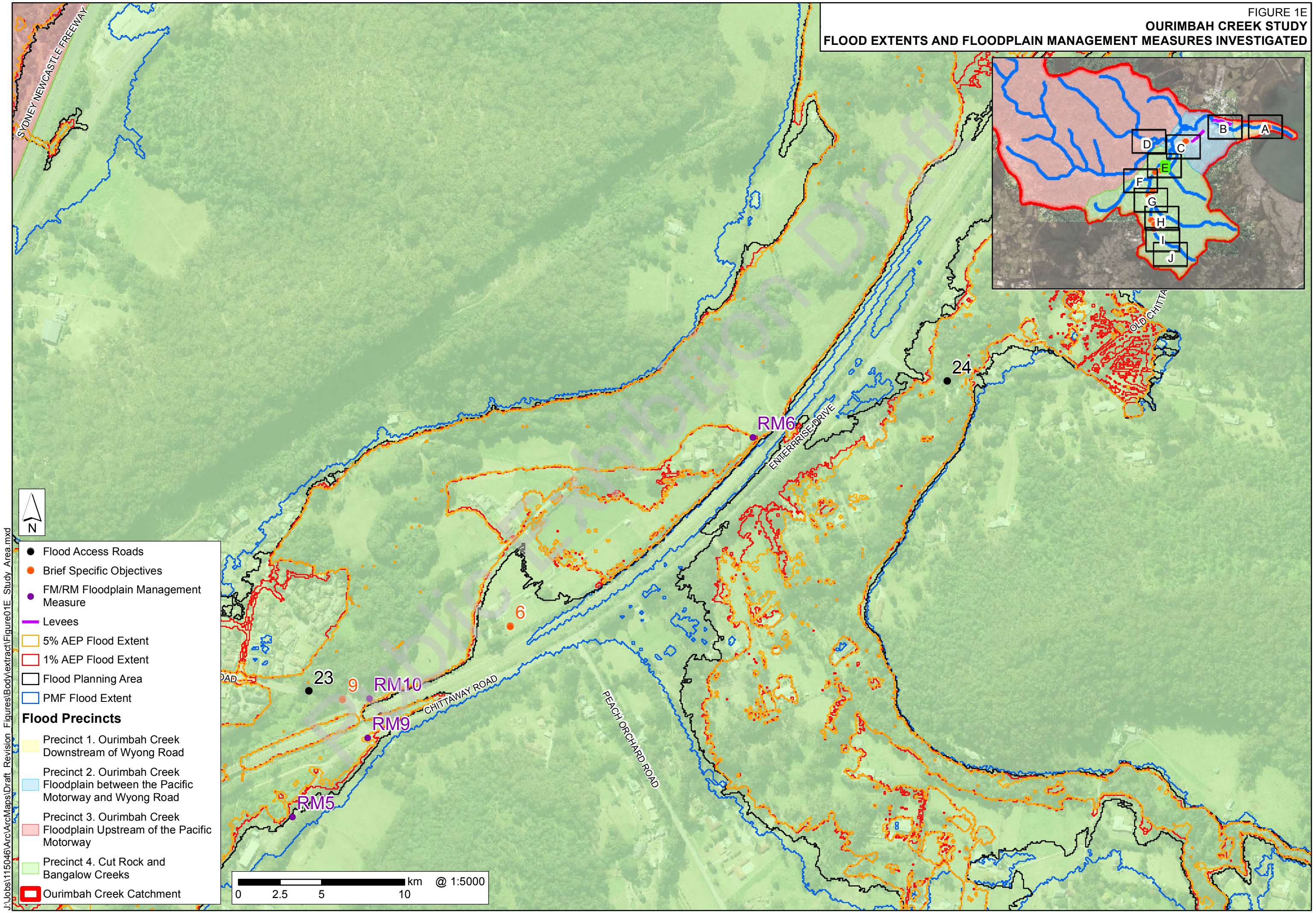
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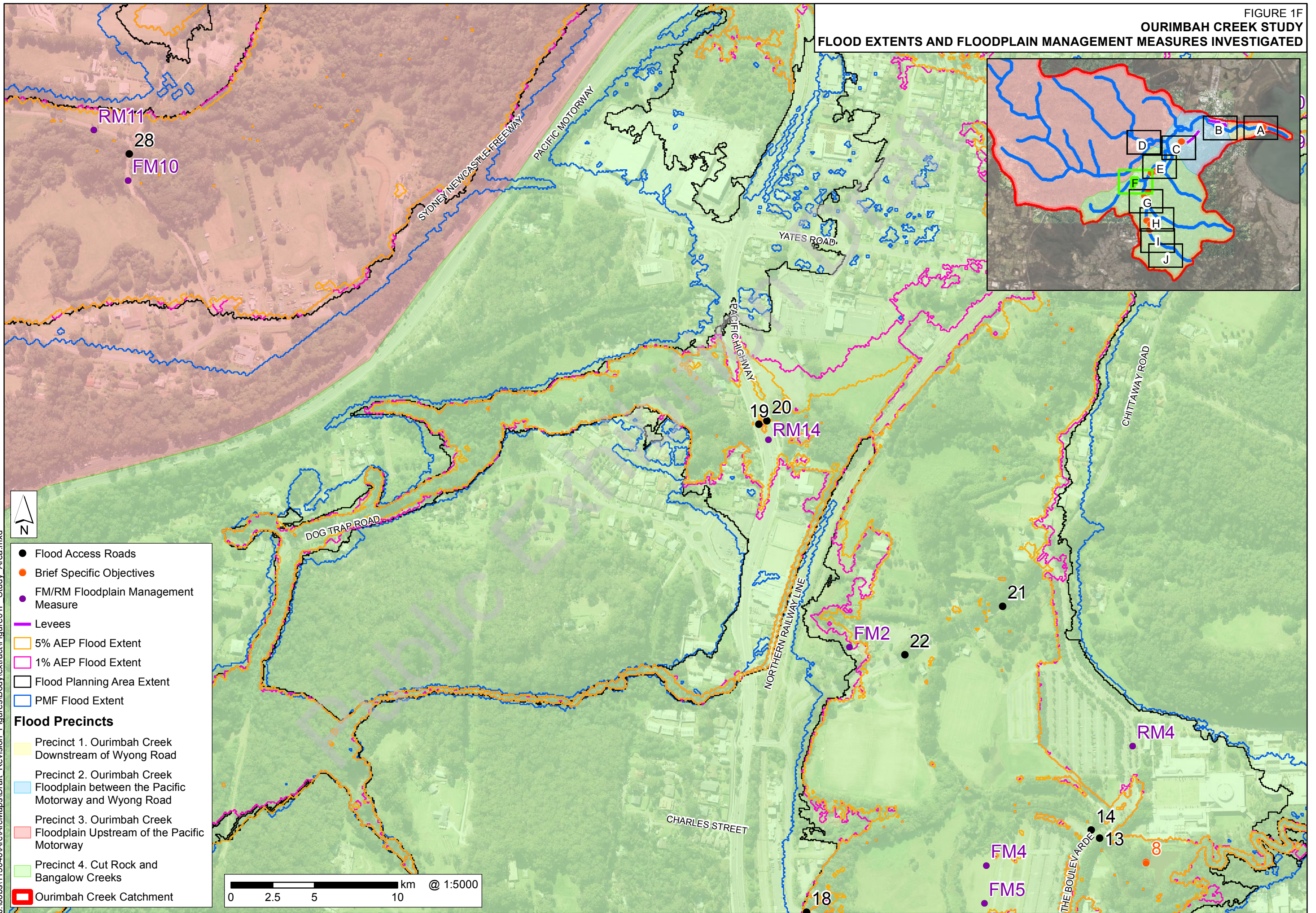


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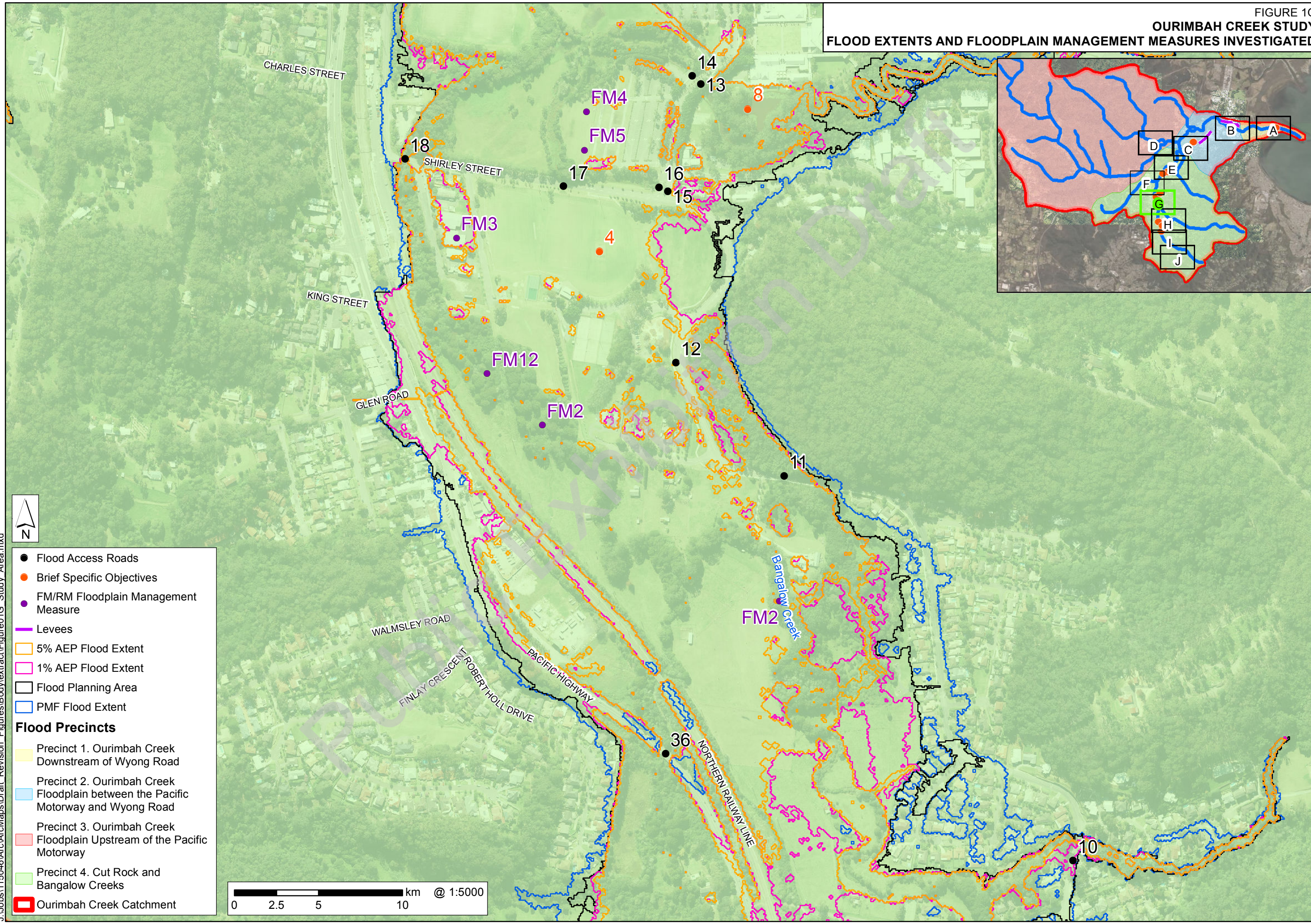
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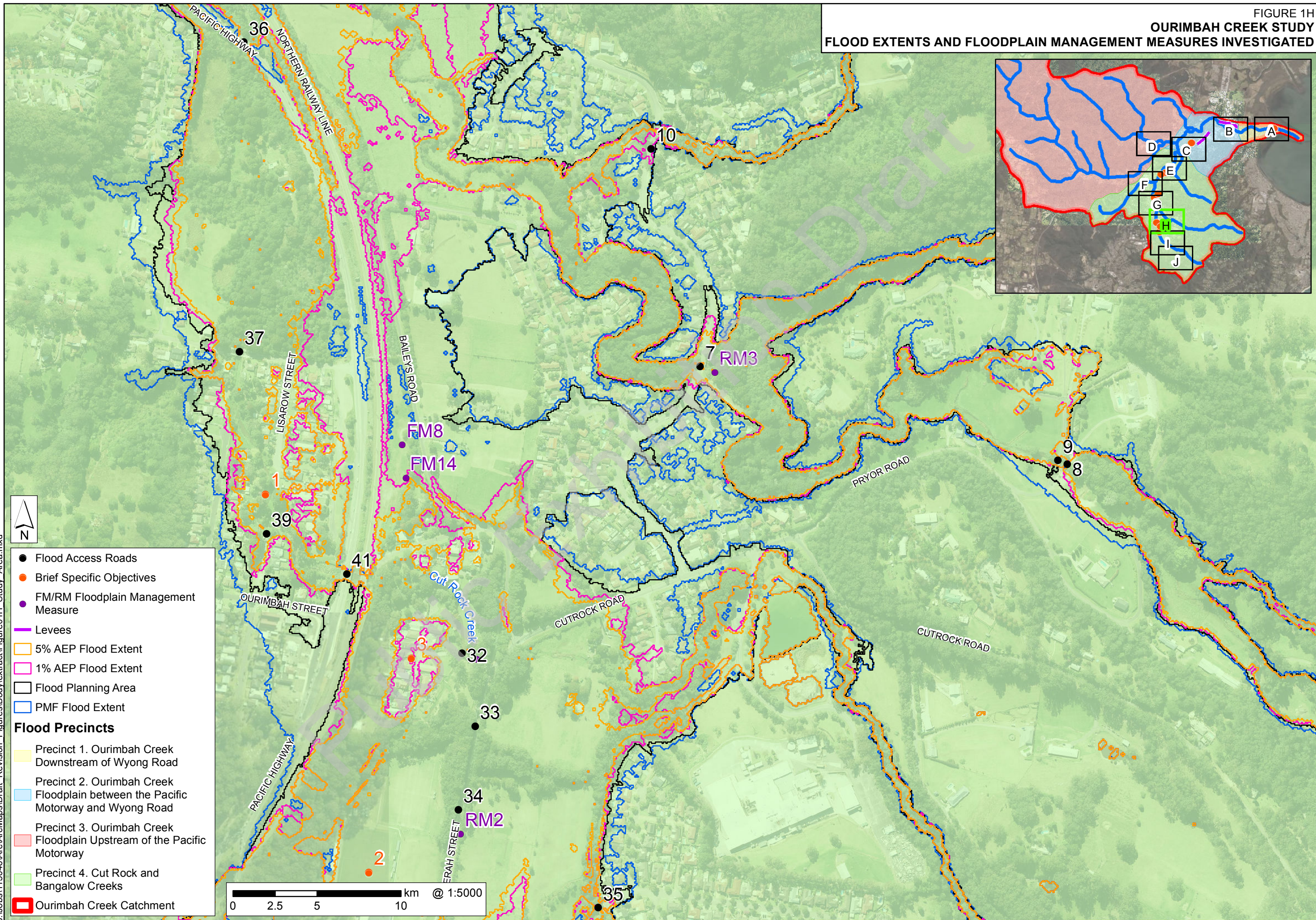
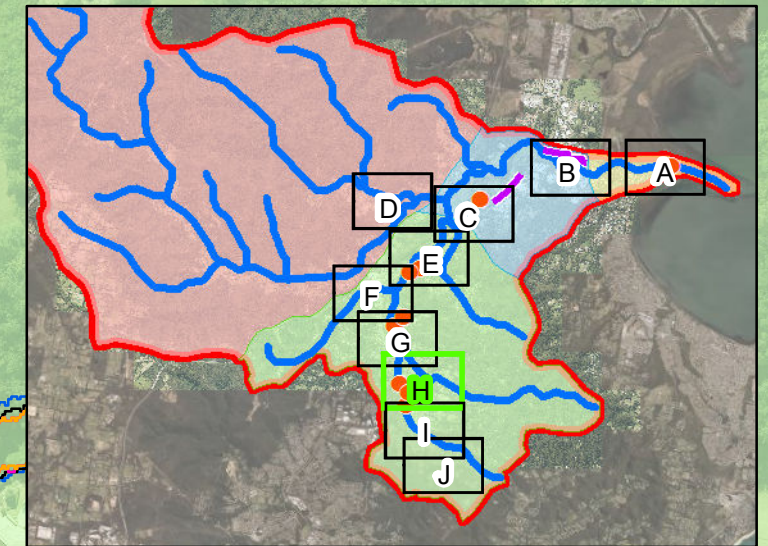


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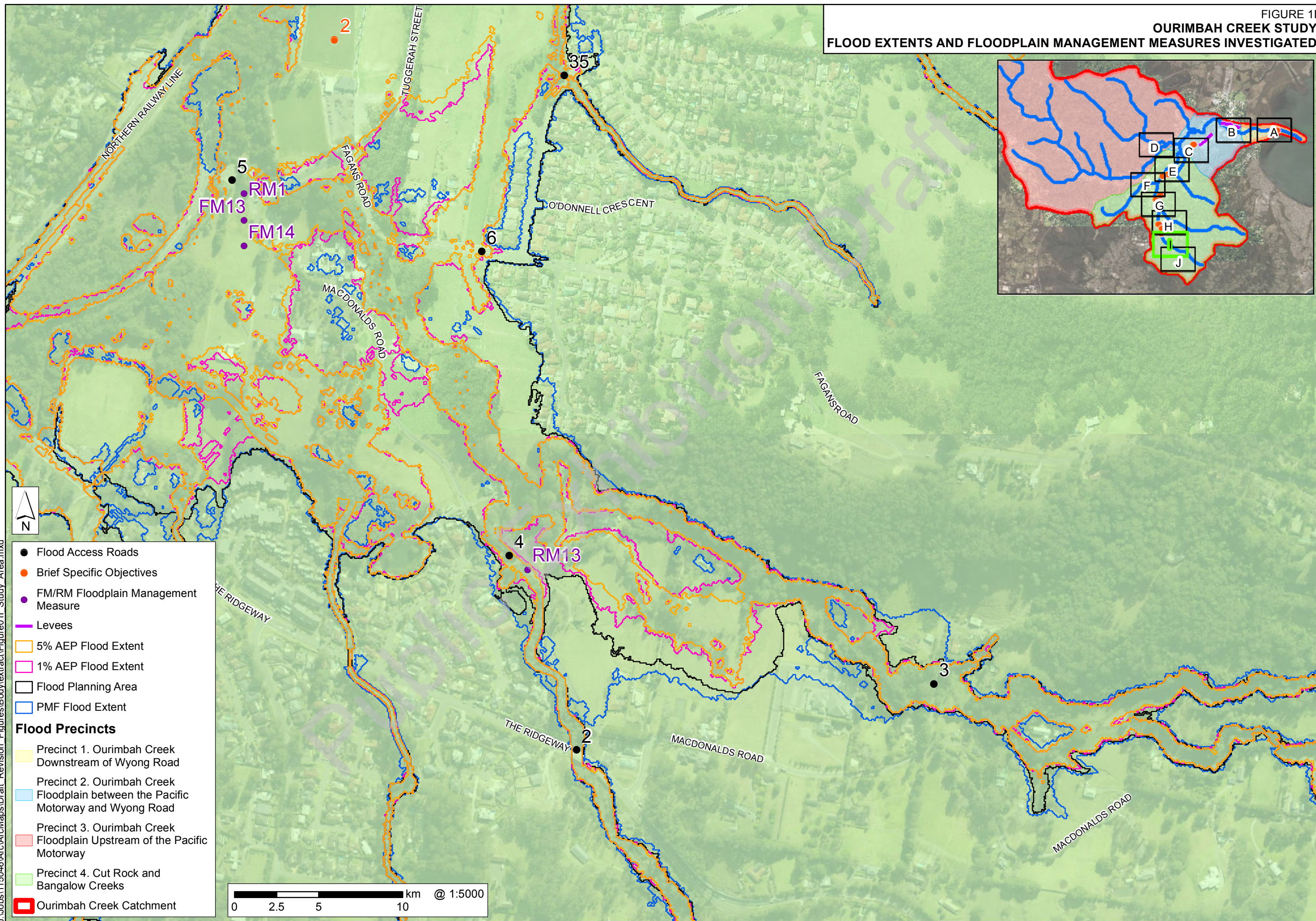


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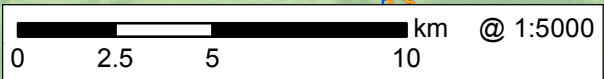


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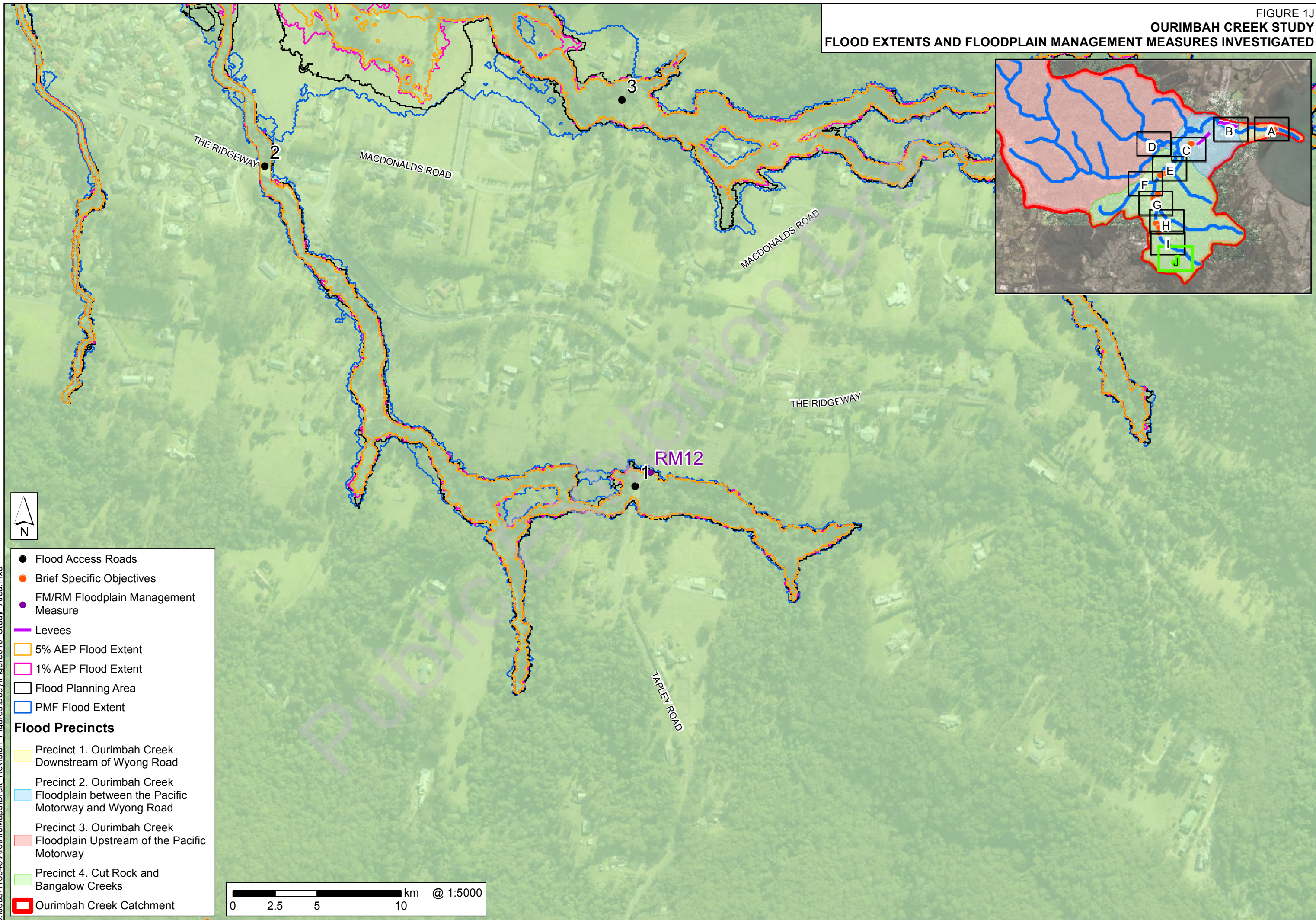




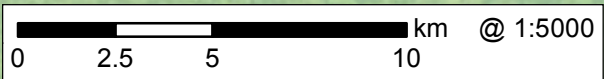
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Appendix A: Glossary of Terms

APPENDIX A: GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
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, if a peak flood discharge of 500 m ³ /s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m ³ /s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act).

	<p>infill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development.</p> <p>new development: refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.</p> <p>redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.</p>
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland

	<p>flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.</p>
flood awareness	<p>Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.</p>
flood education	<p>Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.</p>
flood fringe areas	<p>The remaining area of flood prone land after floodway and flood storage areas have been defined.</p>
flood liable land	<p>Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).</p>
flood mitigation standard	<p>The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.</p>
floodplain	<p>Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.</p>
floodplain risk management options	<p>The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.</p>
floodplain risk management plan	<p>A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.</p>
flood plan (local)	<p>A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.</p>
flood planning area	<p>The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the flood liable land concept in the 1986 Manual.</p>
Flood Planning Levels (FPLs)	<p>FPLs are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the standard flood event in the 1986 manual.</p>

flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	<p>Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below.</p> <p>existing flood risk: the risk a community is exposed to as a result of its location on the floodplain.</p> <p>future flood risk: the risk a community may be exposed to as a result of new development on the floodplain.</p> <p>continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.</p>
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	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 flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL 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 flood planning level.
habitable room	<p>in a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.</p> <p>in an industrial or commercial situation: an area used for offices or to</p>

	store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	<p>Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves:</p> <p>the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or</p> <p>major overland flow paths through developed areas outside of defined drainage reserves; and/or</p> <p>the potential to affect a number of buildings along the major flow path.</p>
mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental

	<p>protection and well being of the State's rivers and floodplains.</p> <p>The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.</p>
minor, moderate and major flooding	<p>Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:</p> <p>minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.</p> <p>moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.</p> <p>major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.</p>
modification measures	Measures that modify either the flood, the property or the response to flooding.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	<p>The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. 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. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.</p>
Probable Maximum Precipitation (PMP)	<p>The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.</p>
probability	A statistical measure of the expected chance of flooding (see AEP).

risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to water level. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.