M1 PACIFIC MOTORWAY REPLACEMENT AND WIDENING: TUGGERAH TO DOYALSON

Appendix G – Hydrology and Hydraulics Technical study

Review of environmental factors

MAY 2014

TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 Purpose 1

1.2 Proposal overview 1

1.3 Structure of this report 3

2 ASSESSMENT METHODOLOGY AND ASSUMPTIONS 4

2.1 Methodology 4

2.1.1 General 4

2.1.2 Relevant guidelines 4

2.1.3 Design objectives 4

2.1.4 Hydrologic modelling 5

2.1.5 Hydraulic modelling 6

2.2 Assumptions and limitations 7

3 EXISTING HYDROLOGIC ENVIRONMENT 8

3.1 Overview of the catchments and waterways 8

3.2 Previous flood studies 14

3.3 Drinking water catchments 14

3.4 SEPP 14 wetlands 14

4 IMPACTS OF THE PROPOSAL 15

4.1 Predicted changes in surface flows 15

4.2 Modelled changes to the flood regime 16

4.3 Potential effects of road runoff 19

5 ASSESSMENT CONCLUSIONS AND MANAGEMENT OF IMPACTS 21

6 REFERENCES 22

GLOSSARY

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 20yr ARI design flood will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

Australian Height Datum (AHD) – Common national survey datum corresponding approximately to mean sea level.

Catchment – The area of land which collects excess rainfall (run-off) and directs it to a receiving water body.

Design flood – A hypothetical flood representing a specific likelihood of occurrence (for example the 100 year ARI or 1% AEP flood).

Flow rate – The rate of flow of water measured in terms of volume over time.

HECRAS – Hydraulic modeling software used to determine flood flow depths and velocities in rivers and hydraulic structures.

Hydraulics – The term given to the study of water flow in waterways (i.e. rivers, estuaries and coastal systems).

Hydrology – The term given to the study of the rainfall-runoff processes in catchments.

RAFTS – A hydrologic model (software) used to simulate the catchment rainfall-runoff process, including the amount of runoff from rainfall, and the attenuation of the flood wave as it travels down a catchment.

RCBC – Reinforced Concrete Box Culverts.

RCP – Reinforced Concrete Pipes.

TUFLOW – 1D and 2D hydraulic model (software). It simulates the complex hydrodynamics of floods and tides using the full 1D St Venant equations and the full 2D free-surface shallow water equations.

Velocity – The speed at which floodwaters are moving (in metres per second). A flood velocity predicted by a 2D computer flood model is quoted as the depth averaged velocity, i.e. the average velocity throughout the depth of the water column. A flood velocity predicted by a 1D or quasi-2D computer flood model is quoted as the depth and width averaged velocity, i.e. the average velocity across the whole river or creek section.

1 INTRODUCTION

1.1 Purpose

Roads and Maritime Services (Roads and Maritime) proposes to replace and widen around 12.3 kilometres of the Pacific Motorway (or M1 Pacific Motorway) to six lanes between Wyong Road, Tuggerah, and the Doyalson Link Road, Kiar.

This report describes the existing hydrologic and hydraulic regimes of the study area, assesses the potential impacts that the proposal may have on these regimes, and identifies management measures to mitigate or manage the predicted adverse impacts.

This hydrology and hydraulics assessment has been prepared as a technical document to support the Review of Environmental Factors (REF) for the proposed replacement and widening of the M1 Pacific Motorway.

1.2 Proposal overview

The proposal would involve the provision of two additional lanes (one northbound and one southbound) on the M1 Pacific Motorway by pavement widening, asphalt overlays and new line-marking. It would generally involve the following:

- On the southern three kilometre section between Wyong Road and Wyong River the additional lane in each direction would be achieved by constructing a widened flexible (asphalt) pavement section in the median, placing an asphalt overlay over the existing traffic lanes, and then implementing new line-marking to achieve three lanes on each carriageway.
- Replacement of the existing pavement and stabilisation of the subgrade through full removal and reconstruction of around 9.3 kilometres of rigid concrete pavement (north of the Wyong River).
- Upgrades to the existing Warnervale Interchange (Sparks Road) including a new separated northbound G-loop entry ramp that connects with the motorway north of the Doyalson Link Road off ramp, reconfiguration of intersections and approaches, and provision of a new pedestrian overbridge at Sparks Road.
- Provision of a new signalised intersection on Sparks Road and the southbound off ramp and northbound on ramp to the motorway.
- Upgrades to the Doyalson Link Road Interchange including reconstruction of the Doyalson Link Road northbound off ramp to extend over the proposed Sparks Road northbound extended on ramp.
- Provision for future southbound off ramp on to Doyalson Link Road and a new motorway northbound on ramp from Doyalson Link Road including a new bridge over the motorway (subject to further investigation including traffic modelling).
- Provision of an additional lane by new line-marking on five northbound and six southbound bridges
- Provision of an additional lanes by bridge widening and new line-marking on the northbound bridge over St Johns Road
- Ancillary facilities to support construction activities including stockpiling, storage, concrete batching and crushing.

The full description of the proposal is provided in Section 3 of the Review of Environmental Factors that this Hydrology and hydraulics technical study supports. An overview of the proposal is provided in Figure 1.

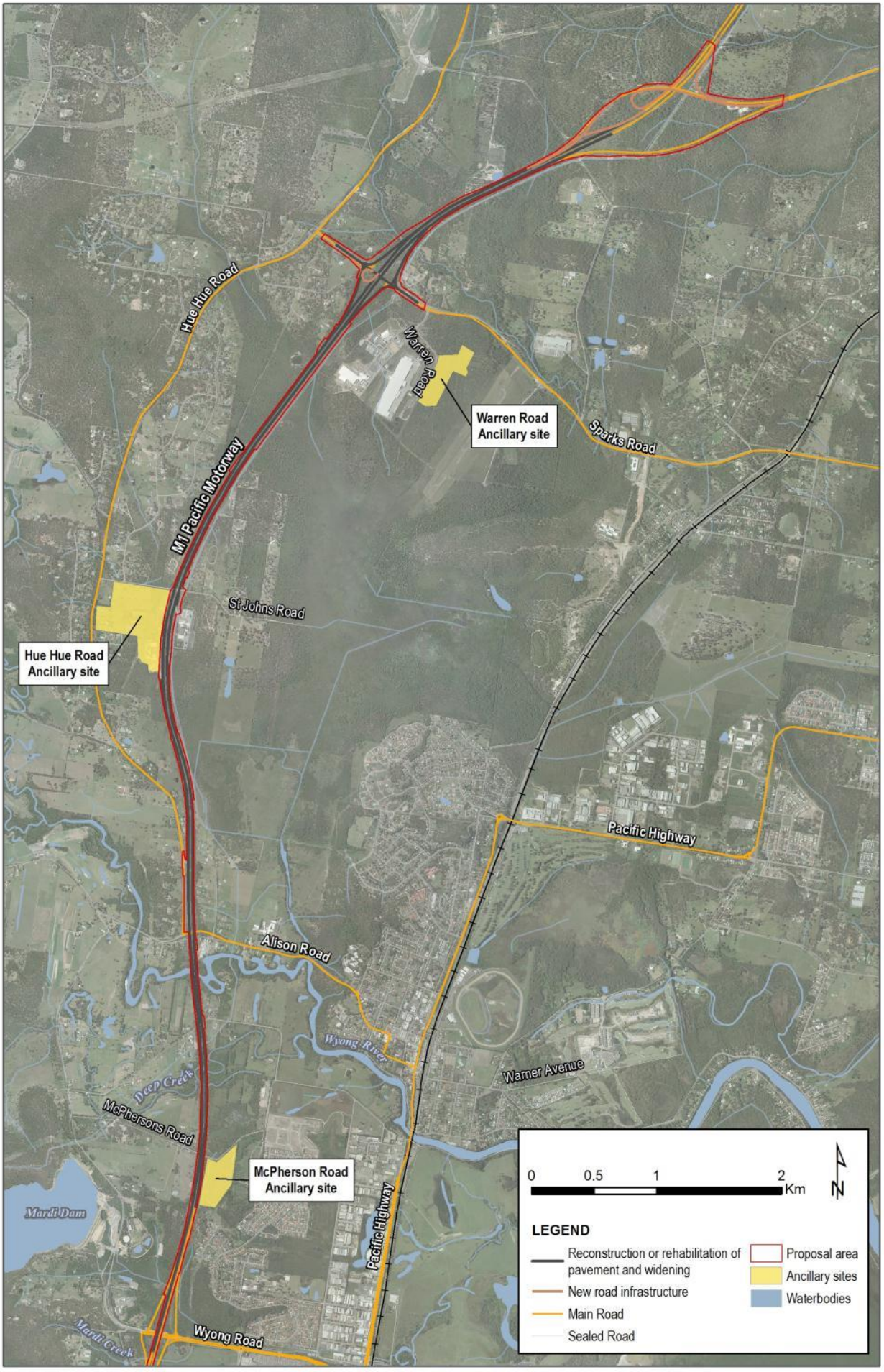

Figure 1 Proposal overview with ancillary sites

1.3 Structure of this report

The structure of the report is as follows:

- Chapter 2 provides a description of the assessment methodology including the hydrology and hydraulic analysis.
- Chapter 3 describes the existing hydrologic environment. Watercourses crossing the proposal and catchment areas are described.
- Chapter 4 examines the impacts of the proposal on regional and local flooding regimes.
- Chapter 5 then describes how the assessed impacts will be managed.

This report should be read in conjunction with the Soil and Water Technical Study which accompanies the REF and assess the water quality aspects of the proposal.

2 ASSESSMENT METHODOLOGY AND ASSUMPTIONS

2.1 Methodology

2.1.1 General

The study methodology has been based on the use of hydrologic and hydraulic modelling to assess the existing stormwater flow regimes and to determine the potential impacts of the proposal.

2.1.2 Relevant guidelines

The following documents have been taken into account in assessing the hydrological impacts of the proposal:

- RTA Water Policy (RTA 2000).
- RTA Code of Practice for Water Management (RTA 1999b).
- RTA QA Specification G38 Soil and Water Management (Soil and Water Management Plan), (RTA 2004b).
- Floodplain Development Manual (former Department of Natural Resources 2005).
- Upgrading the Pacific Highway – Upgrading Program beyond 2006: Design Guidelines (RTA 2006).

2.1.3 Design objectives

With respect to the management of hydrological impacts, the key design objectives of the proposal are to:

- Preserve existing elements such as natural channels, wetlands and riparian vegetation.
- Manage both quality and quantity of stormwater as close to its source as possible, including installing devices that treat stormwater and retain the runoff so that changes to the system are kept to the minimum amount practical.
- Integrate with the construction process so that the total investment in drainage infrastructure is minimised and access is available to all devices that need ongoing maintenance during both the construction phase and the operational phase.
- Minimise the risk of erosion and sedimentation of downstream watercourses.
- Minimise any increase in upstream flood levels by managing the constriction of flow paths.

The hydrologic design criteria for the proposal's drainage system are set out in Table 1.

Table 1: Drainage system design criteria

Item No.	Item	Minimum ARI
1	Channels and open drains	5 years
2	Piped system (including pits)	10 years
3	Culverts where surcharge is allowable	50 years
4	Structures where surcharge is undesirable	100 years
5	Nil width of flow spread onto traffic lanes	10 years
6	Gross pollutant traps	1 year
7	Pavement drainage wearing surface	10 years
8	Major storm event check for no property damage	100 years
9	Major storm event check for no structural damage	2000 years
10	Cycleway	1 year

For this study which aims to assess the broad flooding impacts of the proposal on surrounding land, the 100 year ARI flood capacity has been assessed. Assessment of the capacity of the minor drainage system will be carried out during the detailed design stages of the proposal development.

2.1.4 Hydrologic modelling

Hydrologic modelling was used to determine the design flow rates in watercourses traversing the M1 Pacific Motorway between Tuggerah and Doyalson. A desktop study of available topographic data and aerial photography was carried out to identify key characteristics of the drainage regime and existing watercourses. Major and minor creeks and water bodies were identified.

The combined catchments of Wyong River and Deep Creek were identified as being the largest of the watercourses that cross the alignment. The Wyong River Catchment Flood Study has been prepared for Wyong Shire Council to define the existing flood behaviour in the Wyong River catchment and establish the basis for subsequent floodplain management activities. The flood study provides information on flooding behaviour of both Deep Creek and the Wyong River at the Motorway and the models developed for the flood study were adopted for use in this study.

For watercourses other than those covered by the analysis contained in the Wyong River Catchment Flood Study, flow rates were determined using the Rational Method for Eastern New South Wales described in Australian Rainfall and Runoff (Pilgrim et al, 1987), (ARR). Catchment areas were defined using a combination of ground survey information within the road corridor, two metre resolution photogrammetric survey and ten metre resolution topographic survey information covering the catchment areas. Design rainfall intensities were derived from ARR.

Design rainfall intensity-Frequency-Duration (IFD) for Wyong was obtained from the Bureau of Meteorology (BOM) website for storm durations ranging between five minutes and 72 hours, as shown in Table 2.

Table 2 Design rainfall intensity-frequency-duration (IFD) mm/hour from BOM

Duration	1 year	2 years	5 years	10 years	20 years	50 years	100 years
5 mins	88.5	114	145	162	186	217	240
6 mins	83	106	136	153	175	204	226
10 mins	67.9	87.3	112	126	144	168	187
20 mins	49.4	63.6	81.7	92.1	106	124	138
30 mins	40.1	51.7	66.6	75.3	86.6	102	113
1 hour	27.4	35.4	45.9	51.9	59.9	70.5	78.4
2 hours	18.4	23.9	31	35.3	40.8	48	53.6
3 hours	14.6	18.9	24.6	28	32.5	38.3	42.7
6 hours	9.75	12.6	16.6	18.9	22	26	29
12 hours	6.49	8.43	11.1	12.7	14.8	17.5	19.6
24 hours	4.25	5.54	7.35	8.43	9.83	11.7	13.1
48 hours	2.69	3.51	4.7	5.4	6.33	7.55	8.49
72 hours	2.01	2.63	3.53	4.07	4.79	5.72	6.44

2.1.5 Hydraulic modelling

The hydraulics of the existing waterways that were not addressed within the Wyong River Catchment Flood Study were assessed using the HECRAS hydraulic modelling software.

Cross sections through the main waterways were generated at regular intervals and additional cross sections added. This provided for important factors such as abrupt changes in channel cross section were represented as accurately as possible within the limitations of HECRAS model and the available survey data. The waterway structure dimensions and invert levels interacting with the motorway were inserted into the HECRAS model. The HECRAS model was used to model the 100 year ARI hydraulic characteristics at each of the waterway crossings.

The Wyong River and Deep Creek flooding characteristics were assessed using TUFLOW two dimensional flood modelling software developed for the Wyong River Catchment Flood Study (BMT WBM 2013). The model incorporates the whole of the cleared floodplain areas for Wyong River and other major watercourses.

2.2 Assumptions and limitations

The assessment is based upon the information presented in the Concept Design prepared by Roads and Maritime. Changes to the Concept Design during the detailed design stages could potentially alter some of the findings of this study.

Catchment areas have been defined using topographic survey, supplemented with ground survey within the motorway corridor. In some areas there is limited contour information available to define catchment boundaries and waterway locations.

In watercourses other than those analysed within the Wyong River Catchment Flood Study, ground survey does not extend upstream or downstream of the corridor. Hydraulic boundary conditions have therefore been assumed using limited survey data.

For catchments other than Wyong River and Deep Creek, the hydrologic modelling is based on the use of the Rational Method for Eastern NSW (Pilgrim et al, 1987). Flows are estimated using regional relationships and are not based on site specific discharge measurements or calibrated hydrologic models.

The hydraulic modelling carried out for this study is limited by the accuracy and extent of the ground survey available for this assessment. At most culverts and bridges, the waterway geometry has been defined using limited survey detail which does not accurately define the shape of the waterway. In addition to the survey limitations, blockage of waterway structures from floating debris can occur during flood events and the exact degree of blockage cannot be predicted. The modelling assumes all transverse structures are unblocked at the time of peak discharge. Further assessment of the vulnerability of the various transverse drainage structures to debris blockage would be made during the detailed design stage.

Despite the above limitations, the modelling approach is considered acceptable for the assessment of the relative impacts of the proposal.

3 EXISTING HYDROLOGIC ENVIRONMENT

3.1 Overview of the catchments and waterways

The proposal covers 12.1 kilometres of the M1 Pacific Motorway running south to north between Wyong Road, Tuggerah, and the Doyalson Link Road, Kiar. Fourteen sub-catchments of Tuggerah Lake ranging in size from eight hectares to 357 square-kilometres were identified from the topographic mapping as feeding watercourses that cross the proposal. All drain generally in an easterly direction to Tuggerah Lake. In addition to a number of un-named watercourses, the watercourses that cross the proposal include the following named creeks:

- Mardi Creek.
- Deep Creek.
- Wyong River.
- Buttonderry Creek.

Mardi Creek has a catchment area of about 2.8 square-kilometres upstream of the crossing of the motorway. Within this catchment, Mardi Dam, an off stream storage reservoir, impounds a 1.8 square-kilometre portion of the catchment. This portion of the catchment is diverted for water supply purposes.

Deep Creek has a catchment area of about 5.4 square-kilometres and drains to Wyong River about one kilometre downstream (east) of the existing motorway. In the upper reaches of the catchment, the topography is relatively steep, interspersed with isolated small areas of flatter grade. Four sets of twin bridges have been provided at the Motorway for this catchment which receives overflows from the Wyong River catchment to the north in major flood events.

The largest waterway crossed by the proposal is the Wyong River which has a total catchment area of about 357 square-kilometres upstream of the motorway. Flood waters in the Wyong River are conveyed to the eastern side through twin bridges in addition to the four sets of twin flood relief bridges located in the Deep Creek catchment to the south.

The Wyong River catchment contains comprises mixed land uses including forest and agricultural land with urban development in the lower reaches. The most recent flood on the Wyong River occurred in June 2007, when the Wyong River peaked at the Wyong Railway Bridge at RL 2.63 metres Australian Height Datum (AHD). This was a major event in the catchment resulting in widespread flooding. At Wyong Weir, a 24 hour rainfall total of 335 millimetres was recorded.

Buttonderry Creek has a catchment area upstream of the motorway of about 6.9 square-kilometres. It has a well-defined low flow channel and is densely vegetated, with a meandering alignment. The floodplain generally consists of grassland with scattered trees.

Figures 2 to 5 shows the local catchments of Mardi Creek, Deep Creek, Wyong River and Buttonderry Creek upstream of the motorway. Figure 6 provides an overview of the sub-catchments crossing the proposal.

Figure 2 Mardi Creek Catchment

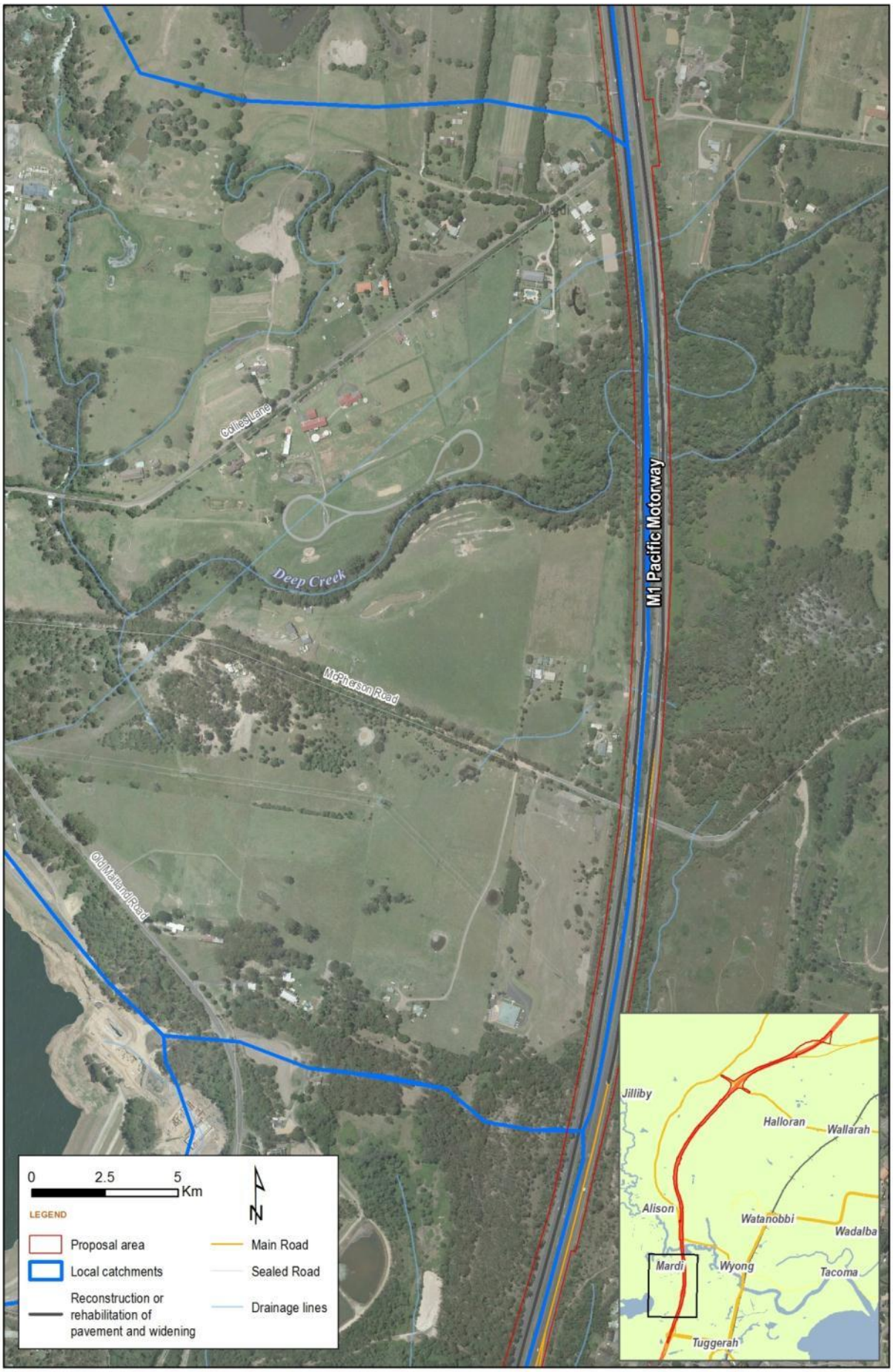

Figure 3 Deep Creek Creek Catchment

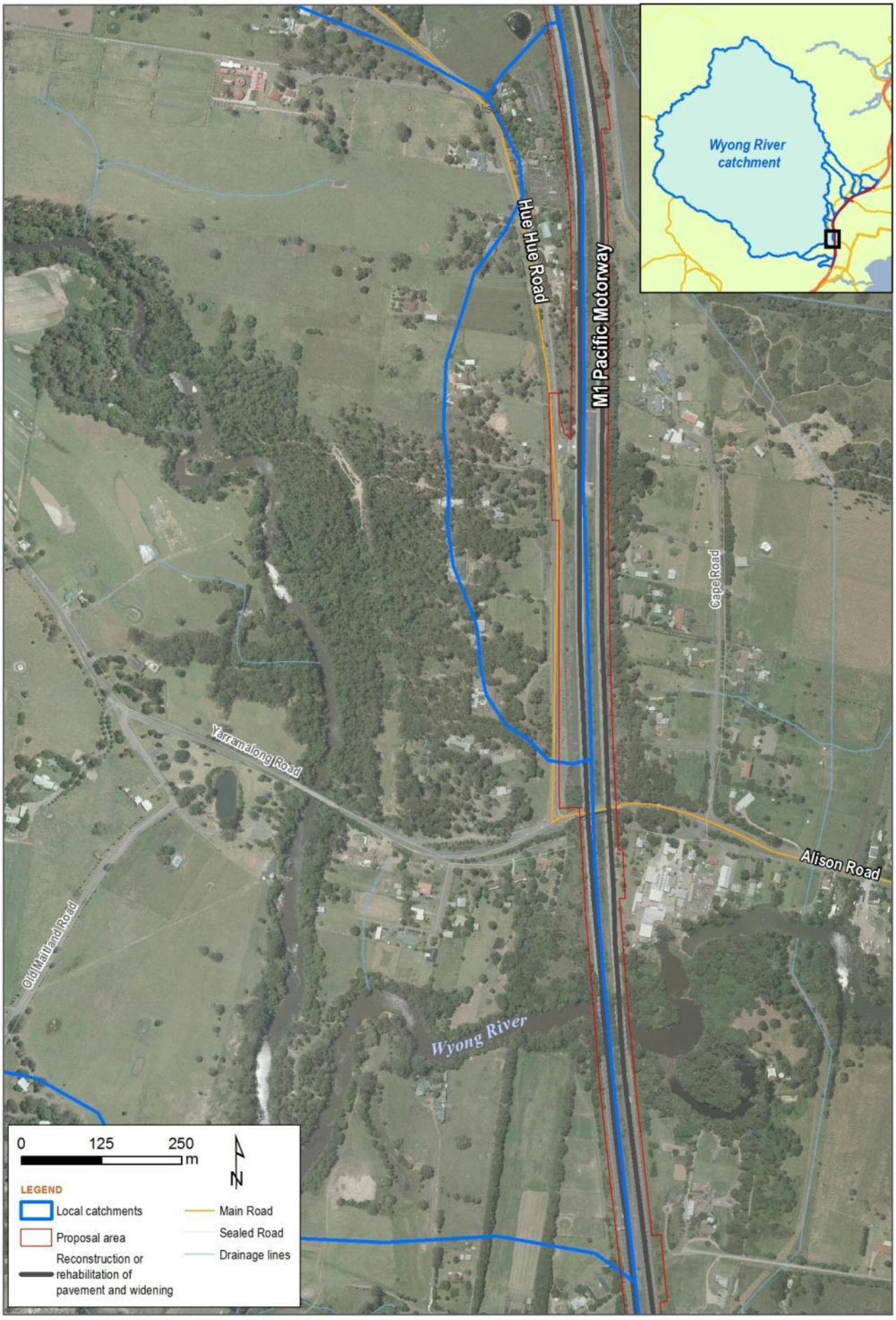

Figure 4 Wyong River catchment

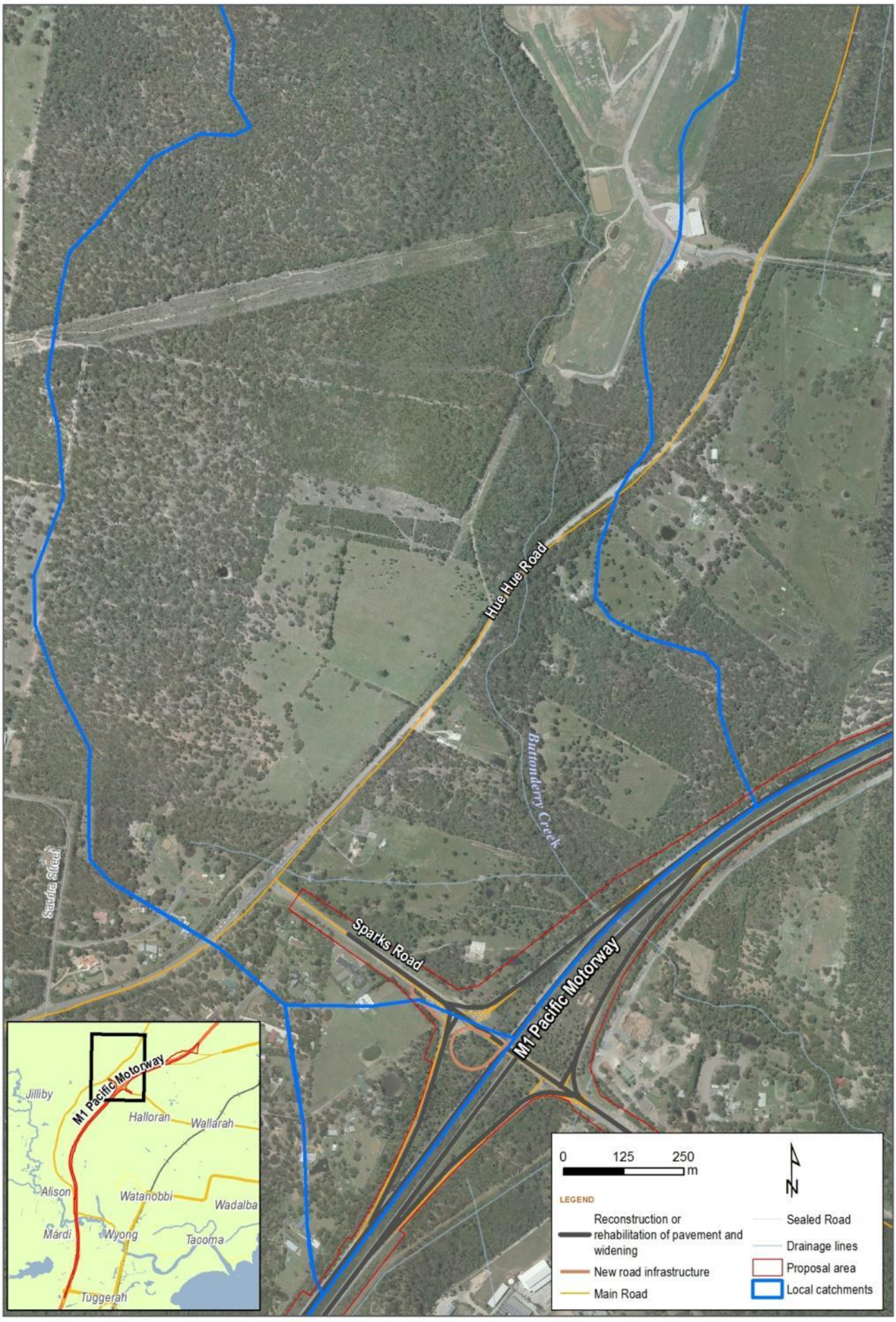

Figure 5 Buttonderry Creek catchment

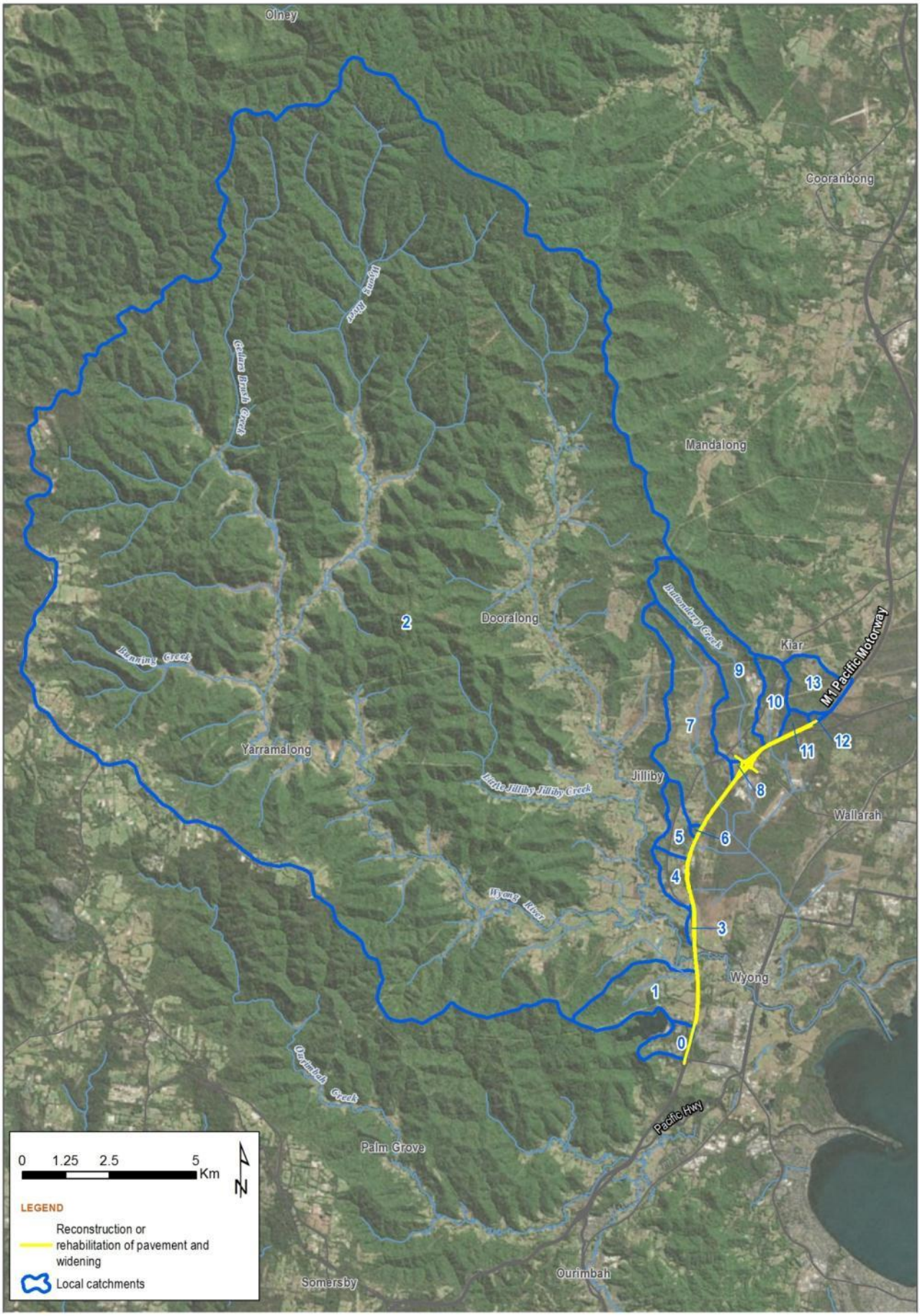

Figure 6 Watercourses and catchment boundaries

3.2 Previous flood studies

Two main studies have been recently undertaken in relation to flooding along the lower reaches of Wyong River, Deep Creek and Mardi Creek catchments. These are described below.

Wyong River Catchment Flood Study, BMT WBM, 2013 (Draft Report)

The Wyong River Catchment Flood Study has been prepared for Wyong Shire Council to define the existing flood behaviour in the Wyong River catchment and establish the basis for subsequent floodplain management activities. The flood study provides information on flooding behaviour of both Deep Creek and the Wyong River at the motorway and the models developed for the flood study were adopted for use in this study.

The primary objective of the Flood Study is to define the flood behaviour within the Wyong River catchment through the establishment of appropriate numerical models. The hydraulic model, simulating flood depths, extents and velocities utilises the TUFLOW two-dimensional (2D) software developed by BMT WBM. With consideration to the available survey information and local topographical and hydraulic controls, a 2D model was developed extending from Tuggerah Lake at the downstream limit, upstream along the major tributary routes. The model incorporates the whole of the cleared floodplain areas for Wyong River and other major watercourses.

Pacific Highway HW10 and Wyong Road, MR335 Intersection and Approaches Upgrade, Concept hydrology / hydraulics assessment, Revision B, SKM 2012

This hydrology/hydraulics assessment was completed in 2012 and examined the predicted impacts of proposed upgrading works at the Pacific Highway / Wyong Road intersection and approaches, located to the east of the M1 Pacific Motorway. The study utilised hydraulic modeling to assess the effect of the loss of flood plain storage resulting from the road works on flood levels in Mardi Creek.

3.3 Drinking water catchments

Wyong River is pumped to the Central Coast water supply system from just upstream (west) of the Wyong River weir. Water is transferred to the Mardi Dam off stream storage. Runoff from a portion of the proposal within the Wyong River catchment flows into the weir impoundment.

3.4 SEPP 14 wetlands

A portion of the proposal is located upstream of the Porters Creek Wetland which is designated as a SEPP 14 wetland. Runoff from a majority of the proposal will drain into this wetland. This includes drainage from all sub-catchments located north of the Wyong River catchment.

Porters Creek Wetland is the largest remaining freshwater wetland on the Central Coast of NSW. It plays a critical role filtering water on its way to the Wyong River which flows into Tuggerah Lakes through a connected series of shallow estuarine lagoons that open to the sea at The Entrance.

4 IMPACTS OF THE PROPOSAL

4.1 Predicted changes in surface flows

The proposal would augment the existing drainage systems. There are no proposed changes to transverse bridge or culvert configurations and catchment areas would remain unchanged. The proposal would not impact on floodplain storage because there will be no earthworks carried out within floodplain storage areas.

The additional pavement surface would generate negligible increases in discharge at each culvert. Therefore the existing flow regimes will remain unchanged at each culvert and there will be no increased risk of flooding, very low risk of increased erosion damage and very minor increases to the hydraulic flows experienced at downstream sensitive environments such as the SEPP 14 Porters Creek Wetland. No impacts on fish passage would result from the proposal.

Table 3 summarises the catchment areas and predicted 10 year, 20 year, 50 year and 100 year ARI flow rates for each watercourse crossed by the proposal. Refer to Figure 6 for the location of each catchment.

Table 3: Watercourse catchment areas and flows

Catchment Number	Catchment area (km^2)	Time of concentration (min)	10 year ARI flow (m^3/s)	20 year ARI flow (m^3/s)	50 year ARI flow (m^3/s)	100 year ARI flow (m^3/s)
0	0.99	45	7.0	9.0	11.6	14.1
1	4.49	81	23.0	29.8	38.5	47.0
2	357	426	705	919	1193	1461
3	0.18	24	1.7	2.2	2.9	3.5
4	1.14	48	7.8	10.0	13.0	15.8
5	1.38	52	9.0	11.6	15.0	18.3
6	0.08	17	0.9	1.1	1.5	1.8
7	8.17	101	36.7	47.5	61.4	75.1
8	0.15	22	1.5	1.9	2.4	3.0
9	6.88	95	32.3	41.8	54.0	66.0
10	1.85	58	11.0	14.3	18.5	22.5
11	0.41	33	3.3	4.3	5.6	6.8
12	0.11	20	1.1	1.5	1.9	2.3
13	2.25	62	12.8	16.6	21.5	26.2

4.2 Modelled changes to the flood regime

The identified waterway structures crossing the proposal are shown on Figure 7 and their characteristics are shown in Table 4.

The proposal would not result in the modification of any of the existing transverse drainage elements. The existing bridges would be retained with no modifications.

The hydraulic performance of the transverse waterway structures is summarised in Table 5 which shows the calculated 100 year ARI flood level at each waterway structure and the road pavement levels for comparative purposes.

As indicated in Table 5, the existing motorway culverts have the capacity to pass the 100 year ARI flood discharge without overtopping. For this reason, any changes to pavement levels will have no effect on flood levels as a result of the proposal.

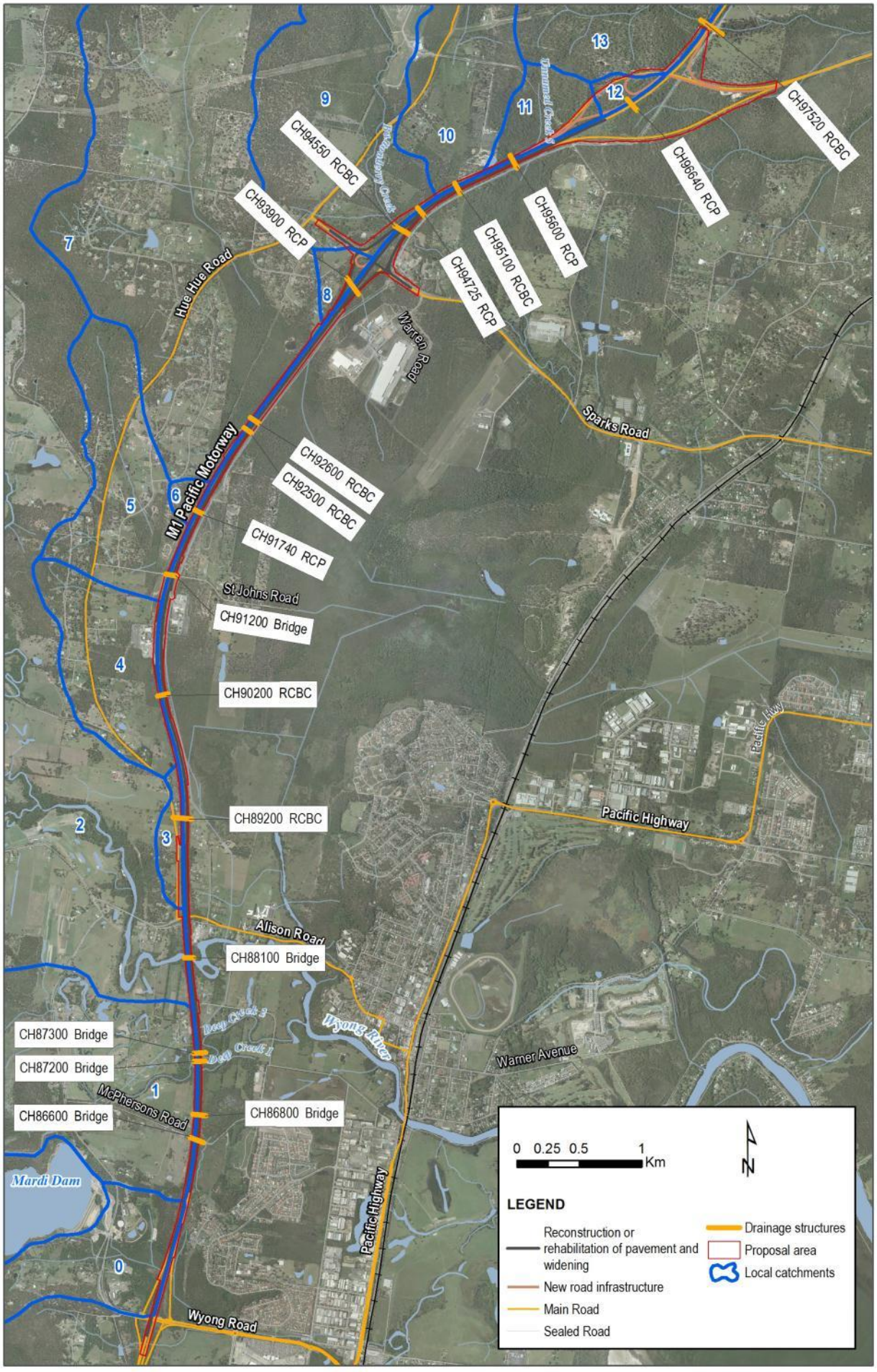

Figure 7 Drainage structures

Table 4 Summary of existing transverse drainage

Catchment	Approximate Chainage (m)	Size	Type	Comments
0	85700	Unknown	Unknown	-
1	86600 to 87300	Unknown	4 x bridges	-
2	88100	Unknown	Bridge	-
3	89200	1 x 900 diameter	RCP	Invert level measured at RL 9.0m AHD
4	90200	3 x 3000 x 1800	RCBC	Invert level measured at RL 1.75m AHD
5	91200	30.6m opening	Bridge	-
6	91740	1 x 900 diameter	RCP	Invert level measured at RL 8.30m AHD
7	92500	3 x 3000 x 1800	RCBC	Invert level measured at RL 4.99m AHD; It is proposed to reconstruct existing 3 cell box culverts and construct new drainage pit and connect to existing network to maintain existing flow regime.
7	92600	3 x 3000 x 1800	RCBC	Invert level measured at RL 4.99m AHD; It is proposed to reconstruct existing 3 cell box culverts and construct new drainage pit and connect to existing network to maintain existing flow regime.
8	93900	1 x 1350 diameter	RCP	Invert level measured at RL 13.80m AHD
9	94550	1 x 4000 x 4000	RCBC	Invert level measured at RL 15.15m AHD
9	94725	1 x 1500 diameter	RCP	Invert level measured at RL 17.01m AHD
10	95100	3 x 3000 x 1500	RCBC	Invert level measured at RL 17.25m AHD; It is proposed to reconstruct existing 3 cell box culverts and construct new drainage pit and connect to existing network to maintain existing flow regime.
11	95600	1 x 1500 diameter	RCP	Invert level measured at RL 18.3m AHD
12	96640	1 x 1200 diameter	RCP	Invert level measured at RL 30.2m AHD
13	97520	1 x 4000 x 4000	RCBC	Invert level measured at RL 14.9m AHD

Table 5: Hydraulic performance of major drainage crossings – 100 year ARI

Culvert and Bridges Chainage	Catchment ID	Design ARI	Design Flows (m^3/s)	Peak Water Level (m AHD)	Design Pavement Level (m AHD)
85700	0	100	14.1	Unknown	18.4
86600 to 87300	1	100	TBA	6.6	7.8
88100	2	100	TBA	6.8	8.9
89200	3	100	3.5	10.64	11.2
90200	4	100	15.8	3.78	7.73
91200	5	100	18.3	8.53	12.6
91740	6	100	1.8	9.92	11.7
92600	7	100	75.1	7.5	8.3
92500	7	100			
93900	8	100	3	15.51	16.5
94725	9	100	66	20.02	20.4
94550	9	100			
95100	10	100	22.5	18.75	20.29
95600	11	100	6.8	21.13	22.54
96640	12	100	2.3	31.6	32.5
97520	13	100	26.2	18.67	27.92

4.3 Potential effects of road runoff

The proposal, if not managed, would have the potential to have the following impacts on the local hydrology:

- Increased flow rate and velocity of surface water runoff due to the increased imperviousness of the footprint area of the proposed widening.
- Concentration of flows as a result of waterway diversions and point outflows from water quality basins.
- Changes in flow regimes as a result of waterway diversions.

Where new drainage works are installed at interchanges and ramps, the drainage system has the potential to concentrate surface water at pipe or channel system outlets.

An assessment of the relative change in discharges at pavement drainage system outlets was carried out to assess the likely impact of the proposal on localised road discharge.

Local discharge increases of up to a maximum of ten per cent in the 100 year ARI are predicted. However these localised pavement flow increases, when combined with flows from the large transverse catchments crossing the alignment, would result in a negligible increase in flow rates in the waterways downstream of the proposal.

5 ASSESSMENT CONCLUSIONS AND MANAGEMENT OF IMPACTS

The proposal makes use of and augments the existing motorway drainage system components with minimal changes to flow regimes. There are expected to be no measureable impacts on discharges or flood levels in the waterways that cross the proposal.

The flood sensitive Wyong River and Deep Creek waterways would not experience any change in flow regime and no modification of the existing bridge structures is proposed. There is no proposed alteration to catchment areas in these catchments. Changes to paved area draining to these creeks are undetectable in terms of the total catchment area. Therefore there would be no changes to flood levels or velocities in these waterways or in other sensitive downstream environments such as the Porters Creek SEP 14 Wetland.

Other smaller waterways would similarly be unaffected by the proposal as there are no changes to transverse drainage structures proposed. Any flow increases resulting from additional pavements would be minor and would be managed within the existing drainage systems. Additional scour protection would be installed on outlets where it is deemed to be required. New drainage systems at the interchanges and ramps would be designed with scour protection on pipe outlets where required to minimise any local erosion.

Discharges from the motorway may increase as a result of the additional pavement area. These increased discharges would not impact on the larger transverse discharges and would not contribute to any perceptible change in flood risk. The impacts of localised flow concentration would be mitigated by the provision of scour protection downstream of culverts and channels. Piped and channelised water would be directed to appropriate legal points of discharge to prevent localised flooding impacts on adjacent land.

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