SINCLAIR KNIGHT MERZ
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Cross River Rail

Environmental Impact Statement

Technical Report No. 6 – Flood study

July 2011

Cross River Rail

TECHNICAL REPORT NO. 6
FLOOD STUDY

JULY 2011

Contents

1 Introduction

1.1 The Project

The Project includes the construction of a range of surface infrastructure that has the potential to change the existing flood regime of waterways, drainage lines and overland flow paths in the study corridor. This includes permanent infrastructure such as surface stations, accesses for underground stations, ventilation buildings and emergency egress, surface tracks and stabling facilities, and bridges and elevated structures, as well as temporary infrastructure associated with construction activities (eg construction worksites).

This report assesses the potential changes to flooding in the study corridor due to the construction and operation of the Project. It describes the existing waterways and flood potential in the study corridor and assesses potential changes due to the Project. Measures are also recommended to mitigate potential impacts to manage any changes to flooding.

The potential impacts of the Project on surface water quality and outline strategies for protecting surface water quality are examined in *Technical Report No.5 – Surface Water Quality.*

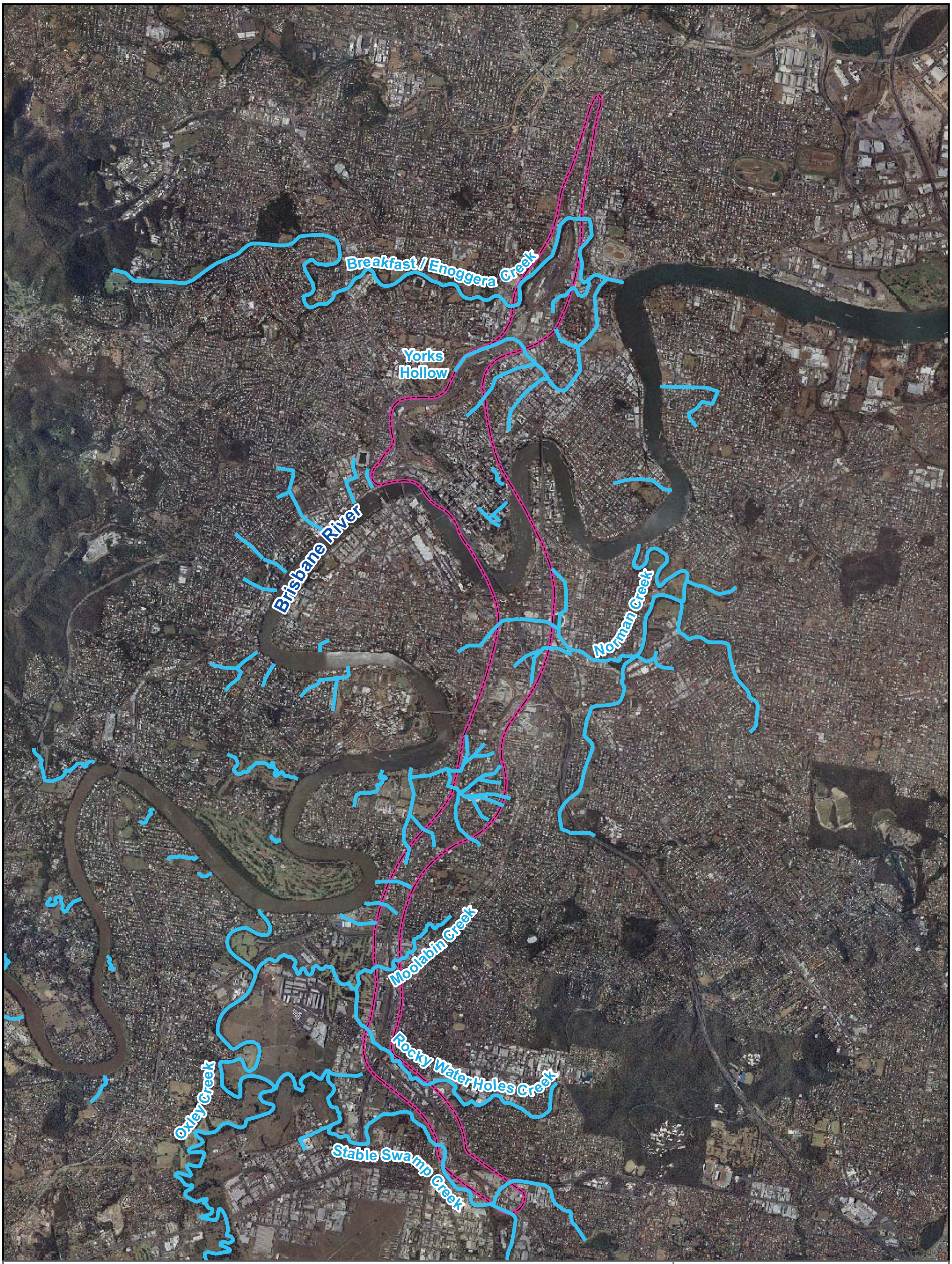
1.2 Study area

The study area for the flooding investigation is defined as the areas of potential interaction between the Project and waterways and floodplains. In some instances, the flooding study area extends outside the Project study corridor. For the purposes of the assessment, the study area has been broken into three regions – Wooloowin to Bowen Hills, Spring Hill to CBD and Woolloongabba to Salisbury. The study areas are presented on **Figure 1-1**.

1.3 Terms of reference

The Draft Terms of Reference relevant to floodplain management are as follows:

> *Due to the potential for the Project to alter drainage patterns, overland flows and the water table, a comprehensive flood study should be included in the EIS. The flood study should:*
>
> - *discuss the likelihood of flooding, history of flooding including extent, levels and frequency. The extent of flood modelling will be to the points at which no significant impact occurs. Flood studies will include a range of annual exceedance probabilities.*
> - *describe the influence on flooding of the effects of drainage or dewatering works, excavation, placement of fill, clearing or any other alterations to existing topography and landform within the study corridor and works sites*
> - *quantify the flood impacts on properties surrounding and external to the study corridor, supported by modelling of flood afflux and illustrated with maps*
> - *identify the likely increased flood levels, increased flow velocities or increased time of flood events as a result of the construction and operation of the Project*
> - *the potential for tunnel and station flooding should be assessed and mitigation measures developed if required based on design flood events*
> - *include details of all calculations along with descriptions of base data and triangulated surface meshes produced in terrain modelling software. Reference must be made to any studies undertaken by the local council in relation to flooding.*
> - *address any requirements of local or regional planning schemes for flood affected areas.*



LEGEND

Study Corridor

Tributaries

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 1-1

Study Areas for Flood Investigations

0 0.5 1 1.5 2 2.5 km

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2 Existing environment

2.1 Overall methodology

The flood potential in the study area needs to be assessed to understand how the Project may alter the existing flooding regime of the investigation area. This chapter describes the following:

- general flooding behaviour and recorded history of flooding of rivers, creeks and overland flow paths within the study area
- planning policy framework relevant to flooding within the study area
- likelihood of flooding within the study area under existing conditions.

These aspects have been assessed through a flood study of the study area.

The first step in the flood study was to identify the overland flowpaths, creeks and rivers within the study area. Overland flowpaths are discussed in **Section 2.1.1**. The creeks and rivers identified within the study area are:

- Breakfast Creek
- Campbell Street Drain
- Brisbane River
- Oxley Creek (and tributaries including Moolabin Creek, Rocky Waterholes Creek, and Stable Swamp Creek).

A literature review of previous studies was undertaken for each of these waterways. Where the literature review identified insufficient information to define the existing likelihood of flooding within the study area for the purposes of this Project, flood modelling was undertaken.

The potential for climate change to affect flooding within the study area was assessed using a standard methodology for each creek. The general approach to climate change is provided in **Section 2.4**.

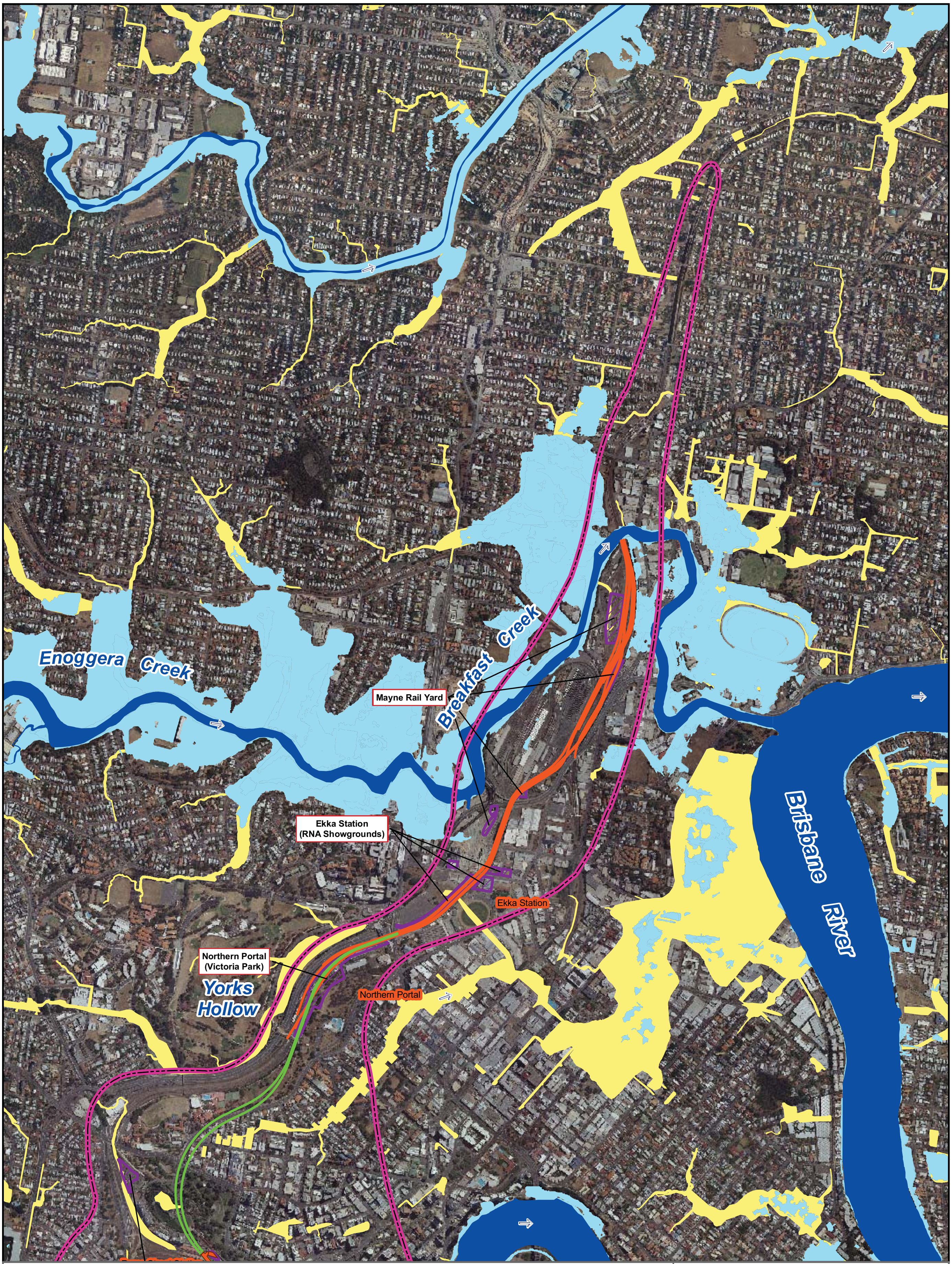
Flood modelling undertaken for this investigation is suitable for the purposes of impact assessment for an EIS. The methodology, modelling and flooding information provided within the following sections should not be relied on for purposes other than the EIS, such as for design.

Based on the results of the literature review and/or modelling a description of the flood potential within the study area was compiled and can be found in **Section 2.3.**

2.1.1 Overland flowpaths

Along the study corridor there are numerous overland flowpaths that interact with the study corridor. Overland flow paths are drainage lines that convey flow that are not part of a creek, river or waterway. These flowpaths are usually dry except in rainfall events. These overland flowpaths are typically activated in short duration, high intensity rainfall events.

Brisbane City Council (BCC) flood flag mapping identifies waterways, creeks and overland flow paths across Brisbane. **Figure 2-1** to **Figure 2-4** show the BCC flood flag mapping along the study corridor. The flood flag mapping was used in conjunction with Aerial Laser Survey (ALS) terrain to identify overland flow paths along the study corridor.



LEGEND

Study Corridor
Flow Direction
Waterways
Creeks, River or Tidal Flooding
Overland Flow Path

Alignment

Above Ground
Underground
Worksites

Flood Flag Map Data Source: Brisbane City Council (2009)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-1

Northern Study Areas Flood Flag Mapping

0 0.2 0.4 0.6 0.8 1 km

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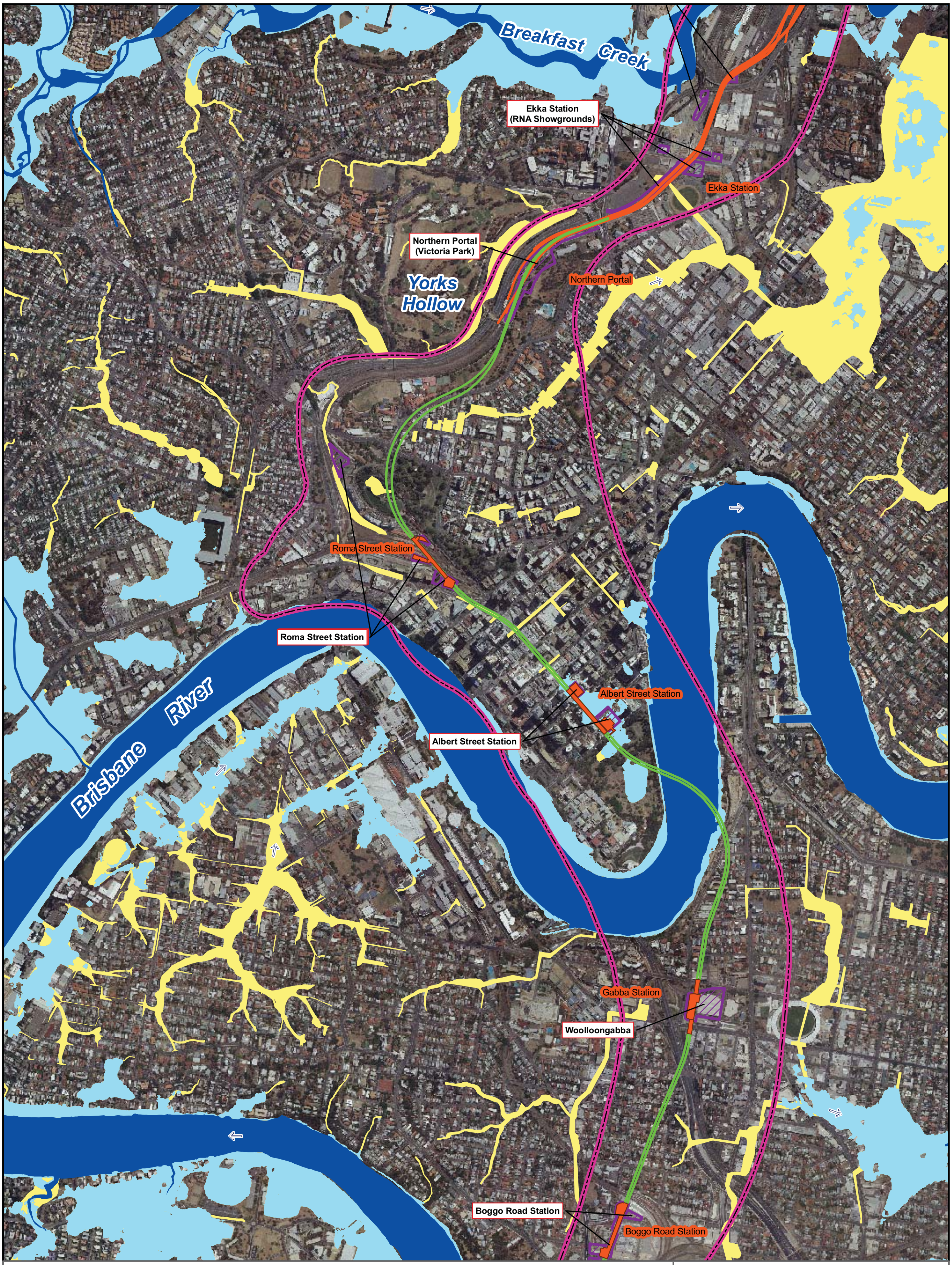

LEGEND

- Study Corridor
- Flow Direction
- Waterways
- Creeks, River or Tidal Flooding
- Overland Flow Path

Alignment

- Above Ground
- Underground
- Worksites

Flood Flag Map Data Source: Brisbane City Council (2009)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-2

**Central Study Areas
Flood Flag Mapping**

0 0.2 0.4 0.6 0.8 1 km

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LEGEND

- Study Corridor
- Flow Direction
- Waterways
- Creeks, River or Tidal Flooding
- Overland Flow Path

Alignment

- Above Ground
- Underground
- Worksites

Flood Flag Map Data Source: Brisbane City Council (2009)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-3

**Southern Study Areas
Flood Flag Mapping Part 1**

0 0.2 0.4 0.6 0.8 1 km

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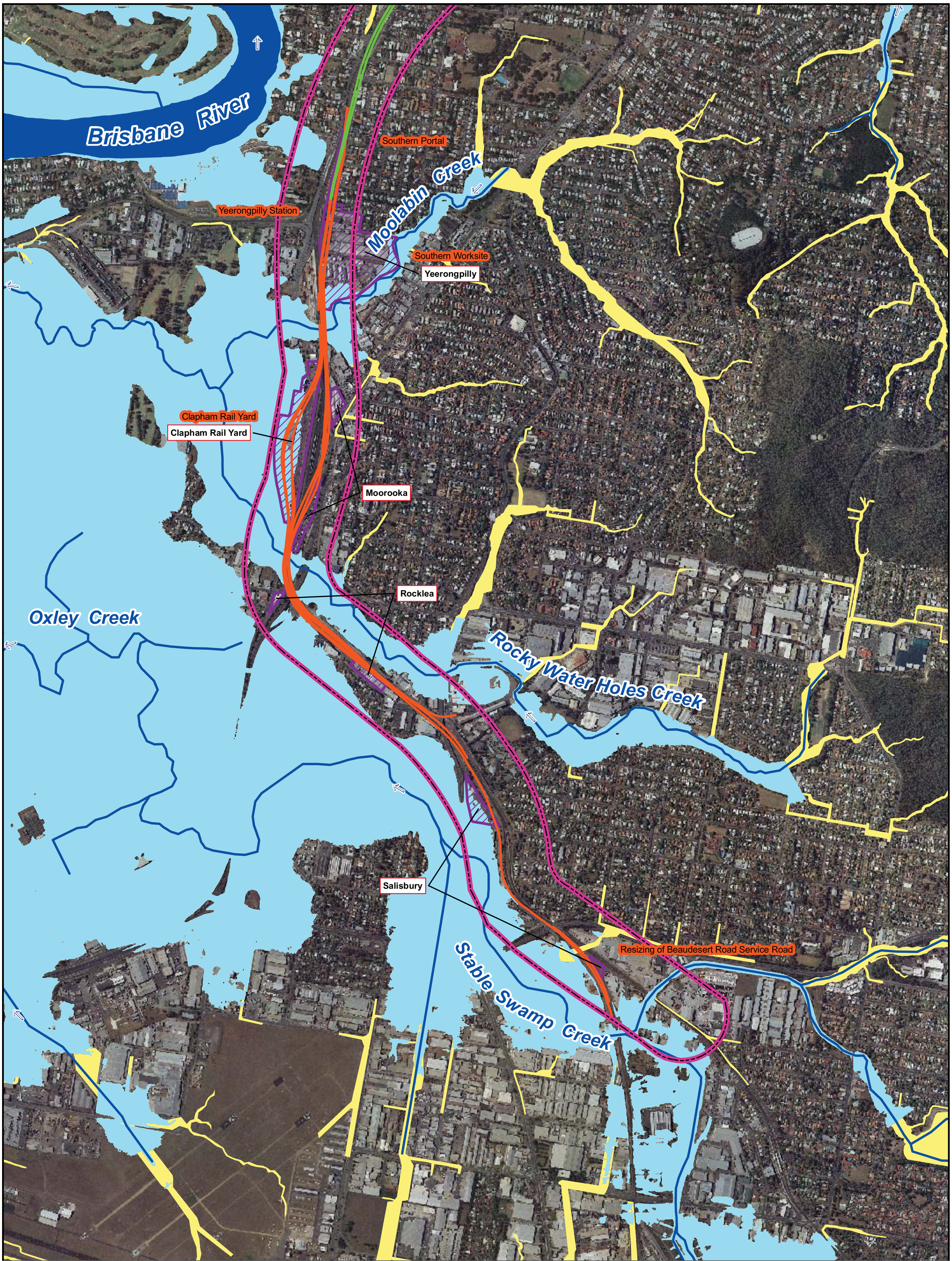

LEGEND

- Study Corridor
- Flow Direction
- Waterways
- Creeks, River or Tidal Flooding
- Overland Flow Path

CRR Alignment

- Above Ground
- Underground
- Worksites

Flood Flag Map Data Source: Brisbane City Council (2009)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-4

Southern Study Areas
Flood Flag Mapping Part 2

0 0.2 0.4 0.6 0.8 1 km

N

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2.1.2 Breakfast Creek

Breakfast Creek is a tributary of the Brisbane River that joins the river at Newstead. Breakfast Creek is known as Enoggera Creek upstream of Three Mile Scrubs in Kelvin Grove.

The following flood studies have previously been conducted for Breakfast Creek:

- Draft Breakfast/Enoggera Creek Flood Study (BCC City Design, 1999)
- Draft Breakfast/Enoggera Creek Flood Study (BCC City Design, 2007).

Breakfast Creek has a long history of flooding, affecting both residences and commercial properties. One of the measures that BCC has employed to manage flooding on Breakfast Creek is to regularly dredge the creek mouth to improve flood conveyance and lower flood levels.

Numerous bridges, elevated structures and surface works have been recently constructed, are constructed or are proposed to be constructed in the area of the Breakfast Creek floodplain upstream of the Brisbane River confluence associated with the Inner City Bypass (ICB), Inner Northern Busway, Clem7 and Airport Link projects. However, the proposed surface works for Cross River Rail would not impinge on the current floodplain (ie the inundated area of the defined flood event) of Breakfast Creek, as it can be seen in **Figure 2-5**.

2.1.3 Campbell Street Drain

The Campbell Street Drain is a piped drainage system located west and east of the ICB and has a catchment of approximately 1.5 km². The catchment incorporates the Victoria Golf Course and Kelvin Grove. The channel drains to an underground network which conveys flow under the RNA Showgrounds, discharging into Breakfast Creek upstream of Horace Street.

The underground drainage network in this catchment accommodates flood events to a certain size/ frequency. For larger, rarer flood events, the excess of flow from the RNA catchment only would discharge through the RNA Showgrounds, flowing to the Brisbane River through Newstead. The catchment to the west of the RNA Showgrounds area would not result in overland flows through the RNA Showgrounds due to the blockage of overland flows formed by Bowen Bridge Road.

LEGEND

- Study Corridor
- Flow Direction
- Waterways
- Creeks, River or Tidal Flooding
- Worksites

Alignment

- Above Ground
- Underground

Flood Flag Map Data Source: Brisbane City Council (2009)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-5

Breakfast Creek Flooding Mapping

0 0.08 0.16 0.24 0.32 0.4 km

N

1:10,000 at A4

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2.1.4 Brisbane River

The Brisbane River runs through the centre of Brisbane. It runs to the west of the study corridor in the Woolloongabba to Salisbury study area, crosses the study corridor within Spring Hill to CBD study area and runs to the east of the study corridor in the Wooloowin to Bowen Hills study area.

The flooding associated with the Brisbane River are long duration rainfall events, as opposed to the flash flooding in the creeks. The floods in the Brisbane River can significantly damage the CBD, as was the case in the 1974 floods.

Previous studies

Numerous studies have previously been commissioned by the Brisbane City Council (BCC) and Ipswich City Council (ICC) to describe flooding in the Brisbane River. The most relevant (and recent) are listed below:

- Brisbane River Flood Study (SKM for BCC, 1998)
- Ipswich Rivers Flood Studies Phase One and Phase Two (SKM for ICC, 2000)
- Recalibration of the MIKE11 Hydraulic Model and Determination of the 1 in 100 AEP Flood Levels (SKM for BCC, 2004a)
- Calculation of Floods of Various Return Periods on the Brisbane River (SKM for BCC, 2004b)
- Northern Link Technical report No. 6 – Flooding (SKM-Connell Wagner JV for BCC, 2008).

Each of these studies was based on the modelling undertaken for the previous study, progressively developing the hydrologic and hydraulic models of the Brisbane River. The hydrologic model of the Brisbane River is constructed in the modelling software platform *XP-RAFTS*, while the hydraulic model uses the *MIKE11* one-dimensional (1-D) hydrodynamic modelling software. Permission to access and use these models for Cross River Rail was obtained from BCC, as custodian. These models were then used as the starting point for the models developed for the assessment of Cross River Rail.

Hydrologic modelling

The Brisbane River catchment upstream of the Brisbane CBD covers an area of approximately 13,000 km² and includes both Somerset and Wivenhoe Dams.

Hydrologic modelling for the 1 in 100 AEP event was adopted from SKM (2004a).

Permission was obtained from BCC and Seqwater to use this previous hydrologic modelling. Information provided by Seqwater and included in this model regarding flood operations of Wivenhoe Dam remains Commercial in Confidence. Seqwater are currently reviewing flood operations for Wivenhoe Dam. This would be incorporated into the hydrologic modelling in the future, if it becomes available.

Hydraulic modelling

A two-dimensional (2-D) hydraulic model of the Brisbane River from the Centenary Bridge to the Gateway Bridge was developed. The hydraulic model was developed using the *TUFLOW* flood modelling software. The model was developed to represent regional Brisbane River flooding and has not been used to assess local or tributary flooding within the study corridor.

Multiple terrain sources were used in building the hydraulic model. The data types and their sources are as follows:

- 2007 ALS 1m resolution terrain supplied by BCC
- 2009 ALS 1m resolution terrain supplied by Department of Transport and Main Road (DTMR)

- Brisbane River bathymetric data owned by Port of Brisbane Corporation and supplied by BCC.

The different terrain sources were combined in the *TUFLOW* flood modelling software to produce a composite two-dimensional surface with a 30 m grid resolution. Creek tributaries (eg Oxley Creek, Bulimba Creek, Norman Creek) were represented with sufficient detail to ensure river floodwaters back-flooded the flood storage of these tributary floodplains.

Manning's n values were determined with the aid of aerial photography. Manning's n is a measure of hydraulic roughness in the model area. **Table 2-1** presents the adopted roughness parameters.

Table 2-1 Adopted Manning's 'n' Values

Land Use	Manning's 'n' value
Parkland	0.040
Commercial	0.300
CBD	0.500
Waterways – upper reach	0.040
Waterways – lower reach	0.034
Roads	0.020
Residential	0.300

Inflows to the *TUFLOW* model were derived from the results of the Brisbane River *XP-RAFTS* and *MIKE11* models developed for the previous studies discussed above. Inflow hydrographs at the Centenary Bridge were extracted from the previous MIKE11 models and input into the *TUFLOW* model at that location. Additional minor source inflows downstream of the Centenary Bridge were extracted directly from the XP-RAFTS hydrologic model and incorporated into the *TUFLOW* model.

A dynamic level time series was adopted as the downstream boundary at the Gateway Bridge. The previous MIKE11 models were re-run with the adopted tidal conditions and a water level time series extracted at the Gateway Bridge.

The Brisbane River was simulated for a range of events. The events simulated are 1 in 20, 50 and 100 AEP. Peak flood levels and depths from these model simulations are presented in **Figure 2-7** to **Figure 2-9**.

The TUFLOW model was also validated against the existing MIKE11 model for the 1 in 100 AEP flood.

History of Brisbane River flooding

The Brisbane River has a long history of flooding with records extending back to the 1840's. Brisbane experienced several large flood events in the 1800's with Brisbane's largest recorded flood in 1841. This flood had a recorded flood level of 8.43 m AHD in the CBD at the Port Office gauge. This was followed by another large flood event in 1844 recorded at 7.03 m AHD. Two more large flood events were recorded in the 1890's.

Brisbane's largest flood in this century was in January 1974. This flood was measured at 5.45 m AHD at the Port Office gauge.

The most recent Brisbane River flood event was in January 2011. This flood was measured at 4.46 m AHD at the Port Office Gauge (BCC, 2011).

Wivenhoe Dam was completed in 1985. This changed the storage characteristic of the upper Brisbane River catchment. This has the effect of lessening the effect of all subsequent Brisbane River floods.

Table 2-2 lists some of the historical flood events recorded at the Port Office gauge.

Table 2-2 Historical Brisbane River Floods

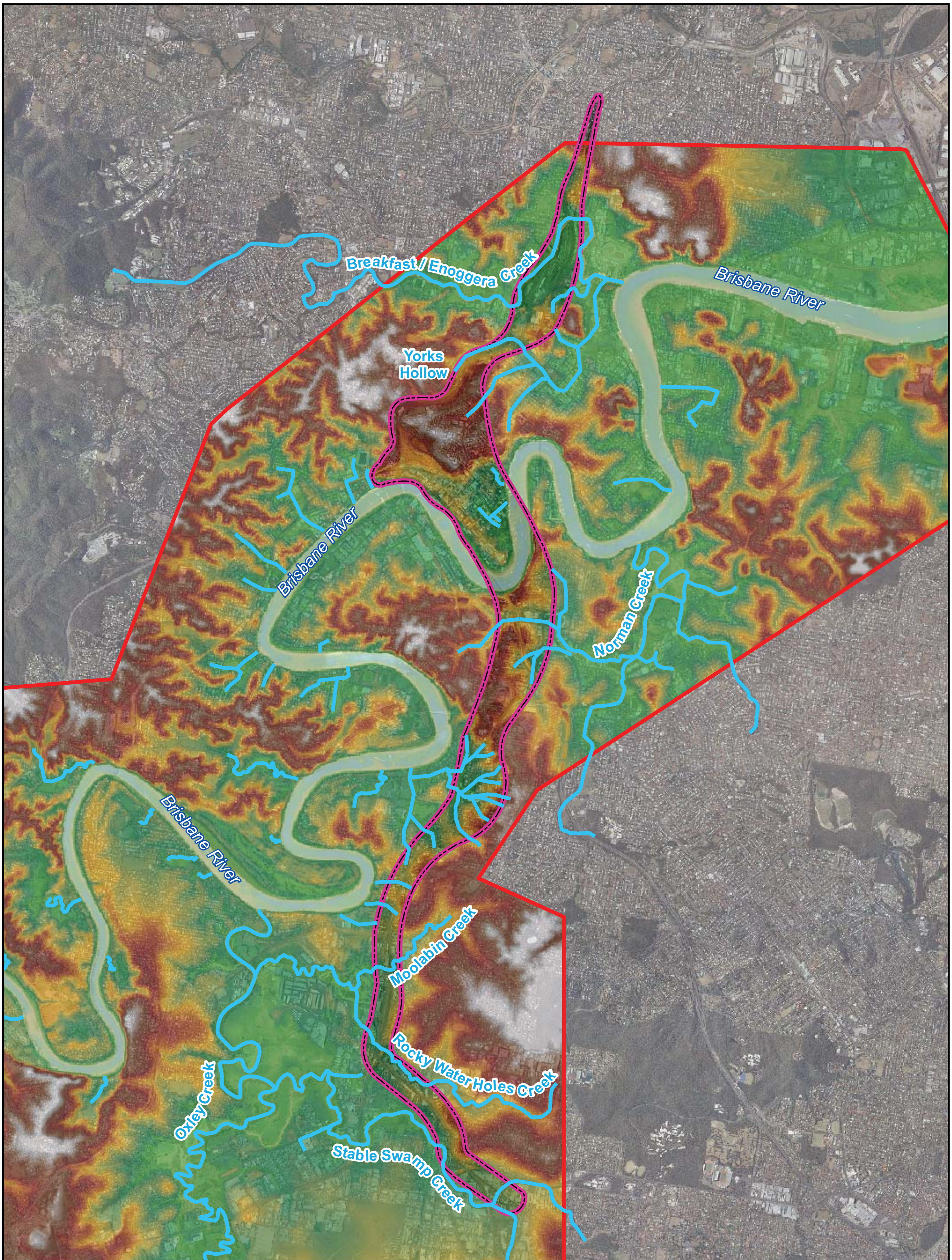
Date	Peak Water level (mAHD)
January 1841	8.43
February 1844	7.03
February 1893	8.35
January 1898	5.02
February 1831	3.32
March 1955	2.36
January 1974	5.45
May 1996	2.70
February 1999	1.41
January 2011	4.46

Limitations

SKM (2008a) noted that the hydrologic modelling of the Brisbane River (adopted for this study) is sensitive to catchment losses, dam operations and the location of the centre of the storm. This sensitivity is due to the size of the catchment and the long duration of critical storms. This means that the storage volume of the Brisbane River is the dominant flood characteristic.

All flood levels predicted in this study, and subsequent conclusions and recommendations drawn about the existing conditions, are subject to key limitations:

- Information relating to the operation of Wivenhoe Dam was drawn from Seqwater. This information is Commercial in Confidence and all subsequent work for this study must be done with the full cooperation and consent of Seqwater.
- Flood levels in the Brisbane River through the study corridor will also be sensitive to future development in the floodplain.



LEGEND

Study Corridor
Model Area
Tributaries

Model Terrain Data (m AHD)
High : 60
Low : -15

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-6

Overview of Brisbane River Flood Model

0 0.5 1 1.5 2 2.5 km
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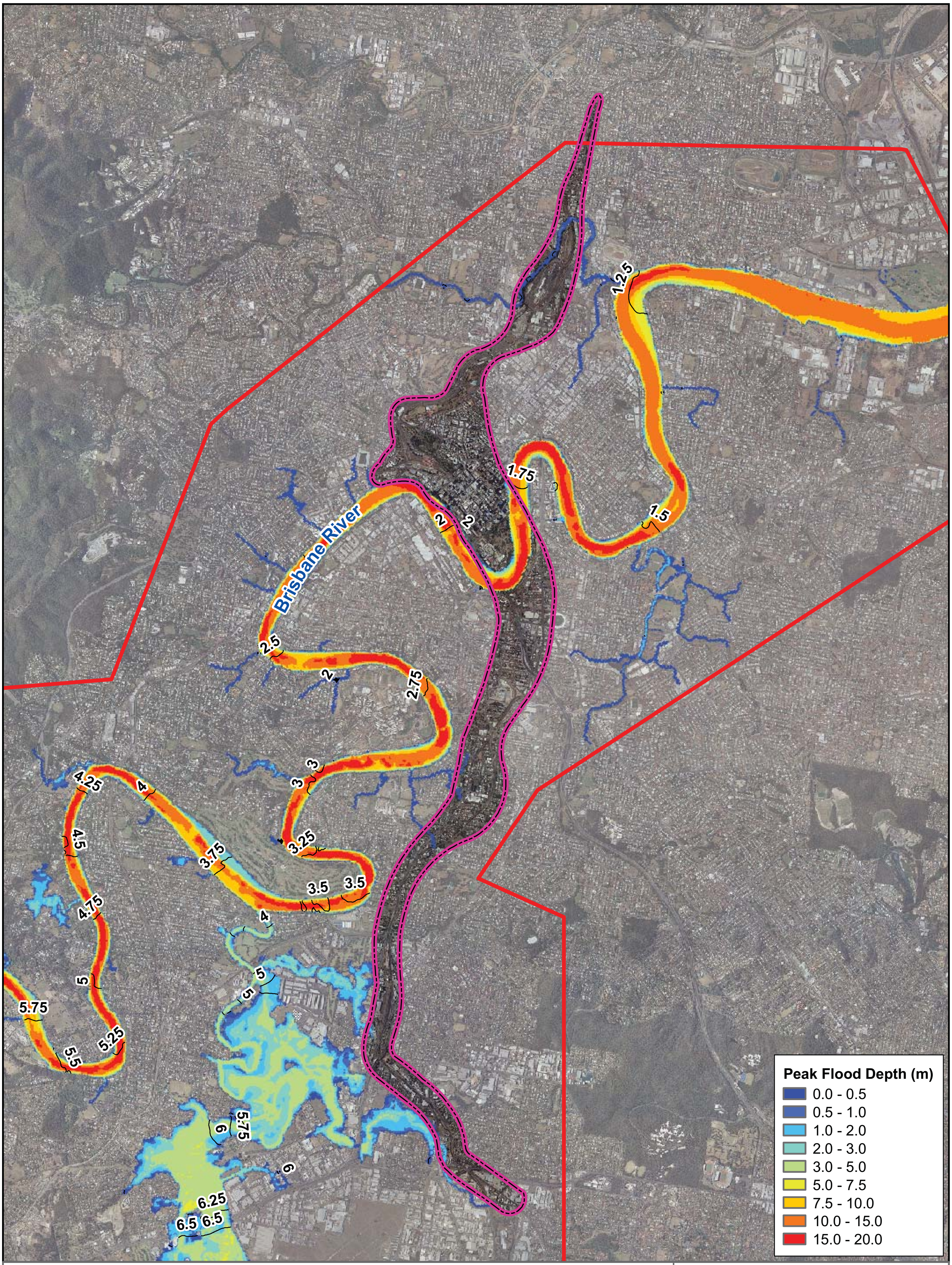

LEGEND

- Study Corridor
- Model Area
- Peak Flood Level (m AHD)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-7

**Brisbane River Flooding
1 in 20 AEP Flood Extent**

0 0.5 1 1.5 2 2.5 km

1:75,000 at A4

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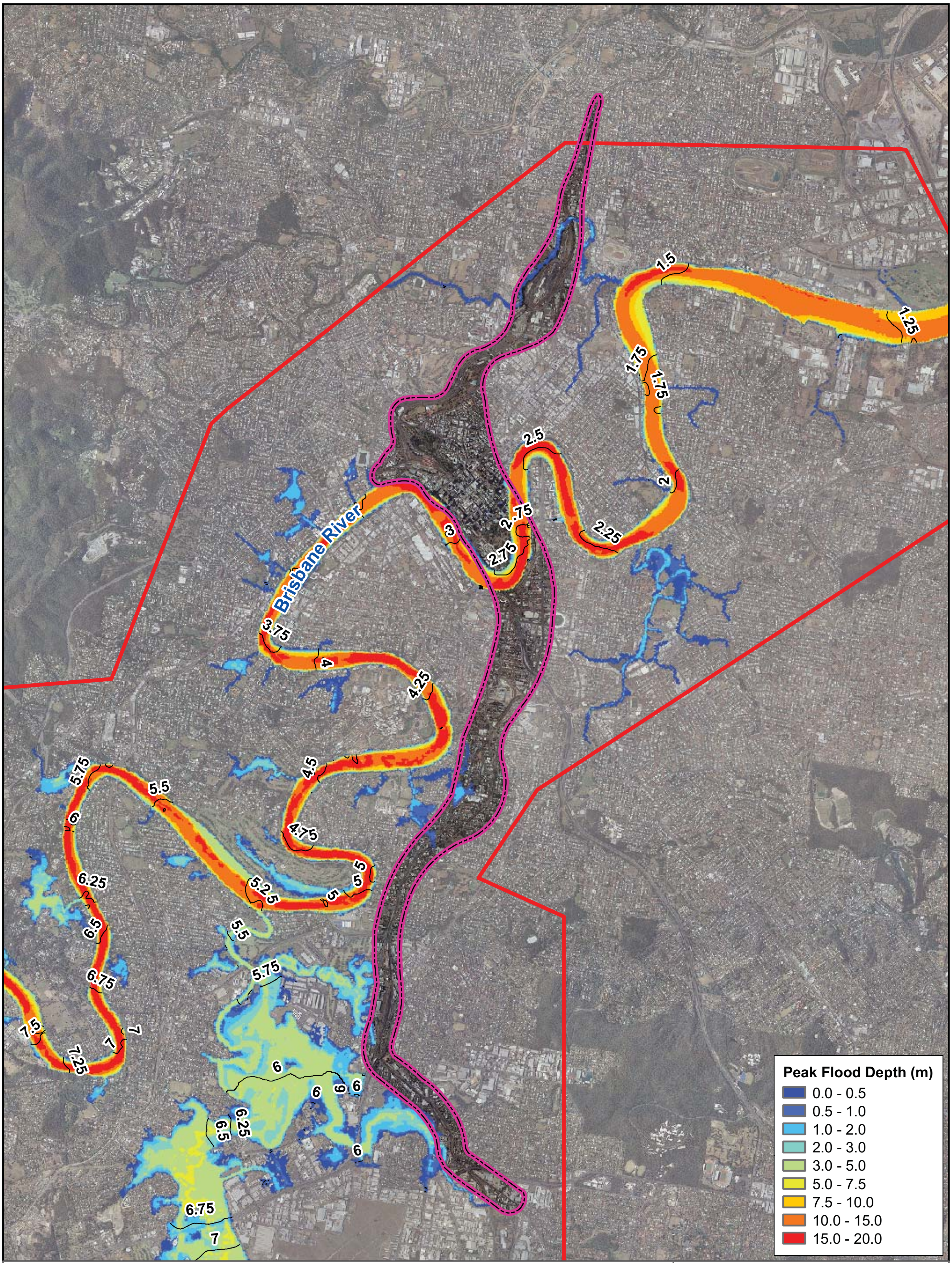

LEGEND

Study Corridor

Model Area

Peak Flood Level (m AHD)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-8

Brisbane River Flooding
1 in 50 AEP Flood Extent

0 0.5 1 1.5 2 2.5 km

1:75,000 at A4

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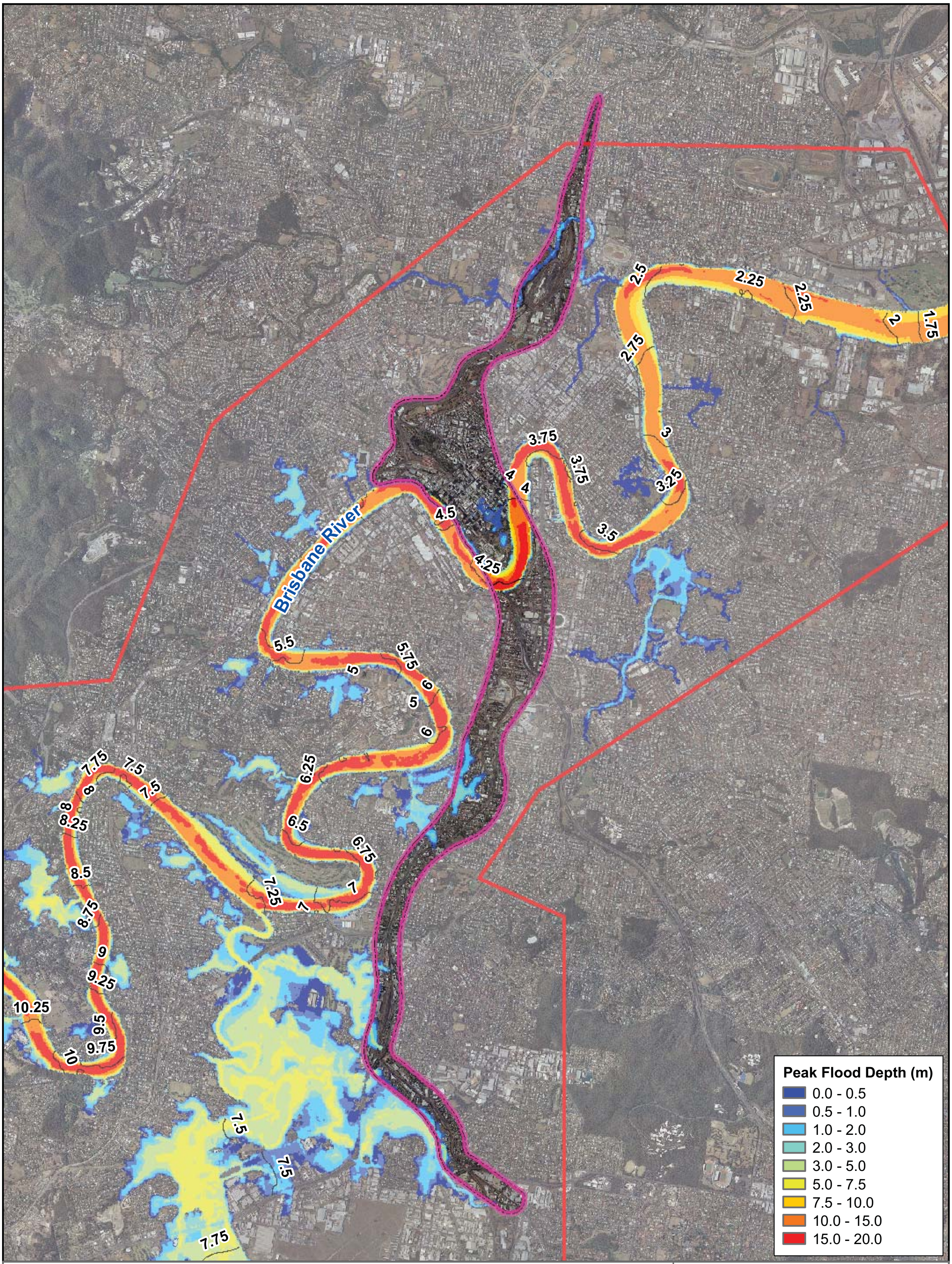

LEGEND

- Study Corridor
- Model Area
- Peak Flood Level (m AHD)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-9

Brisbane River Flooding
1 in 100 AEP Flood Extent

0 0.5 1 1.5 2 2.5 km

1:75,000 at A4

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2.1.5 Moolabin Creek

Moolabin Creek is a tributary of Oxley Creek located approximately two kilometres upstream of the Brisbane River outlet for Oxley Creek. It is located in the Woolloongabba to Salisbury study area.

Previous modelling of Moolabin Creek has been undertaken by City Design in the form of a MIKE11 model run concurrently with Rocky Waterholes Creek. This MIKE11 model was run in version 4.01.

Hydraulic modelling

A combined one-dimensional and two-dimensional model of Moolabin Creek was created using MIKEFLOOD software. MIKEFLOOD links the two-dimensional hydraulic modelling package MIKE21 to the one-dimensional hydraulic modelling package MIKE11. This allows for detailed one-dimensional modelling of hydraulic structures inside a two-dimensional model of the waterway and floodplain.

The terrain information was sourced from the Department of Transport and Main Roads (DTMR) in the form of an ALS of 1 m resolution. The grid size was changed to 3 m resolution to optimise model run times. The model terrain extent covers the most upstream extent of Moolabin Creek to the point where it converges with Rocky Waterholes Creek. The MIKEFLOOD model extent can be seen in **Figure 2-10**.

The hydraulic roughness, represented by Manning’s n values, was allocated using aerial photography and information collected through a site visit. **Table 2-3** shows the adopted Manning’s n values.

Table 2-3 Manning’s n values for Moolabin Creek hydraulic model

Land Use	Manning's n value
Grassed	0.04
Residential and Industry	0.08
Waterways	0.04
Railway	0.1
Roads	0.013
Houses in Floodplain	1

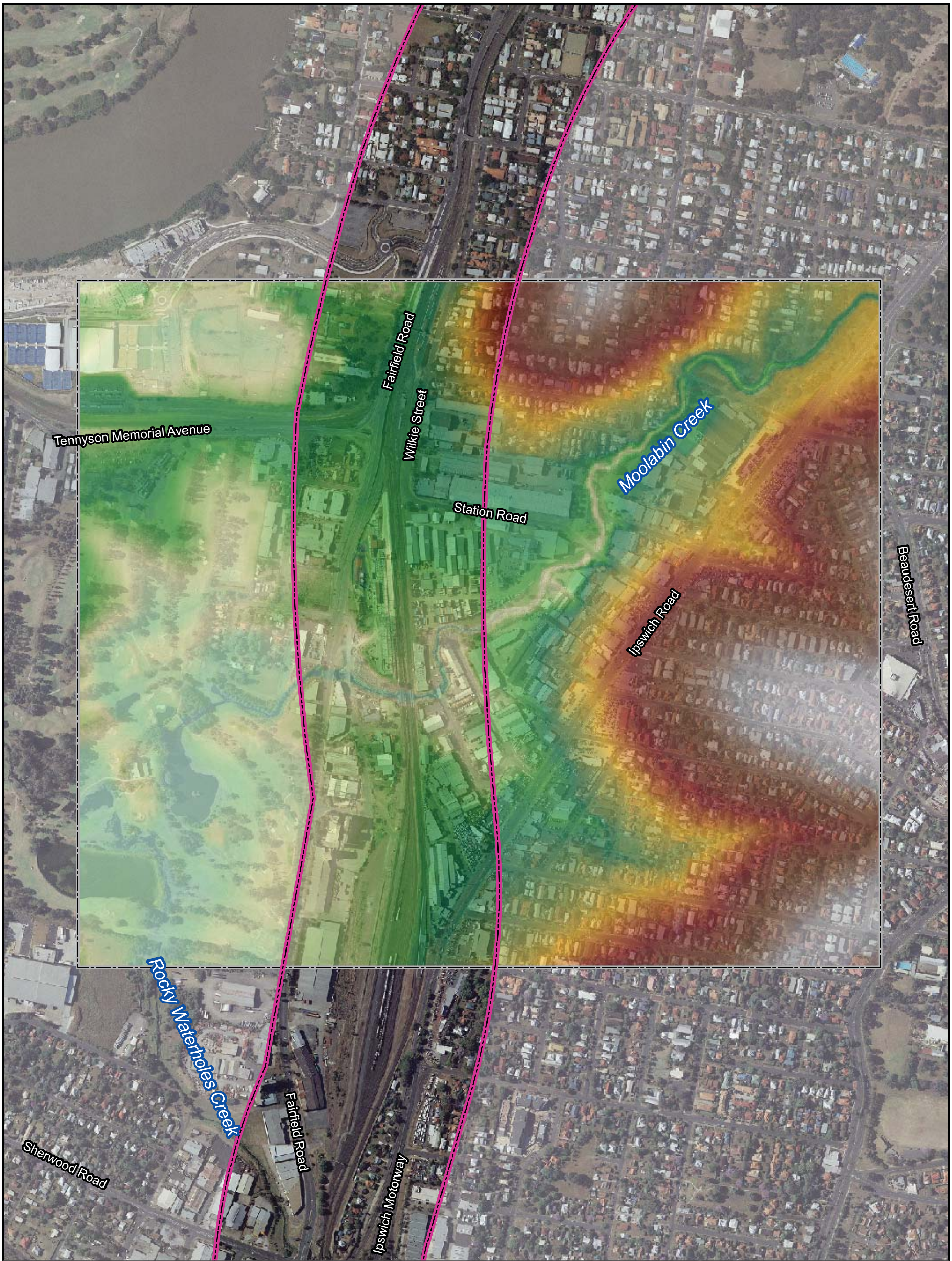
The structures from the original MIKE11 were incorporated into the MIKEFLOOD model. Inflow hydrographs were also obtained from the MIKE11 model inputs. The existing railway bridge deck was not included in the structures, as the deck level for this bridge was above the 1 in 100 year AEP water level reported in the City Design model.

The existing 12 piers in the floodplain, of which six are in the waterway, were represented in the existing model by pier resistance. In the operations scenario, an additional 12 piers was incorporated into the modelling. Out of the 12 piers, one pier was located in the waterway.

A dynamic level time series was extracted from the MIKE11 results and used as the downstream boundary where Moolabin Creek meets Rocky Waterholes Creek.

Existing case scenario

The existing case scenario was run for the 1 in 100 AEP storm. The flood extent is mapped in **Figure 2-11**. Based on these flood model results, peak 1 in 100 AEP flood levels through the study area vary from 8.6 m AHD to 6.7 m AHD.



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LEGEND

Study Corridor

Model Area

Model Terrain Data (m AHD)

High : 40

Low : 1

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-10

Overview of Moolabin Creek Flood Model

0 50 100 150 200 250 m

1:10,000 at A4

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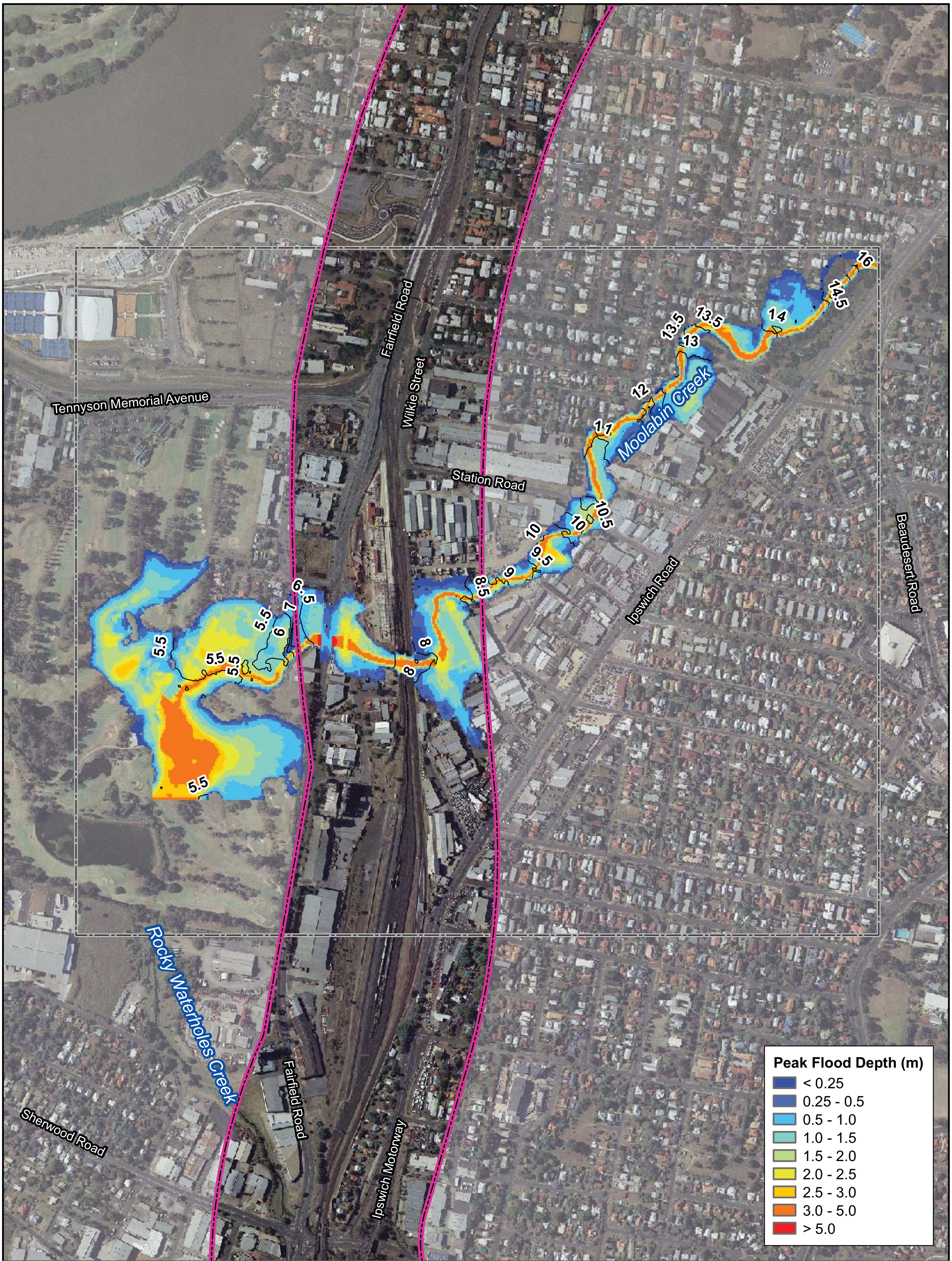

LEGEND

Study Corridor

Model Area

Peak Flood Level (m AHD)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-11

Moolabin Creek Flooding
1 in 100 AEP Flood Extent

0 50 100 150 200 250 m

1:10,000 at A4

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2.1.6 Rocky Waterholes Creek

Rocky Waterholes Creek is also a tributary of Oxley Creek. It joins Moolabin Creek approximately two kilometres upstream from the Oxley Creek outlet. It is located in the Woolloongabba to Salisbury section of the study area.

Hydraulic modelling

Inputs were taken from the City Design MIKE11 model to create a *TUFLOW* model which covers Rocky Waterholes Creek from Beaudesert Road to 200 m downstream of Fairfield Road. The model extent is shown in **Figure 2-12**.

The hydraulic roughness for the hydraulic model was determined using aerial photos and a site visit. The values adopted are shown in **Table 2-4**.

Table 2-4 Manning's n values for Rocky Waterholes Creek hydraulic model

Land Use	Manning's n value
Parkland	0.04
Residential	0.3
Commercial	0.3
Roads	0.02
Waterway	0.06

The MIKE11 structures within the hydraulic model extent were extracted from the City Design model and put into the *TUFLOW* model. Discharge hydrographs from the City Design MIKE11 model results were taken as the upstream flow boundary.

The existing piers for the numerous existing rail bridges crossing the creek and road were represented in the model.

Existing case scenario

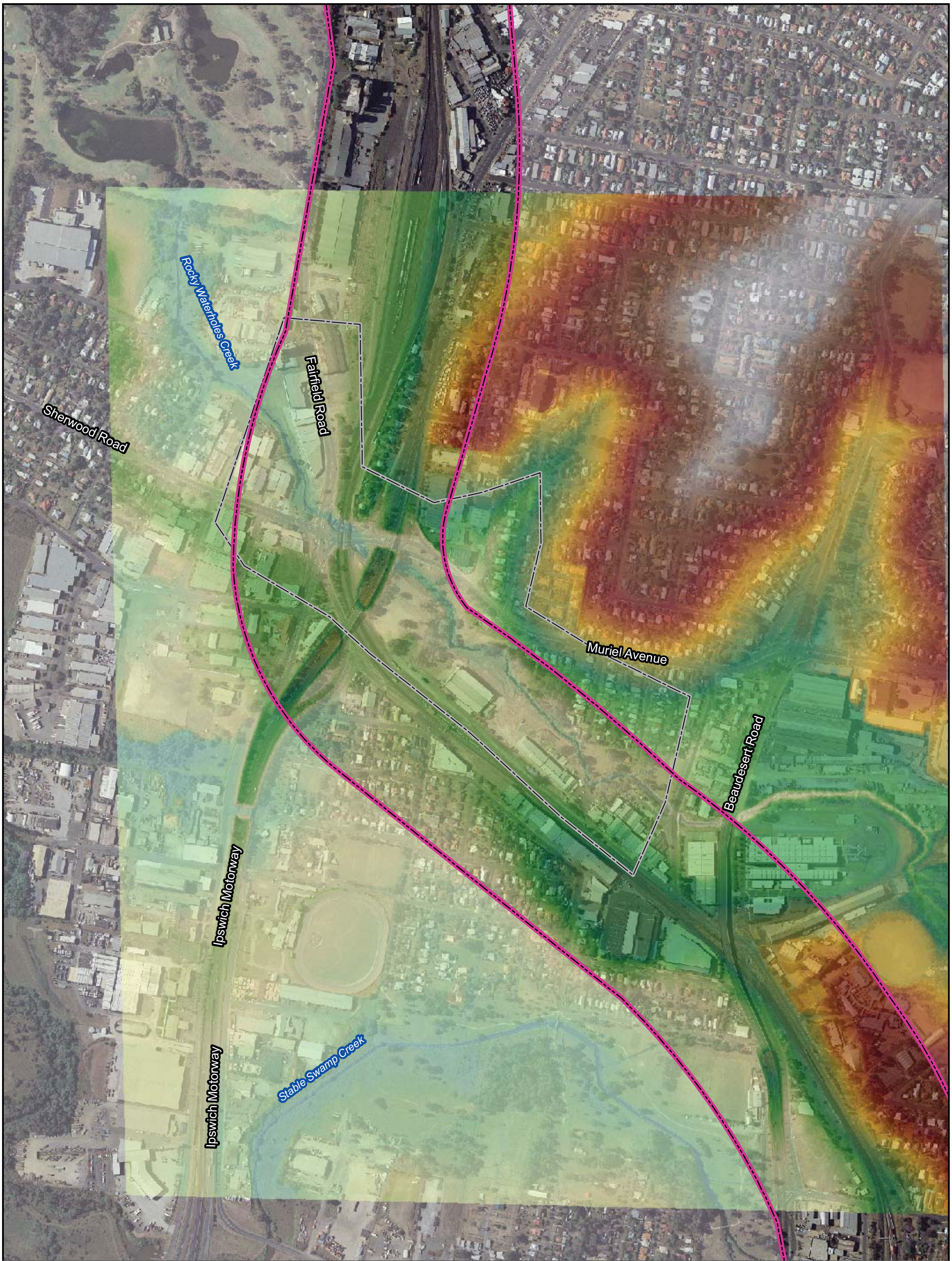
The 1 in 100 AEP flood levels and depths under existing conditions is shown in **Figure 2-13**. Based on these flood model results, peak 1 in 100 AEP flood levels through the study area vary from 6.4 m AHD at Fairfield Road to 6.8 m AHD at Ipswich Road (under the bridge).

Flood velocities over the Muriel Avenue area are relatively high and in the order of 1 to 2 m/s.

2.1.7 Stable Swamp Creek

Stable Swamp Creek is one of the main tributaries of Oxley Creek. It joins Oxley Creek at Corinda. Stable Swamp Creek has been modelled previously by BCC in the form of a one-dimensional hydraulic model using MIKE11 flood modelling software.

Figure 2-4 shows the envelope of Oxley Creek and Stable Swamp Creek flood inundation. Based on these flood model results, peak 1 in 100 AEP flood levels at Beaudesert Road are approximately 6.2 m AHD.



LEGEND

Study Corridor

Model Area

Model Terrain Data (m AHD)

High : 40

Low : 1

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-12

Overview of Rocky Waterholes Creek Flood Model

0 50 100 150 200 250 m

1:10,000 at A4

N

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

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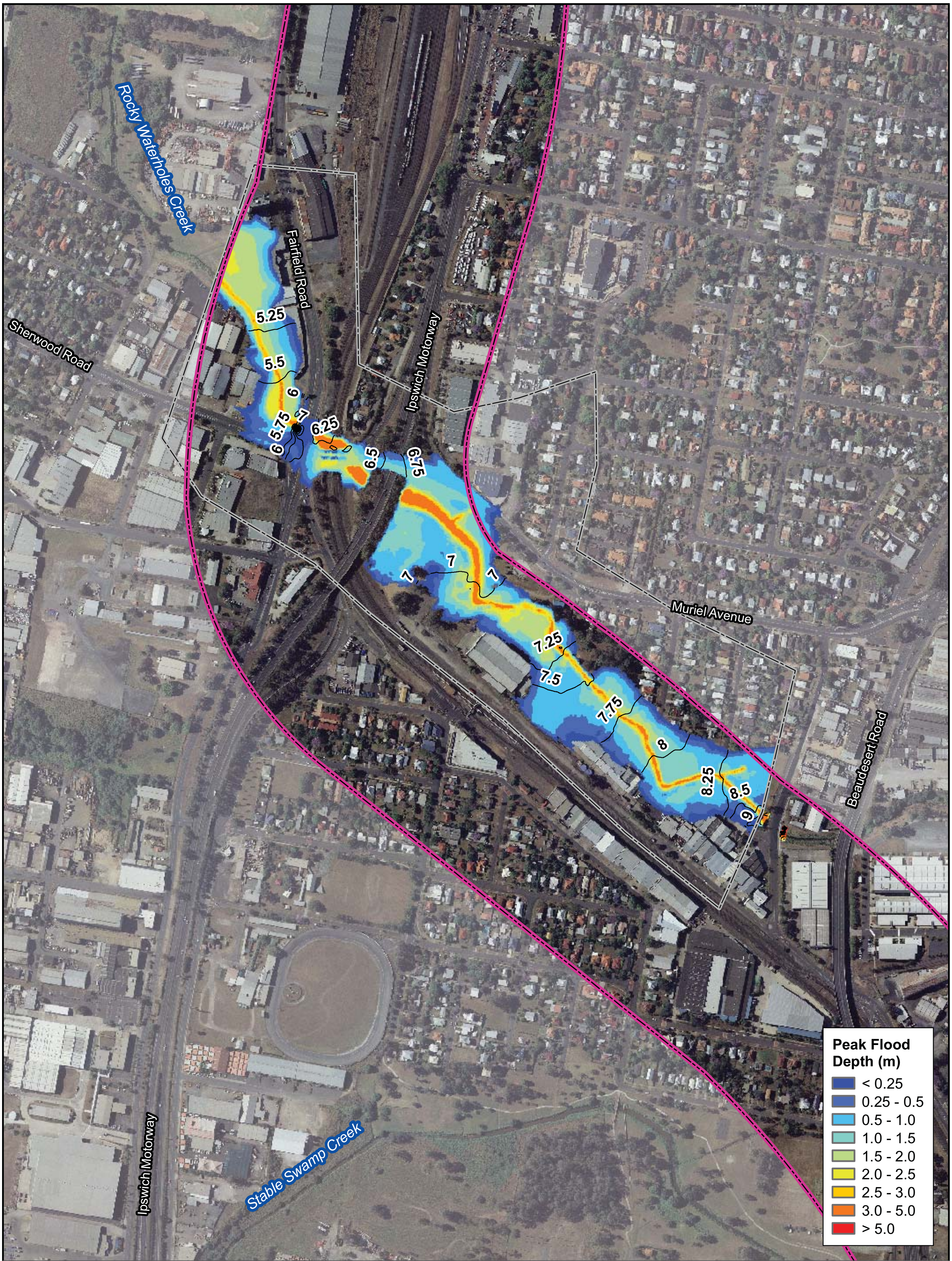

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LEGEND

Study Corridor

Model Area

Peak Flood Level (m AHD)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-13

Rocky Waterholes Creek Flooding
1 in 100 AEP Flood Extent

0 50 100 150 200 m

1:7,500 at A4

N

CrossRiverRail

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2.1.8 Oxley Creek

Oxley Creek is a major tributary of the Brisbane River that joins the river at Tennyson. There are three main tributaries leading into Oxley Creek, these include Moolabin Creek, Stable Swamp Creek and Rocky Waterholes Creek.

Oxley Creek has been modelled previously for the *Draft Oxley Creek Flood Study* (BCC City Design, 2006). This study was reviewed as part of this investigation.

Figure 2-4 shows the extent of flooding for Brisbane River, Oxley Creek and Stable Swamp Creek flood events.

2.2 Policy framework

This section outlines the flooding policy framework for Cross River Rail including *Brisbane City Plan 2000* (BCC, 2003), The *South East Queensland Regional Plan 2009-2031* (SEQRP) (Queensland Department of Infrastructure and Planning, 2009) and State Planning Policy 1/03.

Brisbane City Plan 2000 (BCC, 2003) and associated planning codes provide guidelines on development within flood affected areas. The following planning codes relate to the Project:

- stormwater management code
- filling and excavation Code
- waterway code.

The Brisbane City Plan 2000 planning codes listed above call on the Subdivision and Development Guidelines and Environmental Best Management Practice for Erosion and Sediment Control for Waterways and Wetlands (BCC, 1996).

The SEQRP 2009-2031 (Queensland Department of Infrastructure and Planning, 2009) provides principles and policies for the following areas which are related to the Project:

- natural hazards and climate change adaptation
- overland flow and flood management
- management of natural hazards.

The floodplain covered in the Project will be managed responsibly, by avoiding high-risk areas and developing flood mitigation measures where appropriate. The Project will comply with the policies outlined below.

The natural hazards and climate change adaptation principle and policies are as follows:

> *"Principle*
>
> *Increase the resilience of communities, development, essential infrastructure, natural environments and economic sectors to natural hazards including the Projected effects of climate change.*
>
> *Policies*
>
> *1.4.1 Reduce the risk from natural hazards, including the Projected effects of climate change, by avoiding areas with high exposure and establishing adaptation strategies to minimise vulnerability to riverine flooding, storm tide or sea level rise inundation, coastal erosion, bushfires and landslides.*

1.4.2 Reduce the risk from natural hazards, including the Projected effects of climate change, by establishing adaptation strategies to minimise vulnerability to heatwaves and high temperatures, reduced and more variable rainfall, cyclones and severe winds, and severe storms and hail.

1.4.3 Planning schemes and development decisions shall be in accordance with the Queensland Coastal Plan, including the range of potential sea level rises."

The overland flow and flood management principle and policies as outlined in The *SEQRP2009-2031* (Queensland Department of Infrastructure and Planning, 2009) are as follows:

"Principle

Provide necessary flood immunity for infrastructure and buildings, and resilience to potential climate change flooding, while seeking to maintain the natural flow regime.

Policies

11.6.1 Avoid areas of unacceptable flood risk, including additional risks from climate change, and areas where development may unacceptably increase flood risk elsewhere.

11.6.2 Achieve acceptable flood immunity through water sensitive movement and detention infrastructure that minimises alterations to natural flow regimes, including floodplain connectivity."

The *SEQRP 2009-2031* (Queensland Department of Infrastructure and Planning, 2009) also provides principles for the management of natural hazards.

"Principle

Reduce community risk and exposure to the adverse impacts of natural hazards such as flood, storm tide, bushfire and landslide.

Policies

2.6.1 Address the potential impacts of flood, storm tide, bushfire and landslide through land use planning, development assessment and land management practices.

2.6.2 Coordinate regional data sets and apply a consistent approach in identifying natural hazard areas and associated risks to inform land use planning, development assessment and disaster management plans."

The notes associated with this principle include references and direction to State Planning Policy 1/03 as follows.

The State Planning Policy 1/03 (Department of Local Government and Planning and Department of Emergency Services, 2003), applies to community infrastructure that "*provide services vital to the wellbeing of the community*" including railway lines, stations and associated facilities. State Planning Policy 1/03 states the following outcomes relating to natural hazard to community infrastructure.

"Outcome 1: Within natural hazard management areas, development to which this SPP applies is compatible with the nature of the natural hazard, except where:

- *the development proposal is a development commitment; or*
- *there is an overriding need for the development in the public interest and no other site is suitable and reasonably available for the proposal.*

Outcome 2: Development that is not compatible with the nature of the natural hazard but is otherwise consistent with Outcome 1:

- *minimises as far as practicable the adverse impacts from natural hazards; and*
- *does not result in an unacceptable risk to people or property.*

Outcome 3: Wherever practicable, community infrastructure to which this SPP applies is located and designed to function effectively during and immediately after natural hazard events commensurate with a specified level of risk."

2.3 Discussion of flood potential within the study area

The previous sections have assessed the waterways in the study area and their existing flood potential. This section provides an overview of how each of the Project elements (from North to South) interacts with flooding from creeks, rivers, and overland flow paths.

2.3.1 Wooloowin to Bowen Hills

The Wooloowin to Bowen Hills part of the study area is defined as the portion from the northern extent of the study corridor to Spring Hill. This section of the study area is shown in **Figure 2-14**. The flooding behaviour of this part of the study area is potentially affected by the following watercourses:

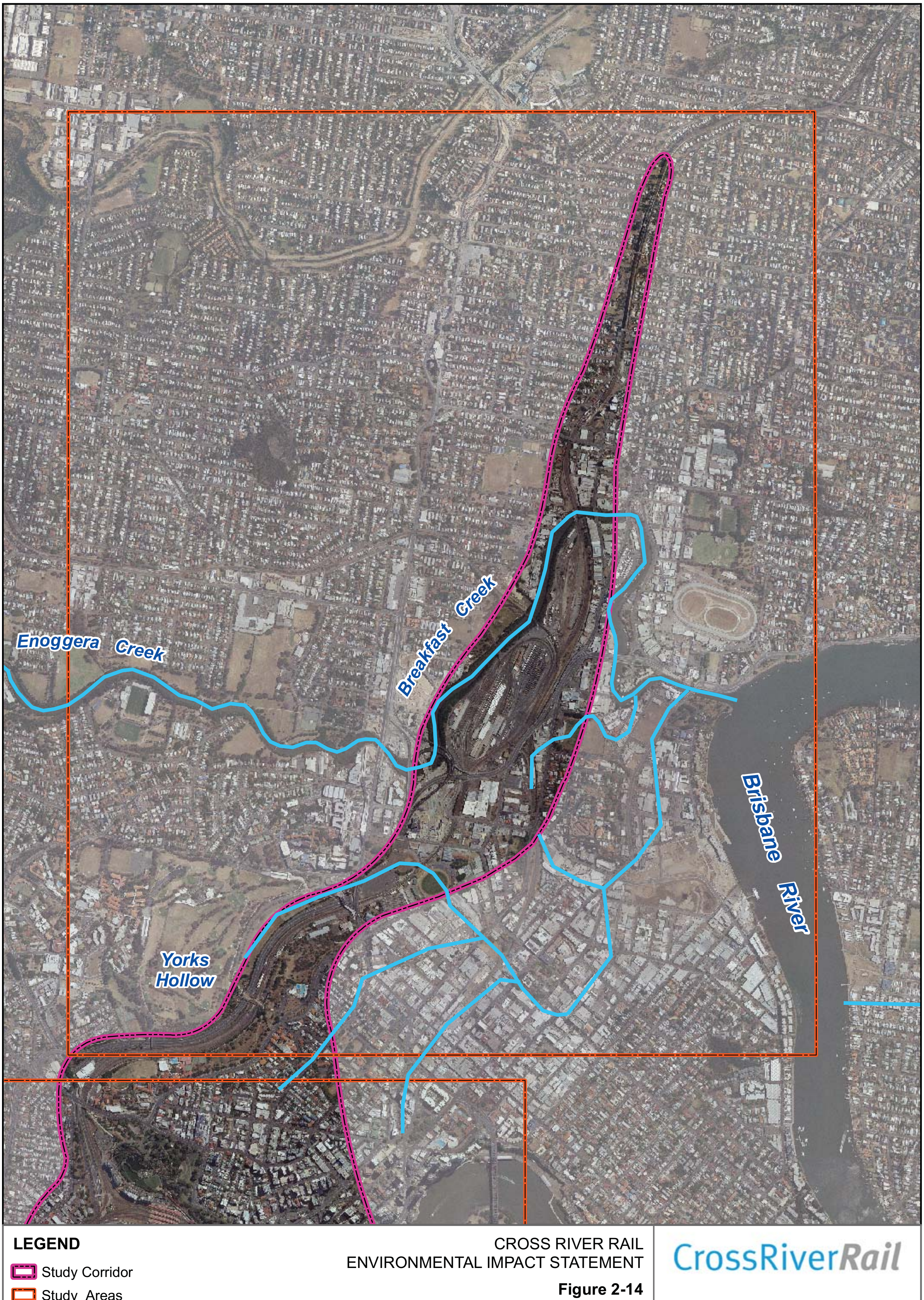
- Breakfast Creek/Enoggera Creek
- Brisbane River flooding backing up Breakfast Creek
- Campbell Street Drain
- local overland flowpaths

Peak flood levels (for the 1 in 100 AEP flood event) in the part of the study area crossing Breakfast Creek are dominated by Breakfast/Enoggera Creek catchment flood events. BCC state the peak 1 in 100 AEP flood level as 3.4 m AHD immediately upstream of the railway bridge (BCC Floodwise Property Search).

Flooding from Breakfast / Enoggera Creek catchment would result in relatively high velocity flows in Breakfast Creek through the study area. These flood events typically occur as a result of rainfall events which are much shorter than those which result in major Brisbane River flooding. Hence, during Breakfast / Enoggera Creek catchment flood events, the Brisbane River is typically at a normal (tidal) level. This results in relatively steep flood gradients through the study area.

During major Brisbane River flood events, the Breakfast / Enoggera Creek floodplains act as a storage of floodwaters from the Brisbane River. These areas rise relatively slowly as the Brisbane River rises. BCC state the peak 1 in 100 AEP flood level arising from Brisbane River flooding back up as 2.6 m AHD in this study area (BCC Floodwise Property Search). Peak Brisbane River flood levels along this study area are shown in **Figure 2-7** to **Figure 2-9**.

The other major watercourse affecting flood behaviour in this study area is the Campbell Street Drain. Flooding from this catchment results is relatively short duration flooding. The underground drainage network in this catchment accommodates flood events to a certain size/frequency of flood event. For larger, rarer flood events, the excess of flow is accommodated by overland flow paths through the sports fields adjacent to the ICB (west of the tunnel), the RNA Showground area and then through the streets and properties of Newstead. The catchment to the west of the RNA Showgrounds area would not result in overland flows through the RNA Showgrounds due to the blockage of overland flows formed by Bowen Bridge Road. Local overland flowpaths and river/creek flood extents for this study area are shown in **Figure 2-14**.



LEGEND

- Study Corridor
- Study_Areas
- Tributaries

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-14

Northern Study Areas for Flood Investigations

0 200 400 600 800 m
1:25,000 at A4

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

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2.3.2 Spring Hill to CBD

The Spring Hill to CBD section of the study area is defined as the portion from Spring Hill to the Brisbane River (at the Botanical Gardens). This study area is shown in **Figure 2-15**. The flooding behaviour of this part of the study area is potentially affected by the following watercourses:

- Brisbane River
- Local overland flowpaths.

Brisbane River flooding can result in inundation of parts of the CBD area, especially lower Albert Street. The mechanism for inundation of these parts of the CBD is either through Brisbane River floodwaters back-flowing through the pipe drainage system and surcharging up onto the Botanical Gardens area and nearby streets and properties.

Alternatively, it is feasible that during a Brisbane River flood event, rainfall on the CBD falls while the river is at or near peak levels. This would result in ponding of water in the lower parts of the CBD as the tailwater level in the river would be elevated and delay gravity drainage.

There are a number of local overland flowpaths in the CBD that cross study area. These overland flowpaths typically flow when the capacity of the underground pipe drainage system is exceeded. **Figure 2-15** shows some of the more relevant overland flowpaths in the CBD. The frequency of overland flooding in the CBD is a function of the rainfall intensity, the degree of blockage of pits and the coincident tide level in the Brisbane River.

2.3.3 Woolloongabba to Salisbury

The Woolloongabba to Salisbury part of the study area is defined as the portion from the Brisbane River (at the Botanical Gardens) to the southern extent of the study corridor. This part of the study area is shown in **Figure 2-16** and **Figure 2-17**. The flooding behaviour of this part of the study area is potentially affected by the following watercourses:

- Brisbane River (backup inundation of floodplains)
- Oxley Creek and tributaries
- local overland flowpaths.

Brisbane River flooding will result in inundation of parts of this section of the study area. The mechanism for inundation of these parts is backup flooding along watercourses as the Brisbane River rises. Peak Brisbane River flood levels along this part of the study area are shown in **Figure 2-7** to **Figure 2-9**.

Oxley Creek has the potential to inundate parts of the study area along the areas of Rocklea and Yeerongpilly. There are three tributaries of Oxley Creek that cross this part of the study area. These are discussed separately below.

The most northern is Moolabin Creek which passes through the study area between Yeerongpilly Station and Moorooka Station. The peak 1 in 100 AEP flood levels along this part of the study area result from short duration flood events in Moolabin Creek with some coincident flooding in Oxley Creek.

Rocky Waterholes Creek passes through the study area between Moorooka Station and Rocklea Station and runs along the study area near Rocklea Station. The peak 1 in 100 AEP flood levels along this part of the study area result from short duration flood events in Rocky Waterholes Creek with some coincident flooding in Oxley Creek.

Stable Swamp Creek passes through the study area near Salisbury Station. The peak 1 in 100 AEP flood levels along this part of the study area result from Brisbane River flood events that backup through Oxley Creek and Stable Swamp Creek as well as local Stable Swamp Creek flood events.

2.4 Climate change considerations

2.4.1 Climate change mechanisms

Potential climate change impacts which would influence flooding in the Brisbane River include changes to rainfall intensities and ocean levels. Given that the Project will become operational in 2021 and have a design life of 100 years, it is recommended that climate change scenarios be further considered during detailed design of flood immunity aspects of the Project at detailed design.

Hydrologic impacts

Climate change predictions incorporate climatic change that could influence a range of different parameters utilised in the hydrologic modelling of design floods. These changes may include:

- increased rainfall intensity during large to extreme events
- altered spatial variation of rainfall during rainfall events
- altered temporal variation of rainfall during rainfall events
- changes in mean seasonal and mean annual rainfall, impacting upon rainfall losses.

At present climate change modelling at the sub-daily time scale has significant uncertainty surrounding its predictions. Therefore, changes to spatial or temporal patterns are not yet well understood, particularly for large and extreme rainfall events. Similar uncertainty surrounds the potential interactions between changes in mean annual and seasonal rainfall and changes in catchment losses.

Therefore, the impacts of climate change are currently incorporated into hydrologic modelling by only considering changes to design rainfall depths and adopting spatial and temporal patterns and catchment losses based upon current conditions. This is recommended due to the lack of clear guidance and inherent uncertainty in assessing the impacts of climate change on other aspects of design flood estimation (such as spatial and temporal patterns and losses). This should be revised in later stages of the Project as further information becomes available regarding these variables.

Tailwater impacts

Climate change also has the potential to impact on downstream ocean conditions through two mechanisms:

- increased Mean Sea Level (MSL)
- modified cyclonic activity resulting in changes to storm surge behaviour.

The Intergovernmental Panel on Climate Change (IPCC, 2007) has released estimates for climate change increases to Mean Sea Level which can be used to estimate the impacts of increased downstream conditions. However, IPCC (2007) notes that future ice sheet contributions, which cannot be well quantified at this time, may increase the upper limit of sea level rise substantially.

2.4.2 Climate change estimates and policy context

As climate change estimates are specific to a time period, the timeline of the Project is important to the assessment. The Project is expected to be constructed by 2020 and have a design life of 100 years. Based on this, beyond 2070 estimates of climate change have been adopted for the purposes of this assessment. These are the longest range projections of climate change that are currently available from credible studies based upon Global Climate Models (GCM).

LEGEND

- Study Corridor
- Study_Areas
- Tributaries

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-15

Central Study Areas for Flood Investigations

0 0.2 0.4 0.6 0.8 1 km

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CrossRiverRail

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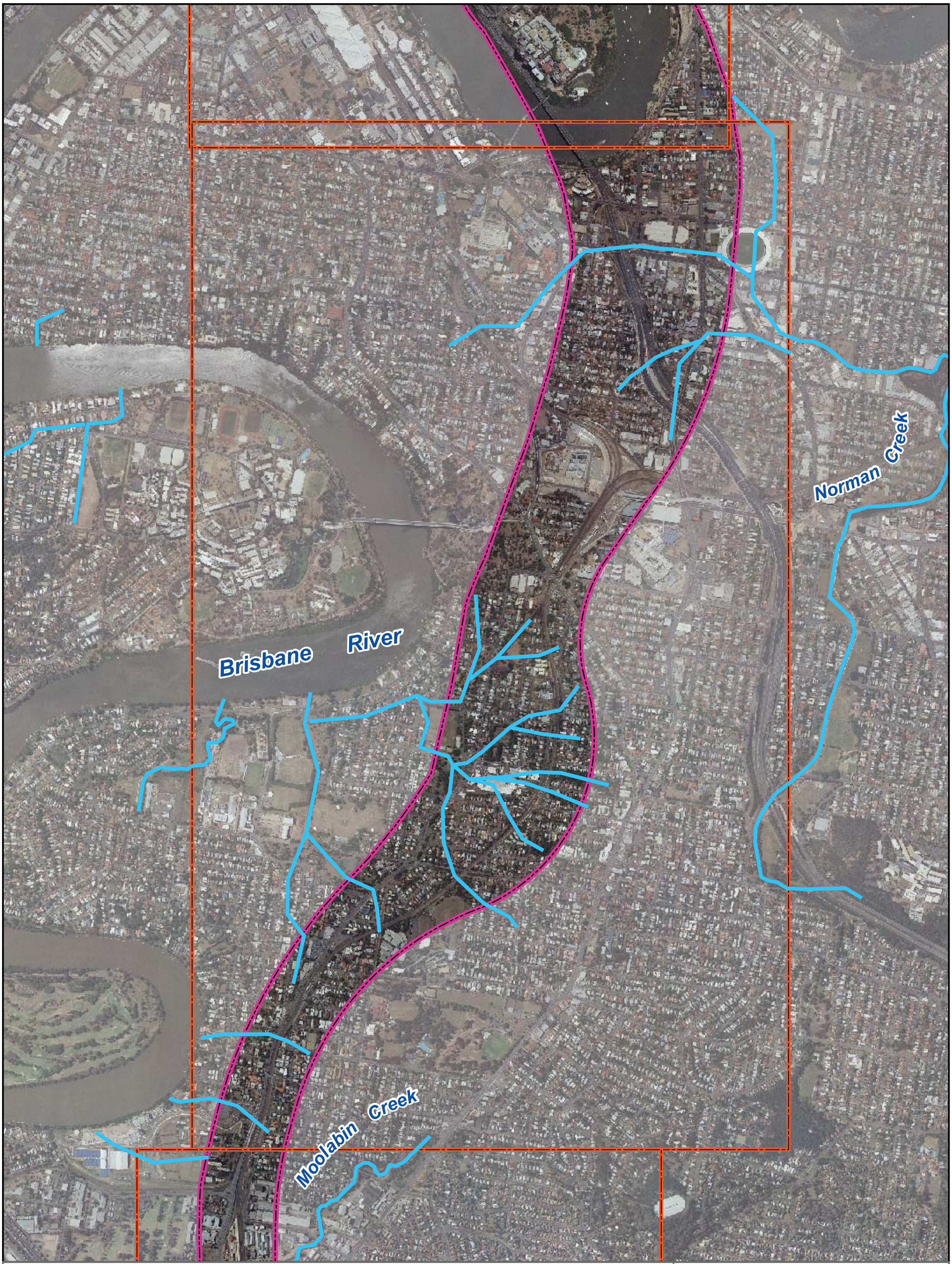

LEGEND
Study Corridor
Study Areas
Tributaries

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-16

Southern Study Areas for Flood Investigations Part 1

0 0.2 0.4 0.6 0.8 1 km
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CrossRiverRail

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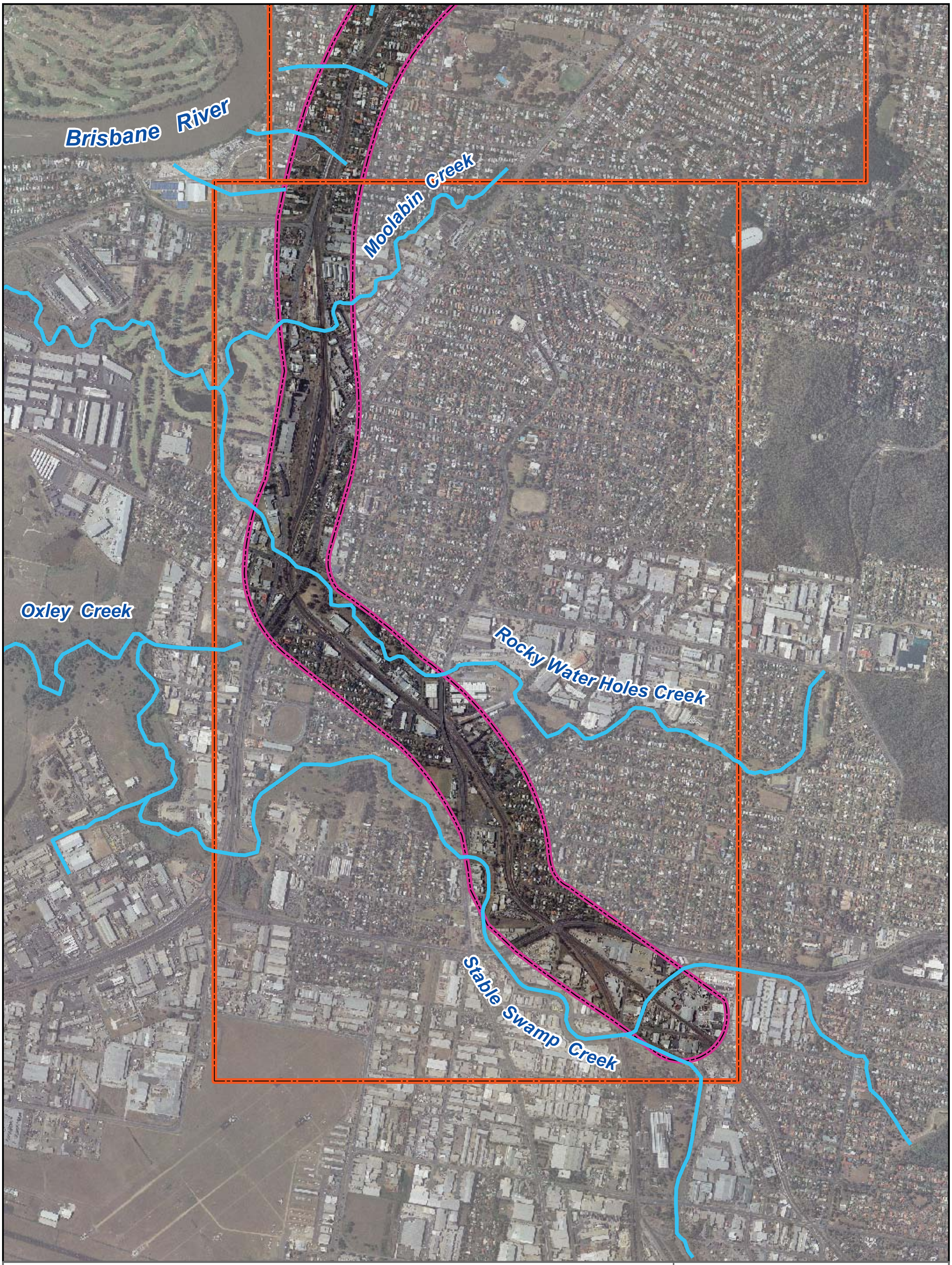

LEGEND

Study Corridor

Study_Areas

Tributaries

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2-17

Southern Study Areas for Flood Investigations Part 2

0 0.2 0.4 0.6 0.8 1 km

1:25,000 at A4

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

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In July 2008, the Queensland Cabinet released a new requirement for all Cabinet and Cabinet Budget Review Committee (CBRC) submissions to produce a Climate Change Impact Statement (CCIS). The Queensland Government is considering climate change implications are a key criterion in its decision making processes for large infrastructure projects.

Table 2-5 presents the climate change estimates adopted for the CCIS. It is noted that the parameters provided by Queensland Cabinet are designed to support assessments across the entire state of Queensland. These estimates therefore may not be the most appropriate for a specific project in a particular location within Queensland.

Table 2-5 Cabinet Requirements (2031 - 2070 and beyond)

	Cabinet Submission Requirements
Sea Level Rise (m)	0.49
Storm Surge (m)	0.5
Storm Surge + Sea Level Rise (m)	0.99

In November 2010, Queensland Government has released the *Increasing Queensland's resilience to inland flooding in a changing climate: Final Report on the Inland Flooding Study* (State of Queensland, 2010) which recommends that rainfall depths are increased by 5% per degree Celsius of global warming, which results in a 20% increase for 2100. The specifications from this study are listed in **Table 2-6**.

Table 2-6 Queensland Government Requirements (2100)

	Queensland Government Requirements
Temperature Increase (°C)	4
Increased rainfall depths / intensities per degree Celsius (%)	5

3 Impact assessment

Both construction (temporary) and operational (permanent) scenarios are being assessed in this study for up to 1 in 100 AEP floods. This impact assessment does not include elements of the Projects which would not have any impact on flooding behaviour of the study area.

The tunnel portals would be located on land well above the 1 in 100 AEP flood levels due to the need for a much higher flood immunity for the tunnel portals. The tunnel would also not have any impact on flood behaviour.

The potential impacts of the Project on flooding behaviour of the study area include:

- potential minor loss of Brisbane River floodplain storage
- potential loss of flood conveyance and floodplain storage associated with the construction site on the north bank of Moolabin Creek and a new rail bridge across Moolabin Creek
- potential loss of flood conveyance due to a new bridge across Rocky Waterholes Creek
- potential loss of floodplain storage within the Stable Swamp Creek floodplain due to raising of the Beaudesert Road Service Road.

Each watercourse potentially affected by the Project is discussed in more detail below.

3.1 Breakfast/Enoggera Creek

The Project would include earthworks in the Mayne Rail Yards associated with a new rail line adjoining the current rail lines on the southern side of Breakfast Creek.

The 1 in 100 AEP flood level for Breakfast Creek flooding in this area is approximately 3.4 m AHD (sourced from Floodwise Property search). The Brisbane River flood levels in this area are lower at 2.6 m AHD.

The ground levels in the area where the additional rail embankment is proposed are approximately 4.0 m AHD and higher.

Based on this assessment of peak 1 in 100 AEP flood levels and the ground levels of the site, it is not expected that the Project would result in any changes to flood behaviour for Breakfast Creek.

To account for the predicted changes to flood flows due to climate change, a 20% increase in inflows was assumed, as discussed in **Section 2.4.2**. Additionally, the tidal level assumed at the mouth of Breakfast Creek was raised by 0.49 m to account for sea level rise. The MIKE-11 model of Breakfast / Enoggera Creek was simulated with these changed inflows and downstream boundaries.

The flood model simulation indicated that the climate change scenario would raise flood levels by 0.8 m from 3.4 m AHD to 4.2 m AHD. This rise would not result in the proposed infrastructure being inundated in a 1 in 100 AEP flood event with the climate change predictions. It would appear from available data that the footprint of the proposed embankment in this area is likely to be above 4.2 m AHD. However, the detailed design phase may identify that levels are below 4.2 m AHD. Hence, there may be some very small volume of flood storage lost in the 1 in 100 AEP case with climate change. This minor loss of flood storage would represent a very small fraction of the flood storage of this reach. Furthermore, it would not result in any discernible loss of flood conveyance. Hence it is unlikely to result in any flood level increases or changes to flood behaviour for the 1 in 100 AEP flood with climate change.

3.2 Campbell Street Drain

The Project would not include any works in the area flooded by a local flood in the Campbell Street Drain catchment. The northern portal would be located on ground with levels in the order of 19.5 m AHD.

The overland flowpath of the Campbell Street Drain catchment near the portal has elevations of approximately 14.5 m AHD and a width of over 50 m. The depth of the overland flowpath is unlikely to be more than 1 m in a 1 in 100 AEP flood event.

Hence, surface works for the tunnel portal at 19.5 m AHD would not affect the overland flowpath.

The proposed additional rail line adjacent to the current rail lines would be well above the local overland flowpath. Within the RNA Showgrounds area, the new rail line would cross a pedestrian underpass. This underpass is currently crossed by the existing rail lines with a high bridge. The new rail line bridge would be similarly high above any potential overland flow through this pedestrian underpass. Hence, it is not expected that the Project would have any effect on this overland flowpath.

O'Connell Terrace is planned for reconfiguration to accommodate additional tracks. However, this would not affect the overland flowpath as it would be an elevated structure.

Under climate change scenarios, the proposed surface works are unlikely to affect the Campbell Street drain overland flowpath.

3.3 Tunnel

The proposed tunnel would not change surface levels that are currently inundated by floodwaters in a 1 in 100 AEP flood event. Hence, the tunnel would not affect flood behaviour for flood events up to 1 in 100 AEP along the route.

Rainfall intensity and mean sea level are projected to increase with climate change. These changes are unlikely to cause the surrounding flooding behaviour to be impacted by the proposed tunnel.

3.4 Brisbane River

The Project would result in very minor reductions in the flood storage volume for large Brisbane River flood events. The main areas where flood storages would be reduced are discussed in the following sections.

3.4.1 Clapham Rail Yard

Ground levels at the western edge of Clapham Rail Yards vary between 7.0 m AHD and 9.0 m AHD. This land would be filled by up to 2 m to raise the land to 9.5 m AHD. The 1 in 100 AEP Brisbane River flood level in the area is approximately 7.0 m AHD. Hence, the small amount of land filled that is currently below 7.0 m AHD would reduce flood storage in the Brisbane River floodplain in the 1 in 100 AEP flood event. Floods smaller than the 1 in 100 AEP flood event would not be affected as these floods do not currently inundate the Clapham Rail Yards.

The estimated increases in rainfall intensities and sea level rise associate with climate change would increase the 1 in 100 AEP flood level to 8.6 m AHD. Hence, there would be further loss of floodplain storage under climate change conditions.

3.4.2 Ventilation and emergency access building

A structure is proposed to be constructed on land between Sunbeam Street and Bledisloe Street in Fairfield. This structure would be constructed for the purposes of ventilation and emergency access from the tunnel. The structure would be constructed to avoid inundation of the tunnel through vent openings in a 1 in 10,000 AEP flood event. Hence, it would remove a small area from the available flood storage in a Brisbane River flood event.

3.4.3 Beaudesert Road Service Road Salisbury

At Salisbury, filling would be undertaken to raise the Beaudesert Road Service Road north of Dollis Street to the level of Beaudesert Road. This is to allow emergency egress from the area during flood events via a gate to Beaudesert Rd. Existing ground levels along the proposed Service Road alignment vary between 6.1 m AHD and 10.6 m AHD.

The Brisbane River flood level is approximately 7.2 m AHD. The filling of areas below 7.2 m AHD would remove a small volume of flood storage of the Brisbane River floodplain in the 1 in 100 AEP event.

3.4.4 Albert Street CBD

There would be filling in the Brisbane River floodplain where the new Albert Street station and where the construction site would be located. Flood protection measures at the station under construction and operation also include raising station accesses by 450 mm above street level to protect against local flooding. The loss of flood storage capacity from the raised station access has been modelled and the impact was found to be negligible.

3.4.5 Rocklea Rail embankment

There would be filling in the Brisbane River floodplain where the railway alignment crossed the floodplain. This is located in Rocklea, approximately 1 km southeast of Clapham Rail Yard.

3.4.6 Brisbane River flood impact assessment

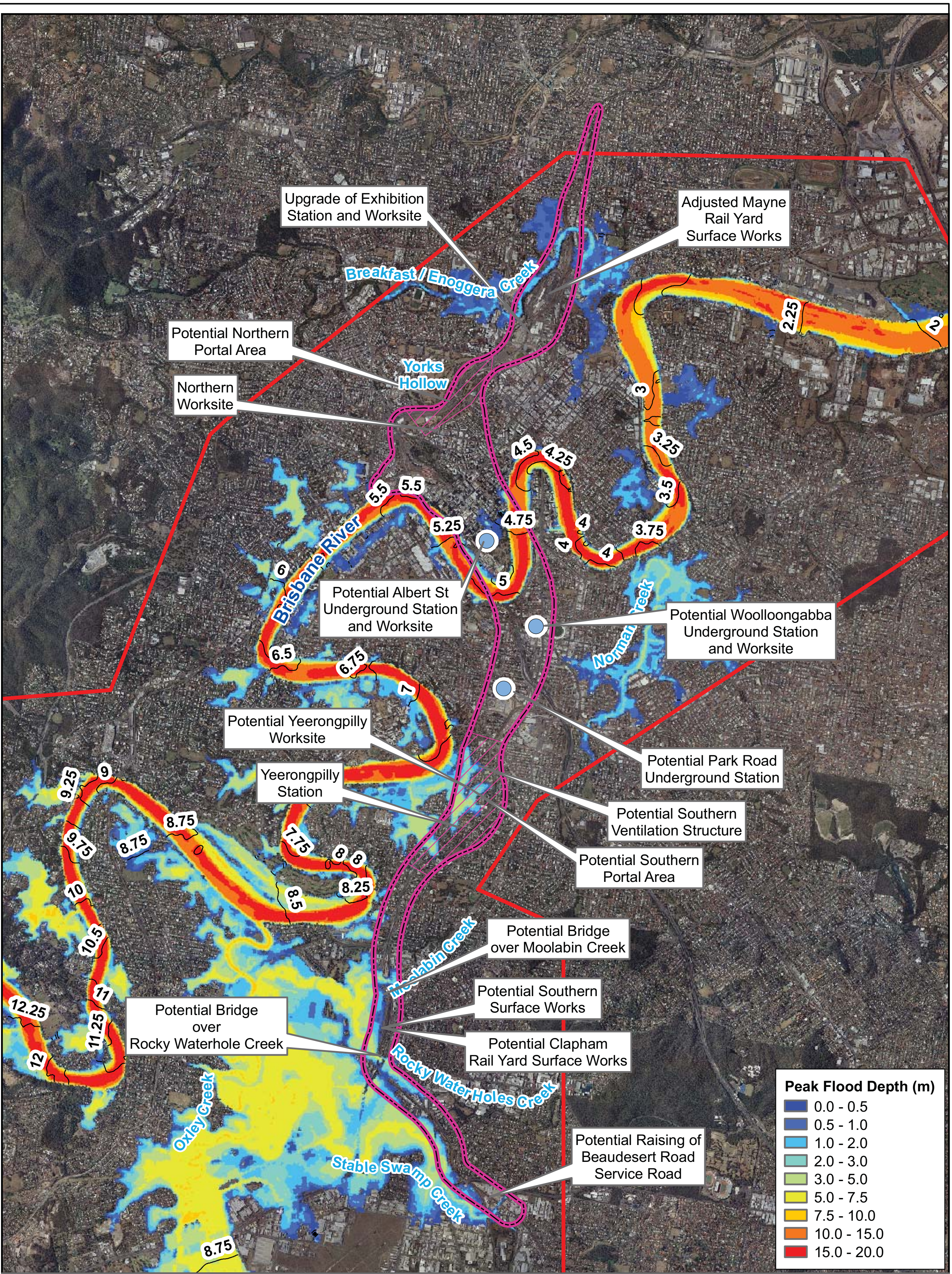
This impact of the proposed minor reductions of floodplain storage for Brisbane River flood events was assessed. The two-dimensional flood model of the Brisbane River (described in **Section 2.1.4**) was used for this impact assessment. The terrain of the flood model was adapted to represent the proposed filling and structure.

The proposed works would not result in any changes to flood storage for the 1 in 20 AEP event. Hence, only the 1 in 100 AEP flood event was simulated. The model was also simulated for the 1 in 100 AEP flood event with climate change scenarios for increased rainfall intensity and sea level rise (refer to **Section 4**).

The results of these simulations were compared with the existing case flood results. The comparison showed that these works would not result in any impacts to peak 1 in 100 AEP flood levels greater than 0.01 m. Flood velocities would not be affected by these works either.

The hydrological inputs to the Brisbane River model were created by increasing the rainfall intensity by 20% in the existing RAFTS hydrological model. The MIKE11 model was then simulated with these revised hydrological model outputs. As well, the ocean level was raised by 0.49 m to account for sea level rise projections. The boundary used for Brisbane River flood modelling does not include an allowance for coincident storm surges. Results of this simulation were then used to simulate the two-dimensional flood model of the Brisbane River under climate change scenarios.

The impacts of the proposed works on the 1 in 100 AEP flood under climate change conditions is presented in **Figure 3-1**.



LEGEND

Study Corridor

Model Area

Peak Flood Level (m AHD)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-1

Brisbane River Flooding 1 in 100 AEP Climate Change Flood Extent

0 0.5 1 1.5 2 2.5 km

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1:75,000 at A4

CrossRiverRail

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The main area in the CBD that would experience an increase in flood level would be in the City Botanical Gardens, which would experience an increase of up to 0.02 m. The filling of the Clapham Rail Yard and the rail embankment at Rocklea causes less than 0.01 m increase in flood level in their respective areas.

The most recent floods which occurred in January 2011 recorded a flood level of 4.46 m AHD in the CBD (BCC, 2011). This flood level was higher than the Defined Flood Event (at the time of the flood event – BCC has subsequently revised the Defined Flood Event). The January 2011 flood was a Brisbane River flood caused by the rainfall in the Brisbane River catchment, rather than in Brisbane itself. Therefore this event has been discussed in the context of Brisbane River flooding and is not discussed at local creek level.

3.5 Albert Street CBD

The Project would not change ground levels in the Albert Street area. Hence, there would not be any effect on the capacity and flood behaviour of the overland flow paths in this area. The overland flow paths in this area are typically through the streets. The flooding in the Albert Street area does not follow a clear flow path. However, it ponds and drains through a piped drainage system. Hence, the conveyance of the overland flow would not be affected by the surface works.

3.6 Oxley Creek floodplain

The Project does not include any works or terrain changes within the flood extent of a 1 in 100 AEP Oxley Creek flood event.

The Oxley Creek model was run for the 1 in 100 AEP event under climate change conditions for increased rainfall intensity and increased sea level rise to ensure that the flood extent did not encroach on the proposed alignment. The flood extent for Oxley Creek is shown in **Figure 3-2**. The flood extent shows that even under climate change conditions, the Project does not impinge on the Oxley Creek flood extent.

3.7 Moolabin Creek

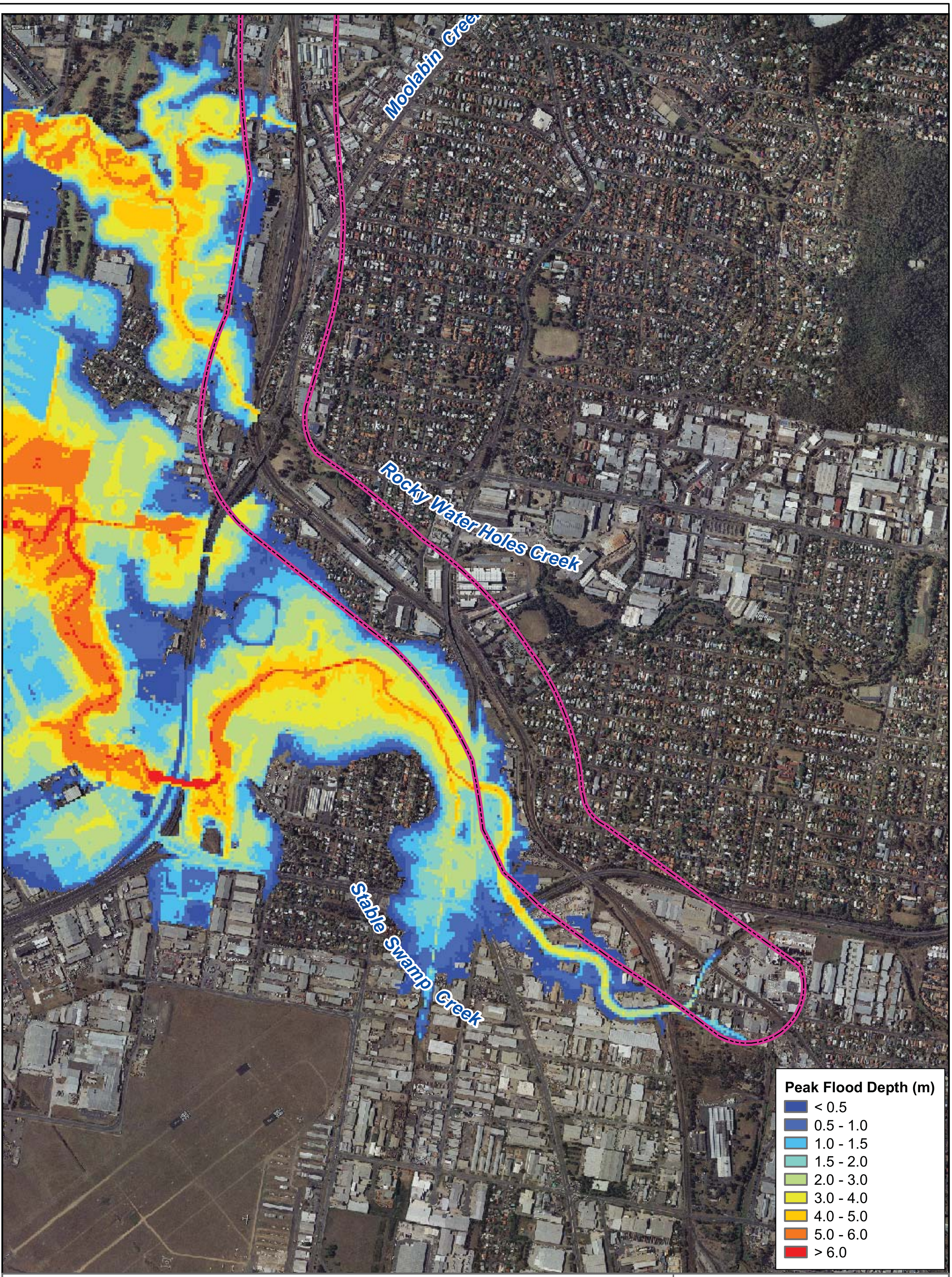
3.7.1 Construction scenario

The construction scenario was modelled hydraulically by the addition of the construction bund in the model terrain as well as piers. The bund was filled to a 1 in 20 AEP flood event level plus 300 mm freeboard.

Lucy Street is proposed as a site entry point for the construction. This road would need to be upgraded to a level of 10.47 m AHD to prevent floodwaters from entering on the construction site in the 1 in 20 AEP flood event.

The flood impact from this construction bund for the 1 in 5 AEP is presented in **Figure 3-3**. The flood modelling indicates that the impacts of the construction bund in this flood event would be negligible (less than 0.01 m).

The flood impact from this construction bund for the 1 in 20 AEP and 1 in 100 AEP flood events are presented in **Figure 3-4** and **Figure 3-5**. The flood modelling indicates that the impacts of the construction bund in this flood event would be in the order of 0.04 m for the 1 in 20 AEP flood event and 0.09 m for the 1 in 100 AEP flood event.



LEGEND

Study Corridor

Model Area

Peak Flood Level (m AHD)

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-2

Oxley Creek Flooding 1 in 100 AEP Climate Change Flood Extent

0 0.2 0.4 0.6 km

1:20,000 at A4

N

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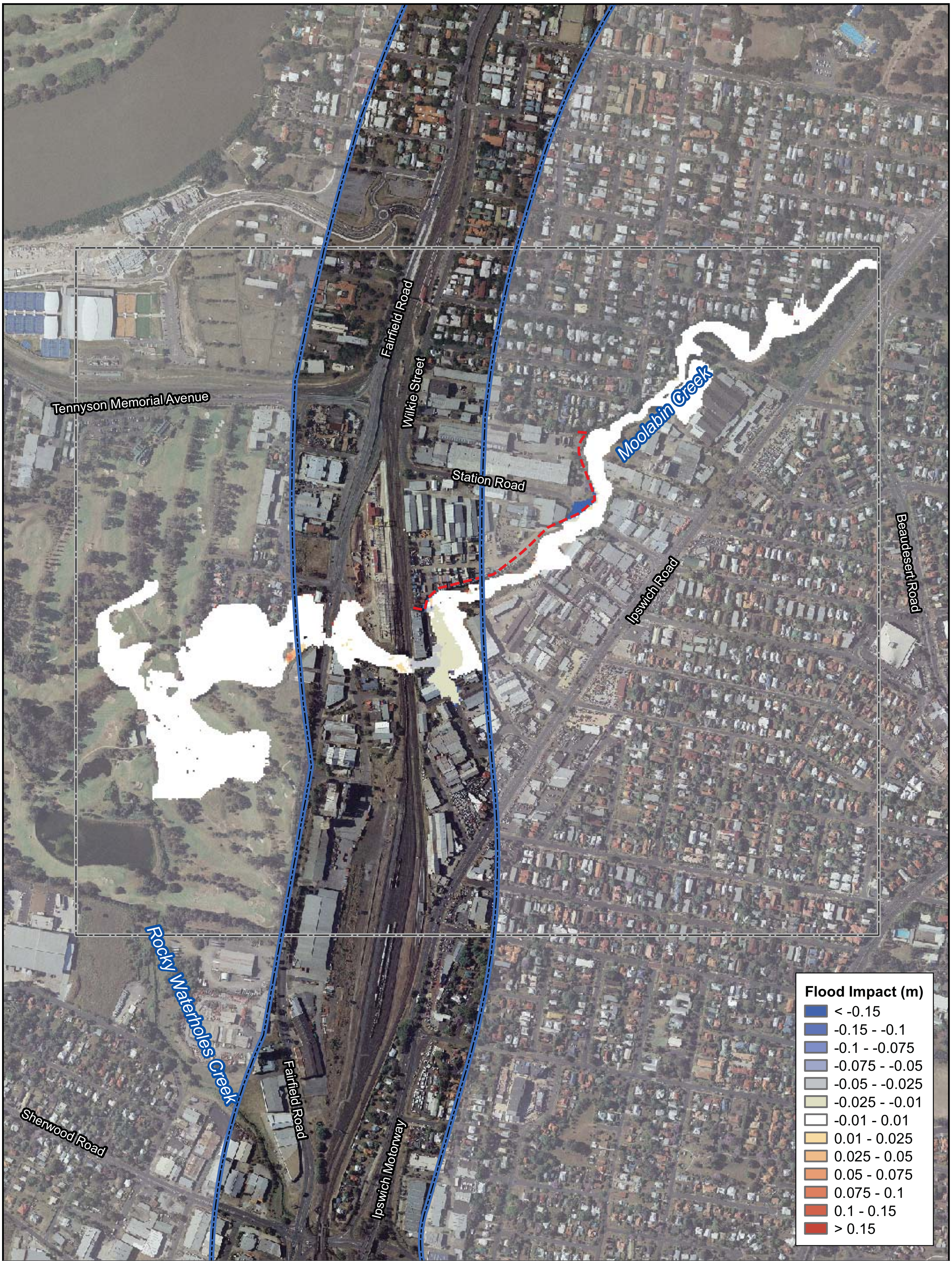

LEGEND

Study Corridor

Model Area

Construction Bund

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-3

Moolabin Creek Flooding 1 in 5 AEP
Construction Phase Flood Impact

0 50 100 150 200 250 m

1:10,000 at A4

N

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CRR JOINT VENTURE

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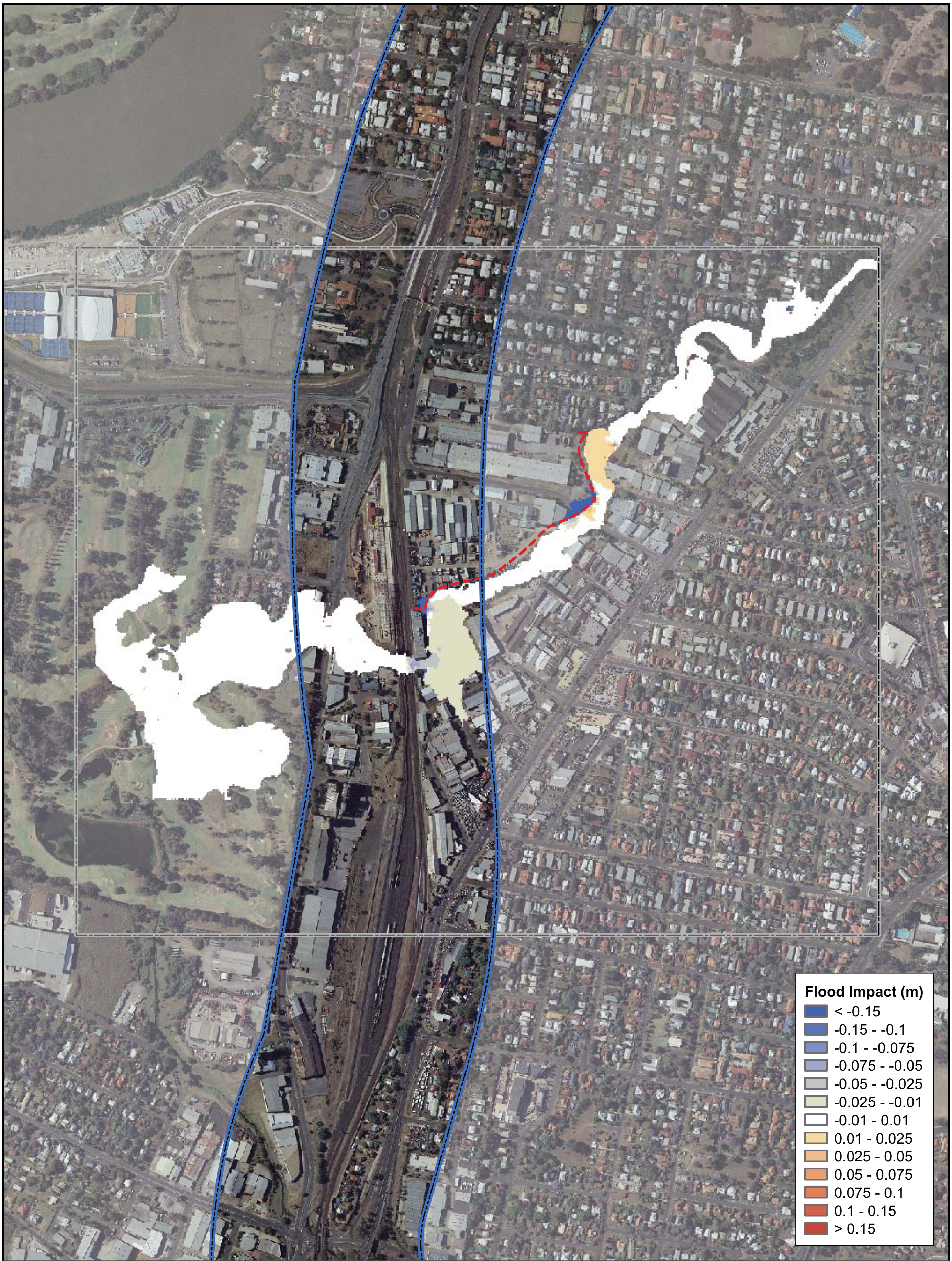

LEGEND

Study Corridor

Model Area

Construction Bund

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-4

Moolabin Creek Flooding 1 in 20 AEP Flood Event Construction Impacts

0 50 100 150 200 250 m

1:10,000 at A4

N

CrossRiverRail

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LEGEND

- Study Corridor
- Model Area
- Construction Bund

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-5

Moolabin Creek Flooding 1 in 100 AEP Construction Phase Flood Impact

0 50 100 150 200 250 m

1:10,000 at A4

N

CrossRiverRail

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There are two commercial/industrial buildings that would be affected by the proposed construction bund. The floor levels of the two properties appear to be on ground level from photographic inspection. These properties would experience approximately 0.09 m increase in water level in the 1 in 100 AEP flood event. The impact from the 1 in 20 AEP is 0.04 m and the impact from the 1 in 5 AEP flood event on these properties are under 0.01 m.

The potential for these flood impacts to be experienced is related to the time that the construction bund would be in place. It was conservatively estimated that the bund would be present throughout the duration of the works on the site. Therefore it is expected that the bund would be in place for approximately five and a half years. Hence, the probability of experiencing a 1 in 100 AEP flood event in that period is approximately 1 in 18 or 5.5%.

There are no impacts greater than 0.01 m for the 1 in 5 AEP flood event. The probability of experiencing a 1 in 5 AEP flood event in this five and a half year period is much higher at approximately 100%.

Flood velocities for the 1 in 100 AEP flood event in Moolabin Creek are not significantly affected under the construction scenario.

3.7.2 Operations scenario

The assessment of the Project in operational phase required the consideration of the additional 12 piers in the floodplain for the new railway structures and the removal of an existing railway bridge. Out of the 12 piers, there is one pier located in the waterway. All other conditions were maintained as for the existing scenario. The design level for the railway bridge at Moolabin Creek is approximately 9 m AHD. Therefore, only the piers would be affect the flow, and hence only piers were considered in the hydraulic modelling.

The modelling indicates there would be negligible impact (less than 0.01 m) from these additional piers on the 1 in 5, 1 in 20 and 1 in 100 AEP flood depths and levels. As well, the flood modelling indicates that there would not be any noticeable changes in flood velocities resulting from the Project. Additionally, there would be no impacts in flood depths in the 1 in 100 AEP under the climate change scenario. An assessment was also undertaken to determine changes to velocities that may affect movement of aquatic fauna. For this assessment, a bank-full flood event was considered. In this event, the reduction in waterway area in the developed case would be 1.6% due to the introduction of the pier. The increase in velocity resulting from the additional pier in the waterway would be up to 1.6%. Therefore, it can be concluded that the additional pier would have a negligible impact on aquatic fauna movement.

3.8 Rocky Waterholes Creek

The two-dimensional flood model developed for this Project was used to assess the potential impacts of the Project on flood behaviour during local flood events in Rocky Waterholes Creek. The model was adapted to represent the proposed piers across Rocky Waterholes Creek. The hydraulic model was simulated with these changes and compared with the results of the base case.

The flood impact for the 1 in 5 AEP flood event is mapped in **Figure 3-6.** It is predicted that the peak flood levels on Muriel Avenue would increase by 0.09 m. The results also show a private property would experience an increase in peak flood levels of up to 0.015 m.

The results from the 1 in 20 AEP event show flood levels on Muriel Avenue would increase by 0.08 m. The flood impact for the 1 in 20 AEP flood is shown in **Figure 3-7.** Similarly to the 1 in 5 AEP flood, the flood level at a private property east of Ipswich Road would increase by up to 0.02 m.

The 1 in 100 AEP impact map in **Figure 3-8** shows that peak flood levels would be increased by up to 0.04 m on Muriel Avenue. There are no impacts to flood levels predicted on private property.

LEGEND

Study Corridor

Model Area

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-6

Rocky Waterholes Creek Flooding 1 in 5 AEP
Operations Phase Flood Impact

0 50 100 150 200 m

1:7,500 at A4

N

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Study Corridor

Model Area

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-7

Rocky Waterholes Creek Flooding 1 in 20 AEP Operations Phase Flood Impact

0 50 100 150 200 m

1:7,500 at A4

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LEGEND

Study Corridor

Model Area

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-8

Rocky Waterholes Creek Flooding 1 in 100 AEP Operations Phase Flood Impact

0 50 100 150 200 m

1:7,500 at A4

N

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Flooding\Report_Figures\151010_Tech_Report_Figures\Figure_3-8_100y_Rocky_Waterholes_Ck_Operations_v1.mxd 07/07/2011 15:00

Although private property is affected by the 1 in 5 and 1 in 20 AEP flood events, there are no structures on the site. Additionally, the majority of the site is inundated in the 1 in 5 AEP event.

The design level for the railway bridge at Rocky Waterholes Creek is approximately 10.7 m AHD. Hence, only the bridge piers would be affected by the flooding. As well, the flood modelling indicates that flood velocities would not be significantly affected by the Project.

Similarly to Moolabin Creek, the hydraulic model for Rocky Waterholes Creek was run for a climate change scenario, using a 20% increase in rainfall depth and a 0.49 m sea level rise. The one-dimensional hydraulic model of Rocky Waterholes Creek was simulated with the changed inflow and downstream boundary to produce an inflow and a downstream boundary for the two-dimesional flood model.

The flood level at Rocky Waterholes Creek bridge for the 1 in 100 AEP under climate change would be 6.7 m AHD. The maximum increase in water level under climate change for 1 in 100 AEP is 0.03 m. Therefore, the proposed infrastructure in Rocky Waterholes Creek would have a minimal impact on the surrounding flood behaviour under climate change scenarios.

An assessment was also undertaken to determine changes to velocities that may affect movement of aquatic fauna. For this assessment, a bank-full flood event was considered. In this event, the reduction in waterway area in the developed case would be 3% due to the introduction of the piers. The increase in velocity resulting from the additional piers in the waterway would be up to 3%. Therefore, it can be concluded that the additional piers would have a negligible impact on aquatic fauna movement.

An assessment of the rate of floodwater rise indicated that the Project would result in a minimal change in the rate of floodwater rise and fall in this area. Muriel Avenue inundation would occur less than two minutes earlier with the Project. The re-opening of Muriel Avenue would be delayed by less than two minutes on the recession of the flood. Overall, the time of inundation of Muriel Avenue would not change by more than three minutes in total.

3.9 Stable Swamp Creek

At Salisbury, filling would be undertaken to raise the Beaudesert Road Service Road north of Dollis Street to the level of Beaudesert Road. This is to allow emergency egress from the area during flood events via a gate to Beaudesert Road. Existing ground levels along the proposed Service Road alignment vary between 6.1 m AHD and 10.6 m AHD.

The Stable Swamp Creek 1 in 100 AEP flood level is approximately 6.2 m AHD. Therefore, the Project will cause a very minor reduction in floodplain storage in Stable Swamp Creek. Flooding behaviour in Stable Swamp Creek is dominated by conveyance characteristics (fast flow within the main channel) and this filling would not impact on the conveyance capacity.

3.10 Minor culvert crossings

The Project would require extension of minor culvert cross-drainage infrastructure to accommodate the widened rail embankments. These crossings will be designed in accordance with the appropriate standards such as the *Queensland Urban Design Manual* (DNRW, 2007). The design principles to be followed would include:

- flood immunity of the existing railway would be maintained
- ensuring no flood impacts on adjacent private property and community infrastructure would occur.

4 Flood mitigation measures

From the impact assessment of the various waterbodies that intersect the study area, flood mitigation measures have been identified. All known Project components have been modelled for the Reference Design. Detailed design refinements will need to ensure that no impacts not discussed in the EIS occur.

Only those Project components where there is possible impact under construction and/or operation phases have been modelled or mapped. General flood mitigation measures which apply to the entire study area include:

- Where there are culverts which cross the alignment, these would need to be extended to accommodate the widened rail corridor. The design of these culverts would have to ensure that there are no increased in the upstream flood levels.
- Where there are changes to local roads created in the study area, their design would require being at-grade and ensuring there would be no reduction in floodplain storage as a result of their construction.

The required flood mitigation measures at each watercourse are discussed in more detail below.

4.1 Breakfast Creek/Enoggera Creek

Following the impact assessment of Breakfast Creek, the Project is not expected to impact flood behaviour in Breakfast Creek under existing climate conditions. However, as modelling under climate change conditions estimate a 0.8 m increase in flood levels, it is recommended that the infrastructure in the Mayne Rail Yards be constructed above 4.3 m AHD.

4.2 Brisbane River

The proposed infrastructure at Clapham Rail Yard would be located above the 1 in 100 AEP flood level, even under climate change conditions. Hence, flood mitigation measures are not required in relation to the operations stage in this area.

4.3 Moolabin Creek

The proposed infrastructure at Moolabin Creek would be located above the 1 in 100 AEP flood level, even under climate change conditions. Hence, flood mitigation measures are not required for this area for the operations phase.

However, during the construction phase, consultations would be required for the two properties which experience flooding caused by the construction bund to discuss mitigation options such as compensation or a temporary move of premises during construction. Adequate mitigation measures would be implemented based on this consultation.

4.4 Rocky Waterholes Creek

The proposed infrastructure at Rocky Waterholes Creek would be located above the 1 in 100 AEP flood level, even under climate change conditions. Hence, flood mitigation measures are not required in relation to the operations stage in this area. However, it is recommended that the construction site adjacent to Clapham Rail Yard is maintained above the 1 in 20 AEP flood level plus 300 mm, similar to the construction site adjacent to Moolabin Creek. Consultation would also be required for the property that is affected in the 1 in 5 and 1 in 20 AEP flood events in the operational phase to discuss appropriate mitigation options. Adequate mitigation measures would be implemented based on this consultation.

4.5 Stable Swamp Creek

The proposed infrastructure associated with the Beaudesert Road Service Road at Stable Swamp Creek is located on the fringes of the 1 in 100 AEP flood extent. It is recommended that further detailed modelling be undertaken during detailed design to ensure that the final design of the raised Beaudesert Road Service Road does not impact on local flood levels in Stable Swamp Creek.

5 Summary

The proposed Project would have the following impacts on the flooding behaviour of the study area:

- At Moolabin Creek, the proposed construction activities upstream of the railway bridge would result in impacts in the order of 0.09 m in a 1 in 100 AEP flood event and 0.04 m in a 1 in 20 AEP event. In a 1 in 5 AEP flood event, the impacts are negligible.
- At Rocky Waterholes Creek, the Project would result in minor increases in flood levels on the Muriel Avenue area. The maximum impacts on the road are up to 0.04 m in a 1 in 100 AEP event, 0.09 m in a 1 in 20 AEP, and 0.08 m in a 1 in 5 AEP flood event. There is one private property affected, with impacts up to 0.02 m in the 1 in 20 AEP flood event and 0.015 m in the 1 in 5 AEP event. The time of road closure would be increased by approximately three minutes in a 1 in 100 AEP flood event.
- The remainder of the Project would not have any discernable impact on flood behaviour.
- The flood immunity of the proposed infrastructure would not be significantly affected by the climate change predictions.
- With mitigation, the residual effects of the Project during construction are predicted to be low over the short term. The residual effects on flood management during operation are also predicted to be low over the long term.

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