Airport Link

FLOODING AND DRAINAGE

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Contents

1. Introduction 1

1.1 General Catchments/Localities 1

1.2 Criteria For Assessment 1

2. Southern Connection 3

2.1 Location and Possible Flooding Mechanisms 3

2.2 Available Data 3

2.3 Design Considerations 4

3. Northwest Connection 6

3.1 Location and Flooding Mechanisms 6

3.2 Available Data 6

3.3 Local Flooding 6

3.4 Hydraulic Assessment of Existing Conditions 7

3.5 Design Proposal **Error! Bookmark not defined.**

4. Northeast Connection 11

4.1 Location and Flooding Mechanisms 11

4.2 Available Data 11

4.3 Hydraulic Assessment of Existing Flood Conditions 11

4.4 Hydraulic Assessment of Construction Flood Conditions 20

4.5 Hydraulic Assessment of Developed Flood Conditions 25

5. References 30

1. Introduction

1.1 General Catchments/Localities

The following assessment describes the existing flooding conditions and potential hydraulic impacts of proposed works along the proposed Airport Link study corridor. The study corridor extends from Bowen Hills to the Toombul and traverses the catchments of two main watercourses, being Enoggera Creek and Kedron Brook.

In assessing the existing flooding conditions along the route, particular focus is given to the location of surface connections that will be impacted by flooding. Connections to surface roads are proposed at the following locations:

- Southern Connection at Bowen Hills;
- Northwest Connection at Gympie Road; and
- Northeast Connection at Toombul

The Southern Connection at Bowen Hills traverses Enoggera Creek some 4km upstream of its confluence with the Brisbane River. This location of the Brisbane River is approximately 16km upstream of the river mouth in Moreton Bay.

The Northwestern Connection at Gympie Road crosses Kedron Brook approximately 13km upstream of Moreton Bay. No other major tributaries of Kedron Brook are located in the vicinity, with only small local catchments draining directly to Kedron Brook.

The Northeastern Connection at Toombul is located within the floodplain of Kedron Brook/Schulz Canal in the vicinity of Sandgate Road. The Sandgate Road crossing is approximately 10km upstream of the mouth of Kedron Brook in Moreton Bay. Minor tributaries enter the main channel of the Kedron Brook in the Eagle Junction and Hendra areas.

1.2 Criteria For Assessment

The assessment undertaken aims to determine the existing general flooding conditions at each of the connections. This includes the nature of flooding of the connections (e.g. fluvial,tidal) and quantifying design flood levels where possible. Existing flooding issues such as sensitive flood prone areas are identified where appropriate and corresponding constraints on development are identified.

With regard to constraints on development, the existing flooding behaviour for two flood event magnitudes is of particular significance, being the 100-year and 10,000-year ARI events.

General development guidelines require that new development does not create adverse hydraulic impacts upon external properties up to the 100-year ARI design event. Where appropriate, mitigation measures should be developed to mitigate adverse impact.

The tunnel ramps and portals for the proposed Airport Link are to be designed to achieve 10,000-year ARI flood immunity as a minimum. This criterion is consistent with the North-South Bypass Tunnel (NSBT) and is based on the consideration of :

- The likelihood of encountering a flood event of this magnitude within the design life of the tunnel;
- The consequences of encountering such an event; and

- The infrastructure that would be required to provide the design flood immunity.

The assessment of the proposed connection options investigates the works required to provide the 10,000-year ARI flood immunity, the impact of proposed works on 100-year ARI flood conditions and identifies mitigation measures to minimise adverse hydraulic impact associated with the works.

2. Southern Connection

2.1 Location and Possible Flooding Mechanisms

The proposed connections to the ICB, Lutwyche Road and the NSBT are to be located near Horace Street and Enoggera Creek. The Horace Street crossing of Enoggera Creek is located approximately 3.5km upstream of the confluence with the Brisbane River. The location along the Brisbane River is approximately 16km upstream of the river mouth in Moreton Bay. The possible flooding mechanisms at the Southern Connection are:

- Enoggera Creek flooding;
- Brisbane River flooding; and
- Moreton Bay storm tide events

The connection options include a number of additional elevated structures crossing Enoggera Creek within the reach between Bowen Bridge Road and Byrne Street.

2.2 Available Data

Recent investigations of flooding impact associated with the NSBT project provides data for the flooding mechanisms identified above. These data are discussed in detail below.

2.2.1 Brisbane River Flooding

The Brisbane River Flood Study (SKM, 2004) provides the following peak water level predictions for the Brisbane River at the mouth of Breakfast Creek for a range of design event magnitudes:

- 10-year ARI Peak Flood Level = 1.17m AHD
- 20-year ARI Peak Flood Level = 1.25m AHD
- 50-year ARI Peak Flood Level = 1.58m AHD
- 100-year ARI Peak Flood Level = 1.91m AHD
- 2000-year ARI Peak Flood Level = 3.64m AHD

2.2.2 Moreton Bay Storm Tide

Moreton Bay Storm Tide peak levels for the 50-, 100-, 500-, 1,000- and 10,000-year ARI events including the effects of wave setup* were sourced from "Storm Tide Threat in Queensland: History, Prediction and Relative Risks" (Harper, 1999).

- 50-year ARI Peak Flood Level = 2.3m AHD
- 100-year ARI Peak Flood Level = 2.5m AHD
- 500-year ARI Peak Flood Level = 3.2m AHD
- 1,000-year ARI Peak Flood Level = 3.6m AHD
- 10,000-year ARI Peak Flood Level = 4.4m AHD

*Note – the storm tide estimates for Moreton Bay are based on work by McMonagle, 1979

2.2.3 Enoggera Creek Flooding

The Breakfast/Enoggera Creek Flood Study (BCC, 1999) predicted peak water levels up to the 100-year ARI event. The predicted flood levels upstream of the Horace Street bridge for a range of design event magnitudes are as follows:

- 2-year ARI Peak Flood Level = 2.01m AHD
- 5-year ARI Peak Flood Level = 2.49m AHD
- 10-year ARI Peak Flood Level = 2.77m AHD
- 20-year ARI Peak Flood Level = 3.07m AHD
- 50-year ARI Peak Flood Level = 3.59m AHD
- 100-year ARI Peak Flood Level = 4.17m AHD

An additional study incorporating extreme events was undertaken by GHD in 2003 (Enoggera Dam Report on Safety Assessment). The study investigated various extreme flooding regimes including dam failure scenarios. The same hydraulic model as used for the Breakfast/Enoggera Creek Flood Study was applied, however the hydrology was developed independently. The peak water levels predictions upstream of the Horace Street bridge for this study are as follows:

- 100-year ARI Peak Flood Level = 3.34m AHD
- 500-year ARI Peak Flood Level = 3.45m AHD
- 1,000-year ARI Peak Flood Level = 3.77m AHD
- 10,000-year ARI Peak Flood Level = 4.86m AHD
- PMF Peak Flood Level = 7.68m AHD

The peak 100-year ARI level upstream of the Horace Street bridge from the Enoggera Dam study (3.34m AHD) is considerably lower than the corresponding prediction from the Breakfast/Enoggera Creek Flood Study (4.17m AHD). The Breakfast/Enoggera Creek Flood Study used a synthetic design storm approach in deriving the hydrology of the system – an internal tool developed by Council to avoid having multiple storm event durations. The Enoggera Dam study used hydrologic Assessment methods outlined in Australian Rainfall and Runoff (AR&R). As the AR&R methods are widely accepted as standard practice throughout Australia, the Enoggera Dam study results were used in this assessment.

2.3 Design Considerations

To provide connections from the Airport Link to the ICB, NSBT and Lutwyche Road, the various connection options require a number of new additional elevated structures to traverse Enoggera Creek. These crossings are to be located in the vicinity of the existing Horace Street Bridge. The NSBT design requires numerous new structures, whereas the Airport Link design requires just one. The current design for NSBT proposes to have all of the bridge structures and abutmets to be clear of the flooded extent of Enoggera Creek up to the 1 in 100 year ARI flood event. This design concept will be followed by the Airport Link. By doing so, flooding impacts on Enoggera Creek are avoided..

2.3.1 Flood Immunity

The estimated 10,000-year ARI flood level at the Horace Street bridge is approximately 4.9m AHD. The location of tunnel portals and height of access ramps need to be designed to provide this level of flood immunity as a minimum.

The proposed tunnel portals for Airport Link are north of the Horace Street crossing of Enoggera Creek in the vicinity of Lutwyche Road/Cedric Street. The vertical alignment of the tunnel connections may require a hump in the pavement to the required 10,000-year flood level to ensure the required flood immunity.

2.3.2 Hydraulic Impact

The additional structure has limited potential to increase flood levels. Given the height of the proposed connections in linking with existing networks and the requirement for 10,000-year ARI flood immunity, the decks of new bridges will be above the existing 100-year flood levels. The main potential impact for the additional structure will be attributable to approach embankments that can impede existing flow paths providing for additional headloss. In order to minimise hydraulic impact of structures the following design considerations are applied:

- Minimise the use of embankment in the floodplain
- Design bridges to span the creek without piers in the watercourse

3. Northwest Connection

3.1 Location and Flooding Mechanisms

The connection options for Gympie Road are located adjacent to the existing Gympie Road crossing of Kedron Brook. These provide Airport Link connections to Gympie Road, Stafford Road, Lutwyche Road and Kedron Park Road.

Gympie Road crosses Kedron Brook some 13km upstream of Moreton Bay. Kedron Brook, in this location, is a wide engineered channel with a high conveyance capacity. There are no other significant watercourses in the vicinity. However, there are a number of small local catchments draining to Kedron Brook. Gympie Road and Stafford Road in particular provide for overland flow paths for flood conveyance to Kedron Brook.

The following flooding mechanisms are identified as potential sources of inundation for the proposed connection at Gympie Road:

- Kedron Brook flooding
- Local catchment flooding
- Moreton Bay storm tide event

3.2 Available Data

3.2.1 Kedron Brook Flooding

Detailed hydrologic and hydraulic modelling was undertaken for the Kedron Brook Flood Study (Connell Wagner, 1995). Predicted peak flood water levels from this study in the vicinity of the Gympie Road crossing are shown in **Table 3-1** for a range of design event magnitudes. It is important to note that 10,000 year ARI event estimates are not available.

- **Table 3-1 – Kedron Brook Peak Flood Levels Near Gympie Road**

Location	Peak Flood Water Level (m AHD)						
	2-yr ARI	5-yr ARI	10-yr ARI	20-yr ARI	50-yr ARI	100-yr ARI	PMF
McCord St	9.75	10.12	10.41	10.71	11.13	11.53	16.10
U/S Gympie Rd	9.24	9.64	9.96	10.26	10.68	11.07	15.82
D/S Gympie Rd	9.16	9.55	9.84	10.12	10.50	10.82	14.45
Fifth Avenue	8.79	9.16	9.45	9.72	10.08	10.38	14.07

3.2.2 Moreton Bay Storm Tide Data

Given the Moreton Bay storm tide data discussed in Section 2.2.2, the level of flooding attributable to this type of event is not as significant as the main Kedron Brook fluvial flood event. The predicted 10,000-year ARI flood levels being 4.4m AHD and 13.0m AHD for Moreton Bay storm tide and Kedron Brook flooding respectively.

3.3 Local Flooding

In addition to flooding from the main Kedron Brook channel, there are a number of small local catchments that may contribute to flooding impact of the proposed connections. None of these catchments provide for significant transverse flows across the proposed route alignments.

Gympie Road and Stafford Road serve as existing overland flow paths in major storm events. The road system in general conveys overland flows directly to Kedron Brook. The catchment areas contributing to these flows are relatively minor and not expected to have major flooding impact on the proposed connections. However, the treatment of local drainage will be an important issue to address to ensure adequate flow paths to Kedron Brook are maintained.

A larger local catchment of some 52ha drains to the Gympie Road/Sadlier Street intersection further to the north. This catchment does not affect the tunnel portals but may impact on local surface works.

To the east of Kedron Brook, Lutwyche Road is the approximate catchment boundary for the small local catchment draining directly to Kedron Brook. Depending on the location of the tunnel ramps and portals, minor local flows also need to be addressed in this location.

3.4 Hydraulic Assessment of Existing Conditions

Major flood mitigation works were undertaken following significant flooding that occurred along Kedron Brook during 1974. A major component of these works was the channel capacity improvements between Webster Road and Nelson Street. The Kedron Brook channel within this reach was enlarged, providing a trapezoidal channel of 50m base width and grassed side slopes of 1:4.

The enlarged channel section provides for sufficient flow capacity to convey the 100-year ARI peak flow for Kedron Brook within the channel limits. Accordingly, there is no overbank flooding from Kedron Brook for the 100-year ARI event. Overbank flooding is limited to the contribution of local catchment drainage.

The indicative 100-year ARI flood envelope for Kedron Brook near Gympie Road is shown in Figure 3-1.

As noted earlier, the Kedron Brook Flood Study (KBFS) did not include a simulation of the 10,000 year ARI design event. To confirm tunnel immunity requirements, this event was simulated using the Kedron Brook Flood Study URBS model and a HEC-RAS model of this reach of tKedron Brook.

The 10,000 year ARI design event rainfall was determined using the Generalised Short-Duration Method described in Australian Rainfall and Runoff and applied to the calibrated URBS model. The model predicted a peak discharge at the Gympie Road bridge of 1340 m^3/s. For comparison, the 100 year ARI and PMF values predicted in the KBFS were 630 and 2150 m^3/s, respectively.

A hydraulic submodel of this reach was developed using the HEC-RAS modelling package. The model was constructed using cross sections from the KBFS RUBICON model. The submodel extends from a location approximately 1350m downstream of the crossing to approximately 700m upstream. Peak discharge predictions from the URBS model were applied to the upstream model boundary. A rating curve was applied to the downstream boundary.

The 100 year ARI simulated using the HEC-RAS submodel and peak water level predictions upstream of the bridge were found to be consistent with the KBFS results (11.2m AHD compared with 11.1mAHD)

The HEC-RAS submodel predicted an existing case peak water level upstream of the crossing of 14.5m AHD under a 10,000 year ARI design event. The model results show that under these existing conditions, a significant portion of the 10,000 year ARI discharge would pass over the existing road bridge (existing pavement levels in the vicinity of the Kedron Park intersection are approximately 12.7m AHD).

3.5 3.5 Design Proposal

After construction of the Airport Link and Northern Busway works, the Gympie Road crossing will consist of:

- A 2 lane Busway plus 3 APL lanes on a new bridge that will be constructed on an alignment similar to the existing crossing.
- A 5 lane super elevated structure, immediately downstream of the new Busway bridge.
- A 5 lane third bridge, immediately downstream of the new super-elevated structure. The third bridge will be at a similar elevation as the upstream bridge.

Flood Immunity

As discussed previously, the tunnels are to be provided with 10,000 year ARI flood immunity. Given that the tunnel will be connected to the surface at the Kedron Park intersection, any overflow that reaches the intersection could flow into the tunnel. As noted above, the HEC-RAS model predicts that under existing conditions, a significant portion of the 10,000 year ARI discharge will pass over the existing bridge structure and may therefore be able to flow into the tunnel.

To prevent this inflow, the entire 10,000 year ARI discharge will need to be passed beneath the structure. Two basic options could be utilised to achieve this result, namely:

- Provide flood protection walls along the upstream kerb of the existing bridge structure; or
- Increased conveyance beneath the bridge structures.

The first option would achieve the increased capacity by generating an increased upstream water level and hence driving head. The additional underflow would generate significantly increased velocity and scour protection for the piers and abutments would be critical. Structural loads on the flood protection walls would also need to be carefully considered. This option is not considered viable.

The second option involves replacing the existing bridge and potentially regrading the approaches. The replacement bridges would need to span the entire trapezoidal channel and would need more capacity than the existing crossing. This may require local earthworks in the vicinity of the crossing. The bridge soffit may need to be higher than the existing structure. Tests undertaken with the HEC-RAS model showed that with increased bridge capacity, both in terms of bridge width and soffit clearance, the entire 10,000 year ARI discharge could be passed beneath the bridge with a significantly lowered upstream water level and velocity through the structure.

The absolute upstream water level will depend upon the final bridge configuration. Depending upon this final water level, some minor flood protection may be required to prevent overflow entering the tunnels. The final design is therefore likely to include a combination of channel works, bridge lengthening and widening, regrading of the bridge approaches and east-west tunnel connection ramps plus some minor flood protection bunding (or similar). The design will need to carefully consider and manage the interfaces with Northern Busway works.

- **Figure 3-2 – Indicative 100-year ARI Flood Envelope for Kedron Brook near Gympie Road**

3.5.1 Hydraulic Impact

With Kedron Brook 100-year ARI flows conveyed entirely within the channel, the hydraulic impact of the proposed connections on Kedron Brook flooding is limited to the impact of additional structures or works within the channel limits. The abutment and pier configurations of additional structures potentially provide for additional flow impedance within the channel section and associated increases in peak flood levels.

For all additional bridge crossings of Kedron Brook, the proposed design minimises impact through:

- Providing increased capacity as described above.
- Construction of pier groups with a similar or smaller profile normal to flow
- Soffit elevation higher than existing structure and above the design Q100 flood level.

The impact of the proposed additional structures has been assessed using the Austroads Bridge Calculation (AustRoads, 1994). The upstream impact of the additional structures was calculated to be less than 40 mm using conservative estimates. That is 40mm is expected to be the absolute upper range of the combined impact created by the additional bridges.

Increases in peak flood levels of this magnitude will be acceptable, as no adjacent property would be adversely affected as the Q100 flood remains within the Kedron Brook channel. The design process will require further hydraulic modelling to accurately define the Q100 peak water surface level upstream of the bridge to allow design of soffit and deck levels of the proposed structures.

There is potential for local catchment flooding to be affected by the protection of the tunnel portal from the Q10,000 flood. The portal is outside of the Kedron Brook Q100 floodplain but local drainage patterns may be affected. This impact on local catchment flooding will need to be addressed in detail during the design process. Given the small size of the local catchments likely to be affected, hydraulic impacts can be managed through relatively minor stormwater drainage works. A key component of the drainage design will be the existing Gympie Road and Stafford Road overland flow paths, ensuring adequate drainage routes to Kedron Brook are maintained.

As discussed, flood walls are a potential option to provide flood immunity for the tunnel portals. These would potentially block existing local drainage paths requiring diversion of some local catchment flow. This would need to be addressed in future drainage design.

4. Northeast Connection

4.1 Location and Flooding Mechanisms

The proposed connection of the Airport Link to the East-West Arterial is located near the Sandgate Road crossing of Kedron Brook/Schulz Canal. This reach of the Schulz Canal is located approximately 10km upstream of the mouth of Kedron Brook in Moreton Bay. The water level of the 10,000 year ARI at Sandgate Road is 7.5m AHD which is approximately the height of the road surface of the Sandgate Road/East West Arterial Road intersection.

The potential flooding mechanisms are identified as:

- Eagle Junction Creek local flooding
- Kedron Brook/Schulz Canal flooding
- Moreton Bay storm tide
- Local flooding downstream of Sandgate Road.

The residential properties in the Eagle Junction area and the Toombul Shopping Centre are sites that are subject to flood inundation and are sensitive areas to changes in flooding conditions. A drainage channel runs through the Eagle Junction area that discharges into Kedron Brook via culverts under the railway embankment. This watercourse is referred to as Eagle Junction Creek.

Recent augmentation of the Eagle Junction Creek railway culverts was undertaken to improve flooding conditions in this area.

The Toombul Shopping Centre is located within the Kedron Brook/Schulz Canal floodplain downstream of Sandgate Road. Existing car park areas adjacent to the channel are subject to periodic flooding.

4.2 Available Data

4.2.1 Kedron Brook/Schulz Canal Flooding

Detailed hydrologic and hydraulic modelling was undertaken for the Kedron Brook Flood Study (Connell Wagner, 1995) and the Airtrain CityLink Hydraulic Study (Connell Wagner, 1999). Predicted peak flood water levels from this study were used as a guide to validation of the existing case hydraulic model.

4.2.2 Moreton Bay Storm Tide Data

Moreton Bay storm tide data was provided in Section 2.2.2. The dominant flooding mechanism at the Sandagte Road connection was the fluvial flood from Kedron Brook and/or Eagle Junction Creek.

4.3 Hydraulic Assessment of Existing Flood Conditions

There are a number of existing structures that impact on the flooding conditions within this reach of Kedron Brook/Schulz Canal including.

- North Coast Rail Embankment - two bridge structures are incorporated in the rail embankment, the main structure on the Kedron Brook channel and a secondary bridge/underpass on the right bank floodplain. Culverts draining Eagle Junction Creek also pass through the embankment.
- Sandgate Road Bridge – existing bridge with spill-through abutments and two pier groups within the channel area.

- Carpark Bridge – existing concrete bridge connecting the carparking areas on the north and south banks of the channel. The existing bridge has a single span (ie no piers) and is equipped with collapsible handrails.
- Widdop Road Bridge - existing bridge with spill-through abutments and a single pier group within the channel area. The bridge is equipped with collapsible handrails.
- Airtrain Piers – a number of piers are located on the floodplain supporting the Airtrain.
- East-West Arterial – on the right bank of Kedron Brook/Schultz Canal between Sandgate Road and Widdop Street, the elevated road limits the inundation extent on the floodplain.

The indicative 100-year ARI flood inundation envelope is shown in Figure 4-1. The source of this data was the Brisbane City Council flood envelope. The nature and extent of flooding was validated using hydraulic modelling for the purpose of this investigation. The following locations are noted as key flooding areas or hydraulic controls:

- Toombul Shopping Centre – the peak 100-year ARI flood level for this area is approximately 5.1 m AHD. The inundation extent shown in **Figure 4-3** indicates that the shopping centre area is prone to flooding in major events. It is noted however, that the ground surface is relatively flat such that modest rises in flood levels would significantly increase the inundation extent. Whilst the depth of surface inundation may be small, there is significant potential for water ingress to below ground areas.
- Eagle Junction Creek Upstream of the rail embankment – this is an existing flood prone area as indicated by the flood inundation extents in **Figure 4-3**. The flooding is a combination of flood flows within the drainage channel and backwater effects from the railway embankment. It is primarily driven by floodwaters backing up from the railway embankment bridges.
- Rail embankment – as presented **Figure 4-3**, there is considerable head loss across the rail embankment confirming the existing structure as a significant hydraulic control. As an indicator, the waterway area to the 100-year ARI flood level for the combined rail embankment structure openings is approximately 50% of the waterway area at Sandgate Road to the corresponding level.
- Transition to D/S Sandgate Road – upstream of the rail embankment an extensive width of floodplain is conveying flow. Downstream of Sandgate Road, adjacent to the Toombul shopping centre the convective flow width is significantly less. Within this transition reach there is the Eagle Junction tributary/Kedron Brook confluence and the Sandgate Road bridge that provides an additional flow restriction.

- **Figure 4-1 - Indicative 100-year ARI Flood Envelope for Kedron Brook near Sandgate Road**

4.3.1 Hydraulic Model Set up

A new hydraulic model was established for the purpose of this investigation. A dynamic, two-dimensional modelling approach was adopted as this methodology will give the best representation of the complexity of flow around the Sandgate Road area. **Figure 4-2** illustrates the MIKE21 model layout. The key elements of the model are:

Model Area and Topography– the limits of the model area were set with consideration of the area that may be affected by the development and the likely extent of the impacts. The downstream boundary was determined to be sufficiently far downstream to have negligible impact on upstream flood impacts. The terrain model was developed based on Airborne Laser Scanning (ALS) data supplied by Connell Wagner.

Structures – The model incorporates major structures including the North Coast railway, Sandgate Road bridge, Widdop Street bridge and the Airtrain piers. Kedron Brook is conveyed through the railway embankment via a bridge opening on the main channel alignment and a secondary bridge/underpass on the floodplain in Kalinga Park. The Eagle Junction tributary is also drained through the railway embankment via culverts.

Roughness – Manning's 'n' roughness is a key parameter for hydraulic calculations. Values for this hydraulic model were determined based on visual inspection of the site, aerial photography and adopted values from the calibrated Kedron Brook Flood Study model. In-channel values for Kedron Brook/Schulz Canal were varied between 0.02 and 0.04. Floodplain values in general varied from 0.03 to 0.1 depending on the extent and nature of vegetation. A value of 0.2 was adopted for residential areas to represent the impediment posed to flow by houses, fences etc. A value of 0.02 was adopted for the car park areas adjacent to the Toombul Shopping Centre and other major roadways through the model area.

Inflow boundary – two major system inflows occur within the modelled area, being the main Kedron Brook/Schulz Canal and Eagle Junction Creek. These were modelled as inflow boundaries to the north and west of the model. Four local drainage paths downstream of Sandgate Road were also modelled including:

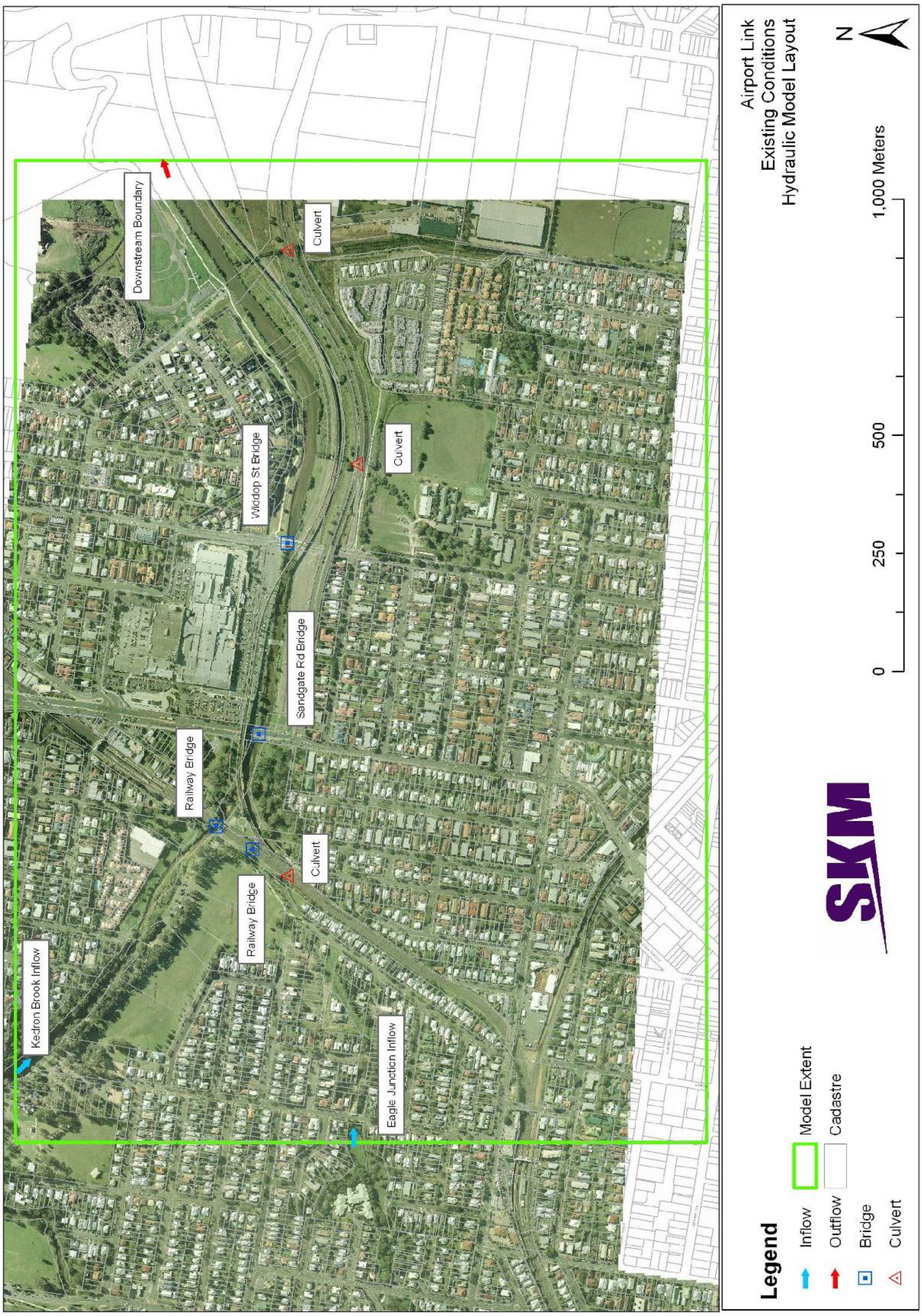
The Hendra locality tributary that drains via culverts beneath the East-West Arterial to the Kedron Brook approximately 200m downstream of Widdop Street. (Hendra Tributary)

The drainage channel that drains via culverts under the East-Arterial just north of Hedley Avenue. (Hedley Av Tributary)

The drainage channel that drains into Kedron Brook from the north through a park. (Toombul Drainage Channel)

Local catchment flooding from the Toombul Shopping Centre area. (Toombul Shopping Centre)

Figure 4-2 - Existing Conditions MIKE21 Model Layout



The URBS hydrologic model created for the Kedron Brook Flood Study (Connell Wagner, 1995) was re-run to provide hydrographs for each of these inflows. The peak discharges for each of these inflows is presented below.

Inflow	Peak Discharge
Kedron Brook	670 m^3/s
Eagle Junction Ck	53 m^3/s
Hendra Tributary	36 m^3/s
Hedley Av Tributary	45 m^3/s
Toombul Drainage Channel	26 m^3/s
Toombul Shopping Centre	24 m^3/s

Tailwater Conditions – a fixed water level boundary was applied at the downstream model boundary. The peak 100-year ARI water level from the Kedron Brook Flood Study (Connell Wagner, 1995) at the model boundary, approximately 850m downstream of Widdop Street. This adopted level was 3.55m AHD.

4.3.2 Existing Flooding Characteristics

As indicated in **Figure 4-2**, the hydraulic modelling found that the flooding of the investigation area was extensive. The main waterway areas experienced very fast moving flows over 2 m/s exacerbated by water throttling through the bridge structures of the railway and Sandgate Road.

There are five major zones of flooding in the existing case. These are:

- Eagle Junction Ck
- Upstream of the Railway
- Between the railway and Sandgate Rd bridges
- Downstream of Sandgate Rd
- South of the East-West Arterial.

Eagle Junction Creek is only a minor contributor to flooding upstream of the railway. Flood flow backs up this channel from Kedron Brook with this volume creating the majority of flooding impacts in this area.

Upstream of the railway, flood flow is not contained within bank and breaks out to cover the whole floodplain. The railway causes a significant obstruction to this flow. The bridges under the railway are relatively small compared to the floodplain width and this reduction in conveyance causes water to back up and pond upstream of the railway embankment. This also causes high velocities through the bridge openings. The peak speeds in the existing case are presented in **Figure 4-4**.

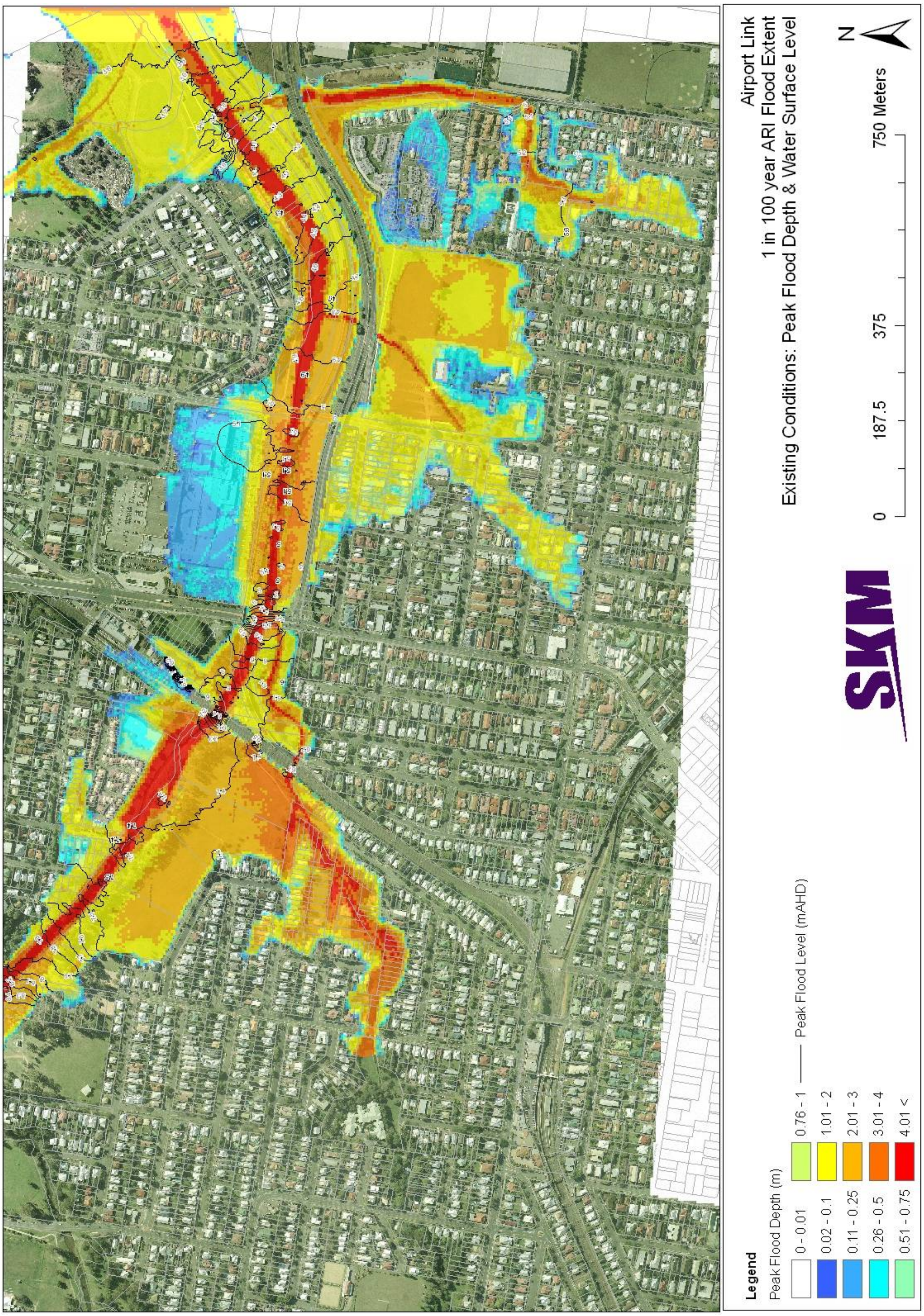
The Sandgate Rd bridge also acts as a major restriction to flow. Flooding between the railway and Sandgate Rd is entirely controlled by these two structures as there is not sufficient distance between the two bridges to allow flowpaths to completely expand after the railway bridge before it is forced to contract through the Sandgate Rd bridge.

Downstream of Sandgate Rd, the majority of the flood flow is contained within the channel although the East West Arterial acts as a barrier along the southern edge of the floodplain.

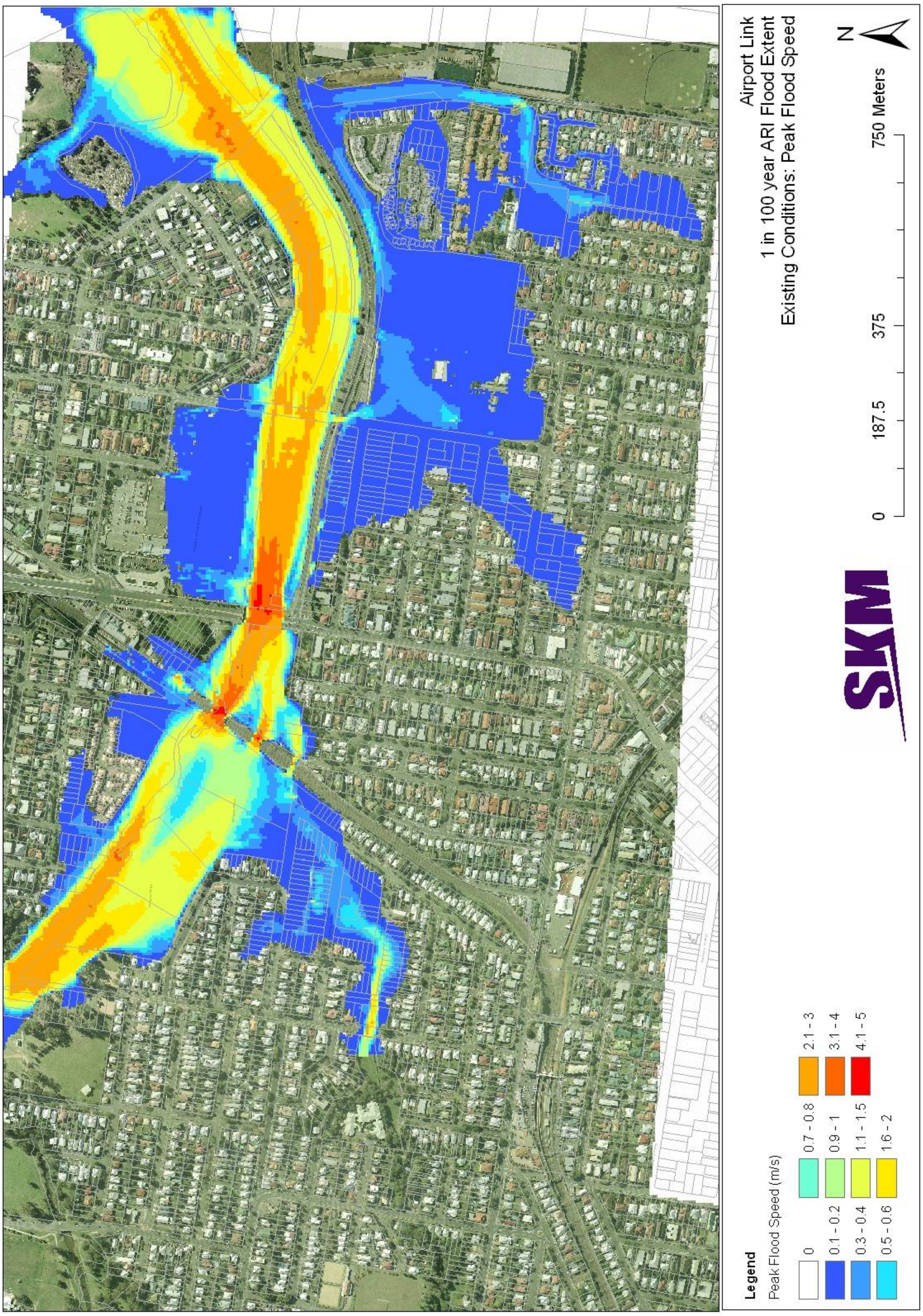
The area to the south of the East West Arterial is predominantly inundated by flow backing up from Kedron Brook via large culverts under the East West Arterial and the Widdop St underpass. The road embankment then acts as a wall blocking this flow from returning to the floodplain and resulting in ponding on the southern side. Some local catchment flooding occurs in this area.

The existing conditions hydraulic model was validated by comparison of peak flood levels from the model with those documented in the Kedron Brook Flood Study (Connell Wagner, 1995). This was undertaken for a range of locations in the modelled reaches of Kedron Brook and Eagle Junction Creek. The hydraulic model results were slightly higher than this study. This is consistent with the findings of the AirTrain hydraulic investigation (Connell Wagner, 1999) which included detailed investigation of structure hydraulics throughout the model area. This difference can be attributed to the different approaches used to model the structures in the two studies. The structure representation from the AirTrain modelling was adopted for this modelling.

- **Figure 4-3 - Existing Flood Extent 1 in 100 Year ARI**



- **Figure 4-4 - Peak Flow Speeds Existing Flooding 1 in 100 Year ARI**



4.4 Hydraulic Assessment of Construction Flood Conditions

Construction activities for the Project affect areas of the Kedron Brook and Schulz Canal watercourses and floodplains. Therefore, there is a potential for short term impacts on the characteristics of flooding in the investigation area. Hydraulic modelling was undertaken to assess these impacts and provide adequate mitigation.

Construction impacts will include:

- Truncation of the Eagle Junction Creek alignment and blockage of the existing creek culverts under the railway.
- Flood protection bunding of the construction area upstream of the railway.
- Construction site access under the railway at the existing underpass location requiring localised lowering of the terrain to pass tall vehicles.
- Flood protection bunding of the construction area and subsequent road alignment between the railway and Sandgate Road alignments.
- Construction of earth embankments encroaching on the Schulz Canal floodplain adjacent to the East-West Arterial Road.

4.4.1 Hydraulic Model Set up

Each of the proposed construction activities was included in the hydraulic model. Refinements were made to the layout and design of the activities to minimise their impacts. The location of the works are summarised in **Figure 4-5**.

The truncation of the Eagle Junction Creek required that the Creek be diverted around the works site. Various alignment routes were tested before settling on the option proposed. The selected alignment provided a sound hydraulic solution while balancing potential social and environmental impacts of undertaking a creek diversion.

Construction of earth embankments to protect transition structures along the East-West Arterial were not explicitly modelled. However, impacts caused by these bunds would be mitigated by the widening of the Kedron Brook/Schulz Canal channel in this area. This widening is proposed for the developed case but could be brought forward to match the timing of construction of these bunds.

4.4.2 Construction Period Flooding Characteristics

The flooding characteristics of the investigation area were modified due to the construction activities. The balance of the impacts is manageable considering the short duration of the construction phase. Inundation mapping in the 1 in 100 year ARI flood event is shown in **Figure 4-6**. **Figure 4-7** shows the impact of the construction on the flooding. Areas shown in shades of red show the degree of increase in flood levels. Areas shown in green are areas where the flood depths have been decreased due to construction.

Upstream of the Railway

The modelling found that the creek diversion could be managed so as to cause minimal impacts on regional flooding upstream of the railway. The diversion delivered the creek flow directly to the construction vehicle underpass. Increased flooding would have been experienced due to the blockage of the Eagle Junction Creek culverts under the railway. However, the lowering of terrain at the vehicle underpass generally increased the capacity of the area to pass flooding under the rail alignment and the impact was mitigated. By conveying Eagle Junction Creek in a broad channel under the railway rather than via culverts provided a better solution in this large Q100 event.

Flood protection bunding of the construction area removed a large area of floodplain storage upstream of the railway and flooding depths were sensitive to this. Generally, water levels upstream of the railway were increased by 40 - 70mm. The impact would have been greater without increasing the capacity of the underpass through excavation for construction vehicle access.

Given that the planned construction period is short and that the impacts are small, it is considered that the level and extent of impact upstream of the railway alignment are acceptable.

Railway to Sandgate Road

The flooding depths between the railway and Sandgate Road were increased as the construction activities encroached upon areas of high velocity flow in the floodplain. The level of impact was measurable with levels increasing by approximately 120mm in some areas.

Mitigation measures were put in place by increasing the capacity of Eagle Junction Creek to act as a better conveyor of floodplain flow that passes through the railway underpass. This assisted in the reduction of the flood levels however the full extent of the impacts could not be removed.

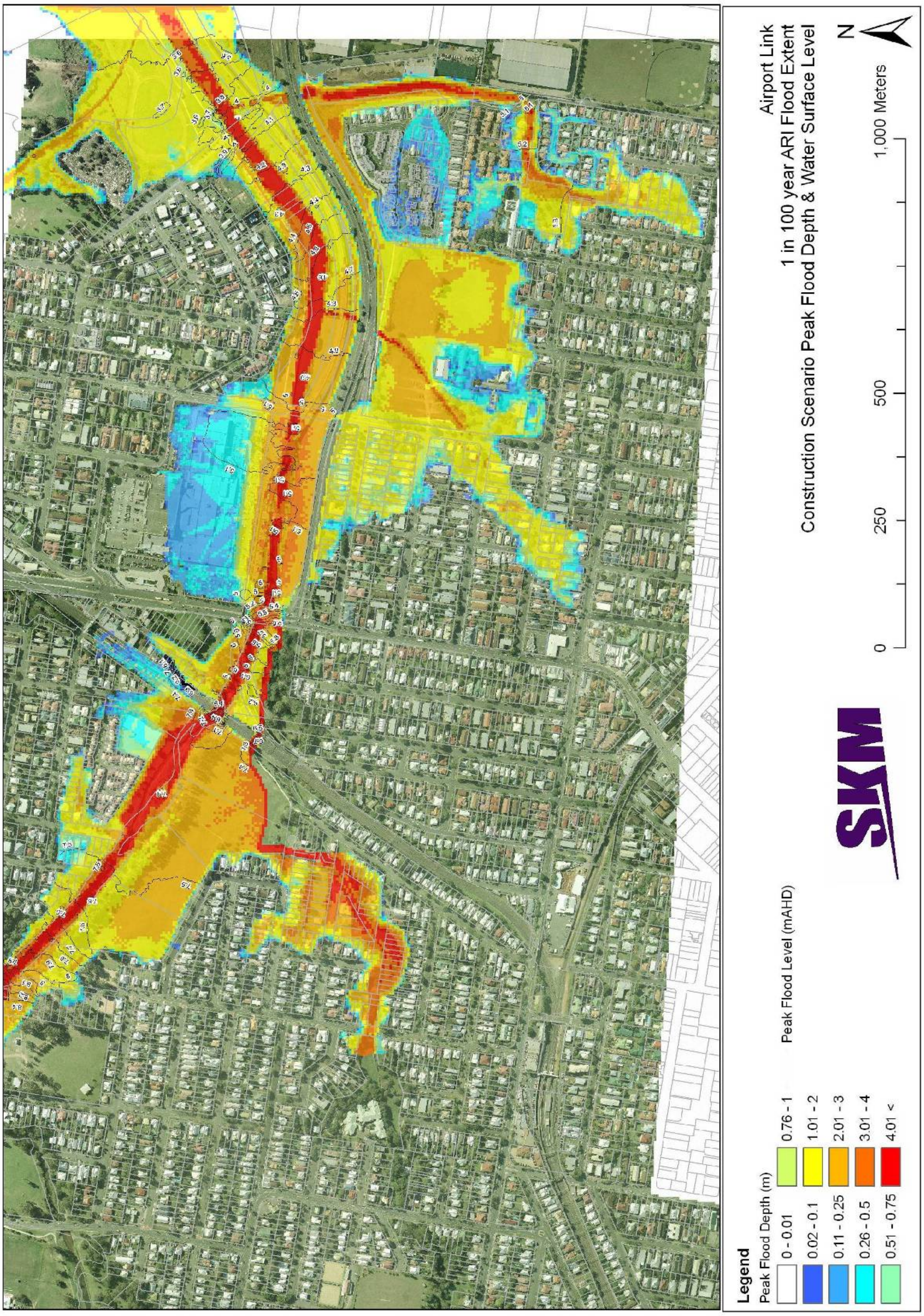
The railway and the Sandgate Road bridges over Kedron Brook are very inefficient in the Q100 flood. Therefore, they are also inefficient at passing impacts of the encroachment upstream and downstream. Some of the increased flood levels upstream of the railway may be attributed to the increased flooding in the area between the bridges. However, the flooding impacts were largely limited to that zone.

Downstream of Sandgate Road

Flooding depths downstream of Sangate Road were generally not affected by construction. Some minimal impact occurs in the southern carpark of the Toombul Shopping Centre with maximum impacts of 30mm in this area. It has been recommended that the Kedron Brook/Schulz Canal channel downstream of Sandgate Rd be widened in the developed case to mitigate longterm impacts. If this were to be constructed at the beginning of the construction phase, flood impacts in this area would be minimised. This could also potentially help improve upstream impacts.

- **Figure 4-5 – Construction Case Model Layout**

Figure 4-6 – 1 in 100 year ARI Flood Extent During Construction



■ Figure 4-7 – 1 in 100 year ARI Impacts During Construction

4.5 Hydraulic Assessment of Developed Flood Conditions

4.5 Hydraulic Assessment of Developed Flood Conditions

In the developed case, the construction site upstream of the railway will be removed and remediated. Attempts will be made to reinstate the hydrologic regime to its pre-development condition.

The Eagle Junction Creek diversion will be removed and the creek will return to its original flow path through the railway culverts. Downstream of the railway, the encroachment on the floodplain will remain as the new transition structures for the tunnel will require flood protection. Downstream of Sandgate Road, the new transition structures from the main tunnel drive will require flood protection and the earth embankments will encroach on the Schulz Canal floodplain.

Refer to **Figure 4-8** for the layout of the developed works model.

4.5.1 Hydraulic Model Development

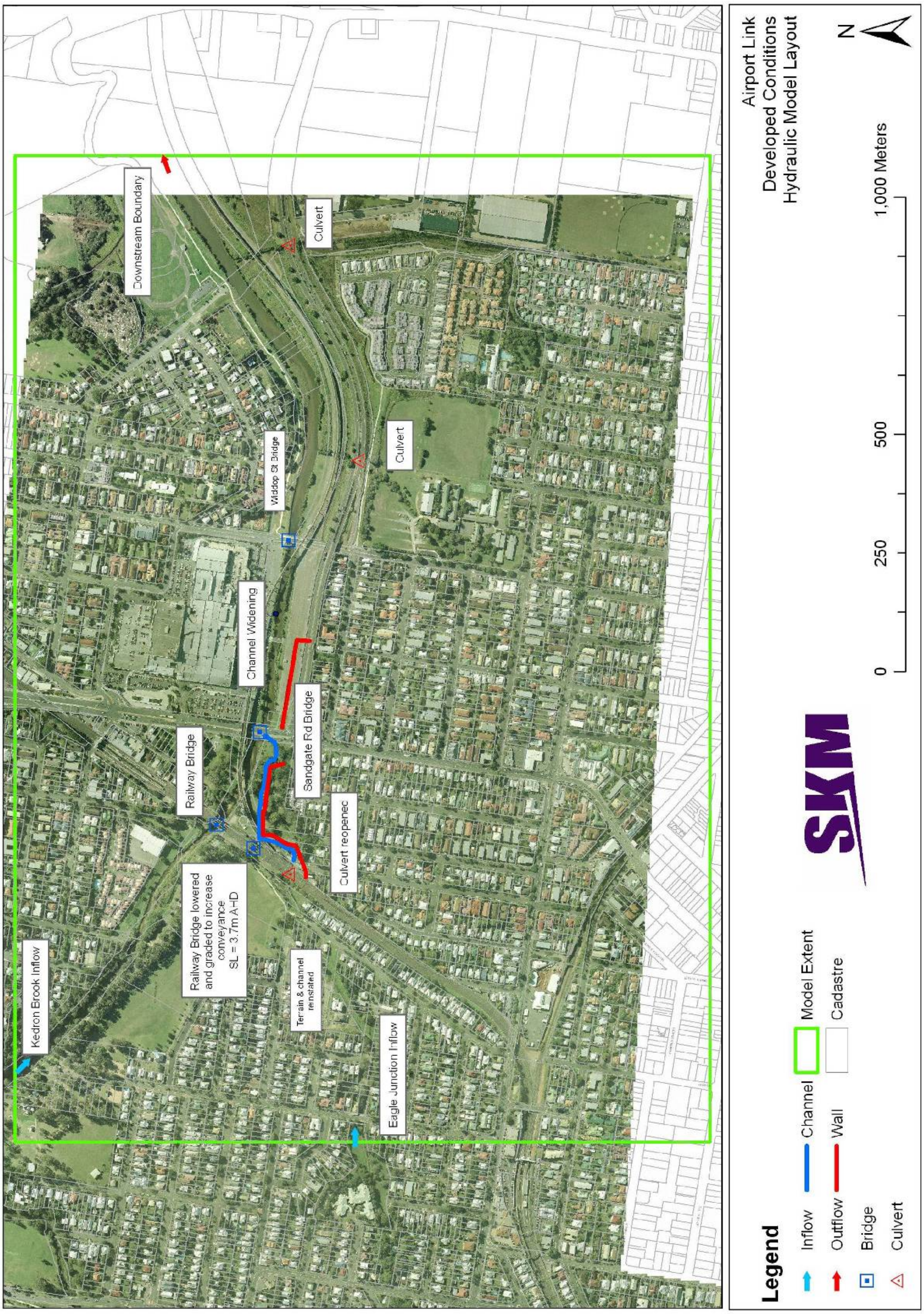
The hydraulic model was modified to represent the developed case. Upstream of the railway, the diversion of Eagle Junction Creek was removed and the creek reinstated identically to its representation in the Existing Case model upstream of the railway. Downstream of the railway, the Eagle Junction Creek diversion implemented during the Construction Phase was retained and this channel was extended upstream, between the railway and the flood protection wall, to the outlet of the reinstated culverts under the railway.

The railway bridge which was used as a truck underpasss and channel during construction was reinstated to a surface lower than in the existing case at 3.7m AHD and graded to join existing terrain upstream and the diversion channel of Eagle Junction Creek downstream. This extra conveyance helps minimise impacts upstream of the railway.

The model represented the construction of the transition structures onto Sandgate Road and the East West Arterial as solid obstructions to flow that cannot be overtopped. This was representative of how the structures will behave in the future.

The Kedron Brook channel, downstream of Sandgate Rd, was widened by 10m to help minimise impacts in the downstream reach. **Figure 4-8** shows the model layout for the final developed case.

Figure 4-8 – Developed Case Model Layout



4.5.2 Developed Flooding Characteristics

Figure 4-9 shows the flooding characteristics of the investigation area in the 1 in 100 year ARI flood when fully developed. Diverting Eagle Junction Creek back to its original alignment and removing the construction area removed flooding impacts upstream of the railway alignment. Some reduction of water surface levels occurs in some areas upstream of the railway. This reduction could be as much as 30mm.

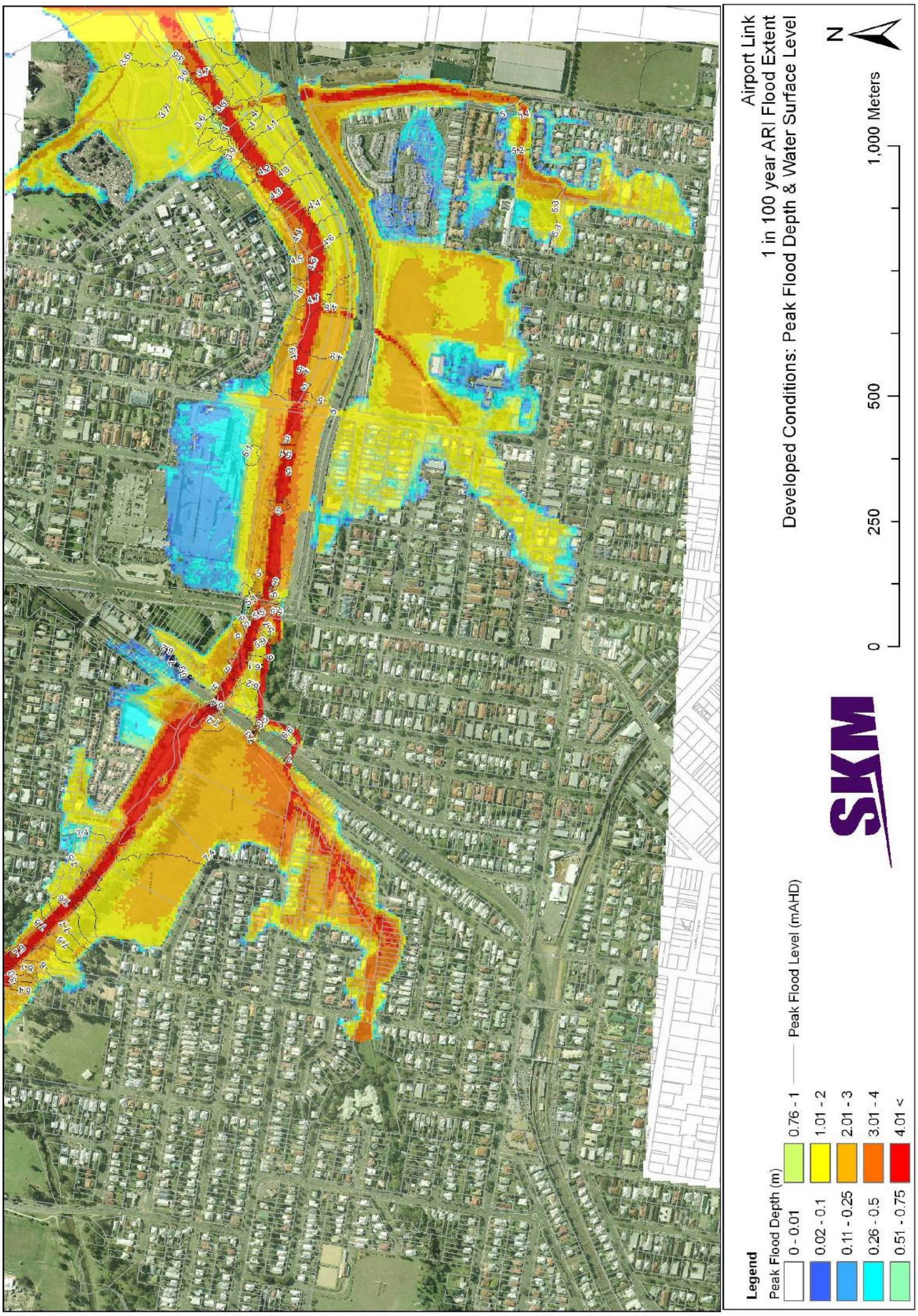
Flooding impacts remain in the corridor between the railway and Sandgate Road as the on ramp and off ramp transition structures encroach on the floodplain of Kedron Brook that flows at high velocity in the existing case. Additional floodplain capacity could be added by widening the Kedron Brook channel. However, this will have only minimal effect on impacts between the two structures as the flow is trapped in this area by the two structures. Widening the channel in this region simply allows more water to pool in the reach.

There are no houses or properties on the southern floodplain in this reach. However, on the northern floodplain, there will be some limited property impacts. It is possible that there will be an increase in water levels of up to 60-70mm on properties already affected by flooding. Localised mitigation works that will be identified through detailed design are able to avoid adverse impacts on these properties.

Downstream of Sandgate Road, it was found that the construction of the earth embankments to transition out of the main tunnel onto the East West Arterial encroached on the Schulz Canal floodplain. This impacted on flood levels however the impact was mitigated through the increase of the main Canal cross section. Increasing the cross section increased the conveyance of the Q100 flood through the area and removed the adverse impacts. Importantly, the impacts were not propagated downstream.

Figure 4-10 shows the regional impacts of flooding in the final developed scenario.

■ **Figure 4-9 – 1 in 100 year ARI Developed Case Flood Extent**



- **Figure 4-10 – 1 in 100 year ARI Impacts for Developed Case**

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