

4.1.2.4 Strangers Creek – Norwest Station (Site 7)

Norwest Station is located on Norwest Boulevard, west of Strangers Creek. Strangers Creek in the vicinity of Norwest Boulevard is a highly modified system consisting of a series of ponds interconnected with drainage culverts, draining a catchment area of approximately 36 hectares. In larger flood events the ponds would overtop and flows would travel across Norwest Boulevard. The precinct is elevated above Strangers Creek and is not affected by mainstream flooding. However, the local road drainage system runs along the precinct from the west via Norwest Boulevard and Brookhollow Avenue. The existing road drainage network layout is shown in Figure 8, including local overland flows for the 20 and 100 year ARI, and the PMF.

4.1.3 Bella Vista Station to Rouse Hill Station

4.1.3.1 Elizabeth Macarthur Creek – Bella Vista Station (Site 8) to Kellyville Station (Site 11)

The rail alignment between Bella Vista Station (Site 8) and Kellyville Station (Site 11) runs parallel and in close proximity to Elizabeth Macarthur Creek. Development in the upstream catchment (south of Celebration Drive) is well established, consisting of a mixture of residential and commercial development. The catchment draining to Elizabeth Macarthur Creek between Celebration Drive and Samantha Riley Drive is currently largely undeveloped. However, significant urbanisation is currently underway and ongoing as part of the North West Growth Centres. A particular area of future development is the Balmoral Release Area.

Flood extent mapping for Elizabeth Macarthur Creek is provided in Figure 9 for the 20 and 100 year ARI events and PMF. As shown, Sites 8, 9 and 10 are typically located clear of the Elizabeth Macarthur Creek floodplain, with a relatively small eastern fringe of Sites 8 and 9 being flood affected. A portion of Site 10 in the north lies within the defined flood extents of both the 100 year and PMF.

4.1.3.2 Caddies Creek (including Tributaries 3, 4 and 5) – Windsor Road/Old Windsor Road (Site 12) to Windsor Road Viaduct (Site 15)

Within Sites 12 and 13 the project consists of rail viaduct that spans the broad floodplain of Caddies Creek, including its confluence with Elizabeth Macarthur Creek and Caddies Creek Tributaries 3, 4 and 5. The creek lines in this area are moderately incised with well vegetated main channel and overbank areas. Flood extent mapping for Caddies Creek is provided in Figure 10 for the 20 and 100 year ARI events and PMF.

Site 14 (Rouse Hill Station) is located north of Caddies Creek Tributary 3 and would be susceptible to inundation from flows overtopping Windsor Road at the Tributary 3 culverts. Detailed modelling undertaken for Tributary 3 shows that the Tributary 3 culvert crossing has in excess of a 100 year ARI capacity. Consequently, Site 14 is not expected to be affected by flooding up to the 100 year ARI event, apart from runoff from the local drainage network. Windsor Road overtops in the PMF and the southern edge of Site 14 could therefore be affected by flooding in the PMF. Flood extent mapping for Caddies Creek Tributary 3 is provided in Figure 11 for the 20 and 100 year ARI events and the PMF.

Site 15 is located immediately north of Rouse Hill Station. In this area the project crosses over Windsor Road on an elevated viaduct. Site 15 is located within the Caddies Creek catchment but outside the floodplain of mainstream flooding. A small drainage line crosses Windsor Road immediately north of the Rouse Hill Station Precinct.



North West Rail Link EIS

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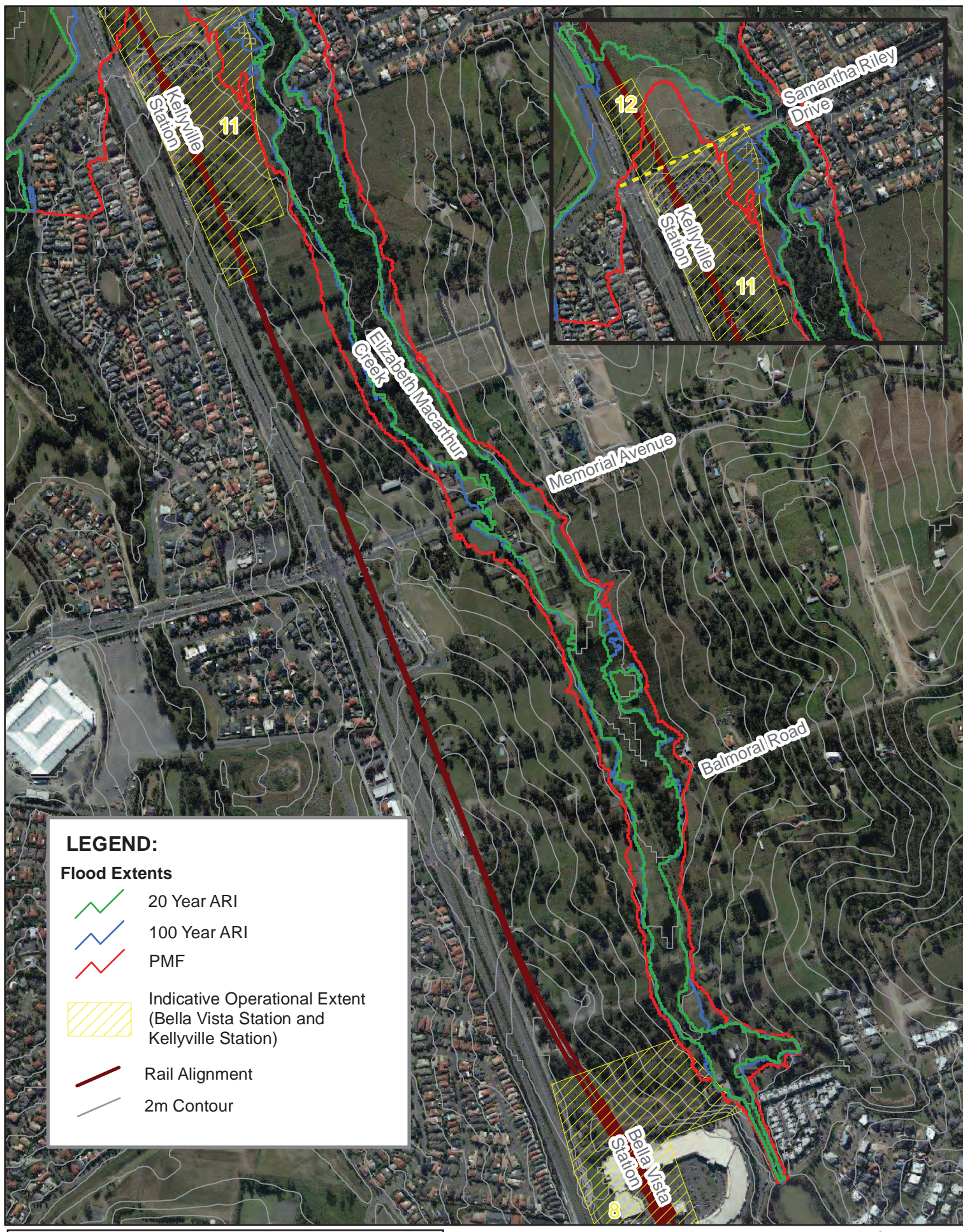
Site 7

60224114

Source: AECOM

0 0.025 0.05 0.1 km

Fig. 8



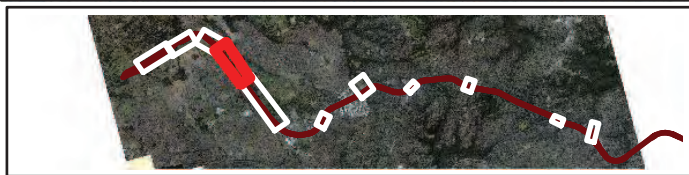
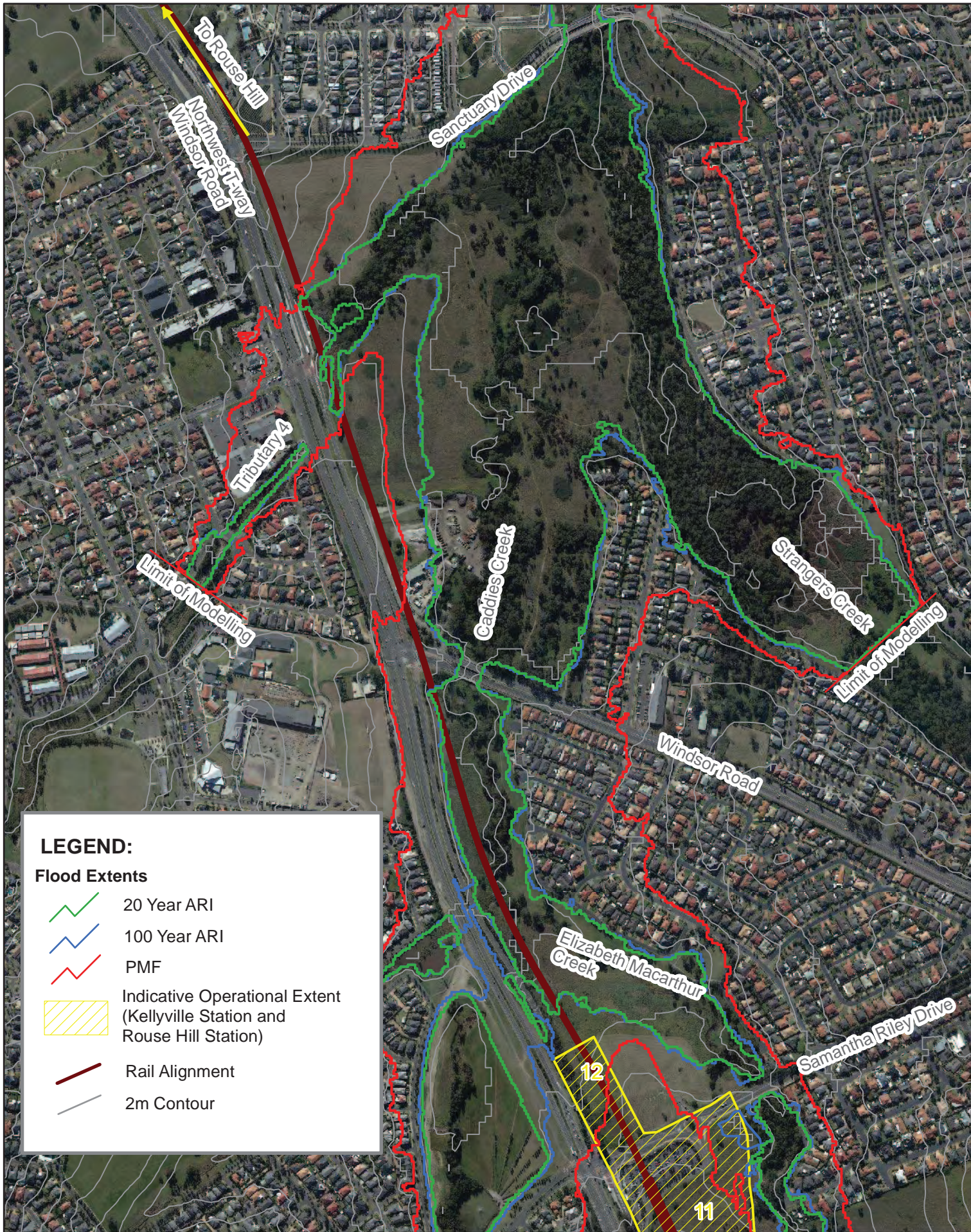
LEGEND:

Flood Extents

- 20 Year ARI
- 100 Year ARI
- PMF

Indicative Operational Extent
(Bella Vista Station and
Kellyville Station)

- Rail Alignment
- 2m Contour



North West Rail Link EIS

Sites 12 to 13

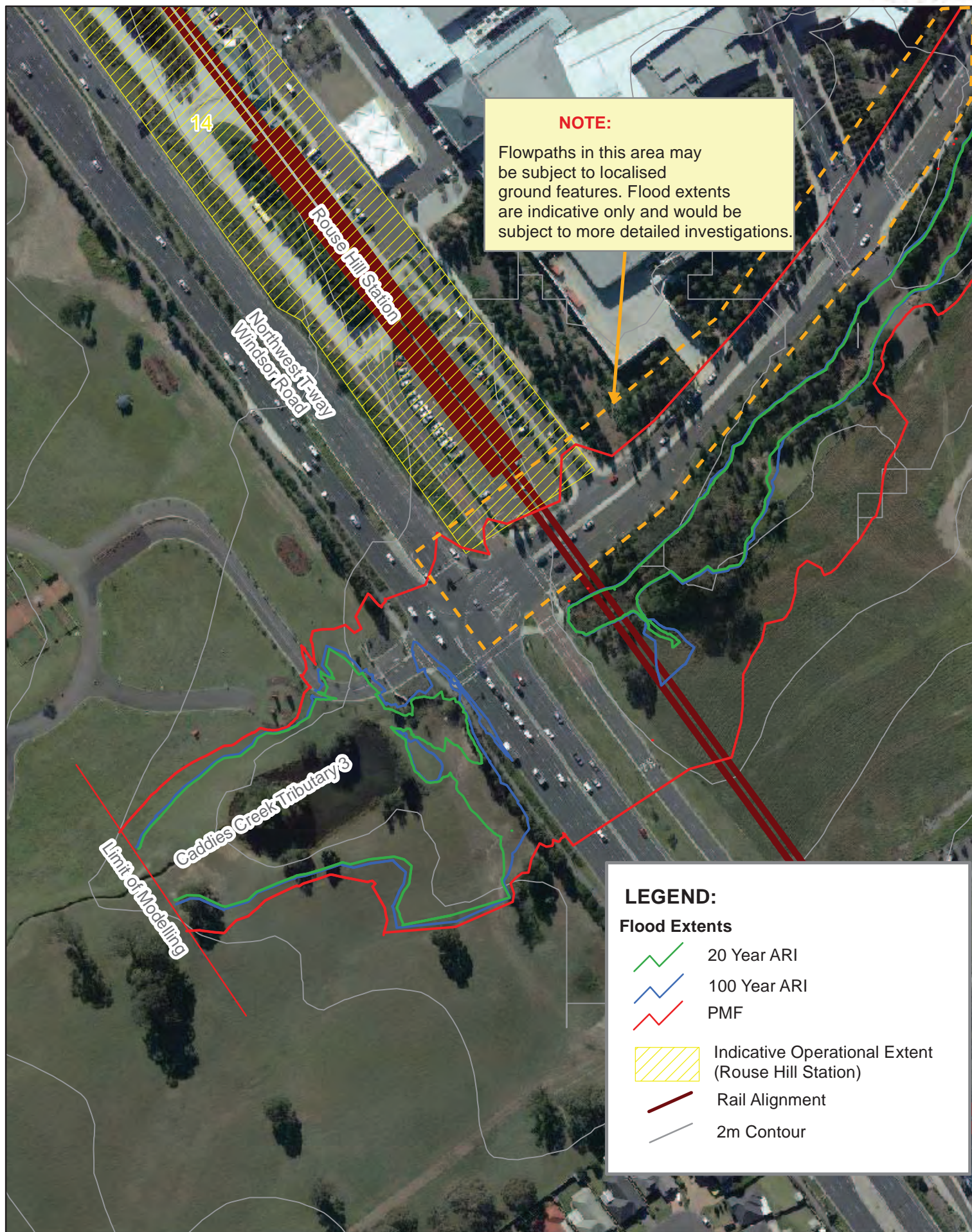
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0 0.075 0.15 0.3 km

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Fig. 10



4.1.4 Rouse Hill Station to Tallawong Stabling Facility

4.1.4.1 Second Ponds Creek – Windsor Road Viaduct to Cudgegong Road (Site 16)

Second Ponds Creek at the NWRL alignment has an upstream catchment area in the order of 620 hectares. The catchment has undergone significant urban development over recent years. Parts of the catchment, particularly in the immediate vicinity of the Project corridor, are largely undeveloped and consists mainly of rural residential. Urban development in the catchment is ongoing. Existing areas of rural development are earmarked for urbanisation as part of the Area 20 Precinct.

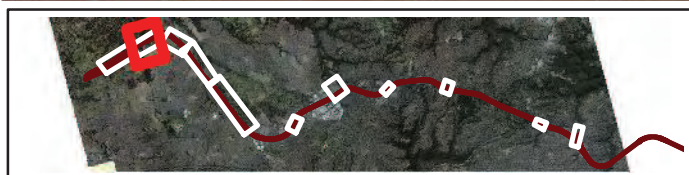
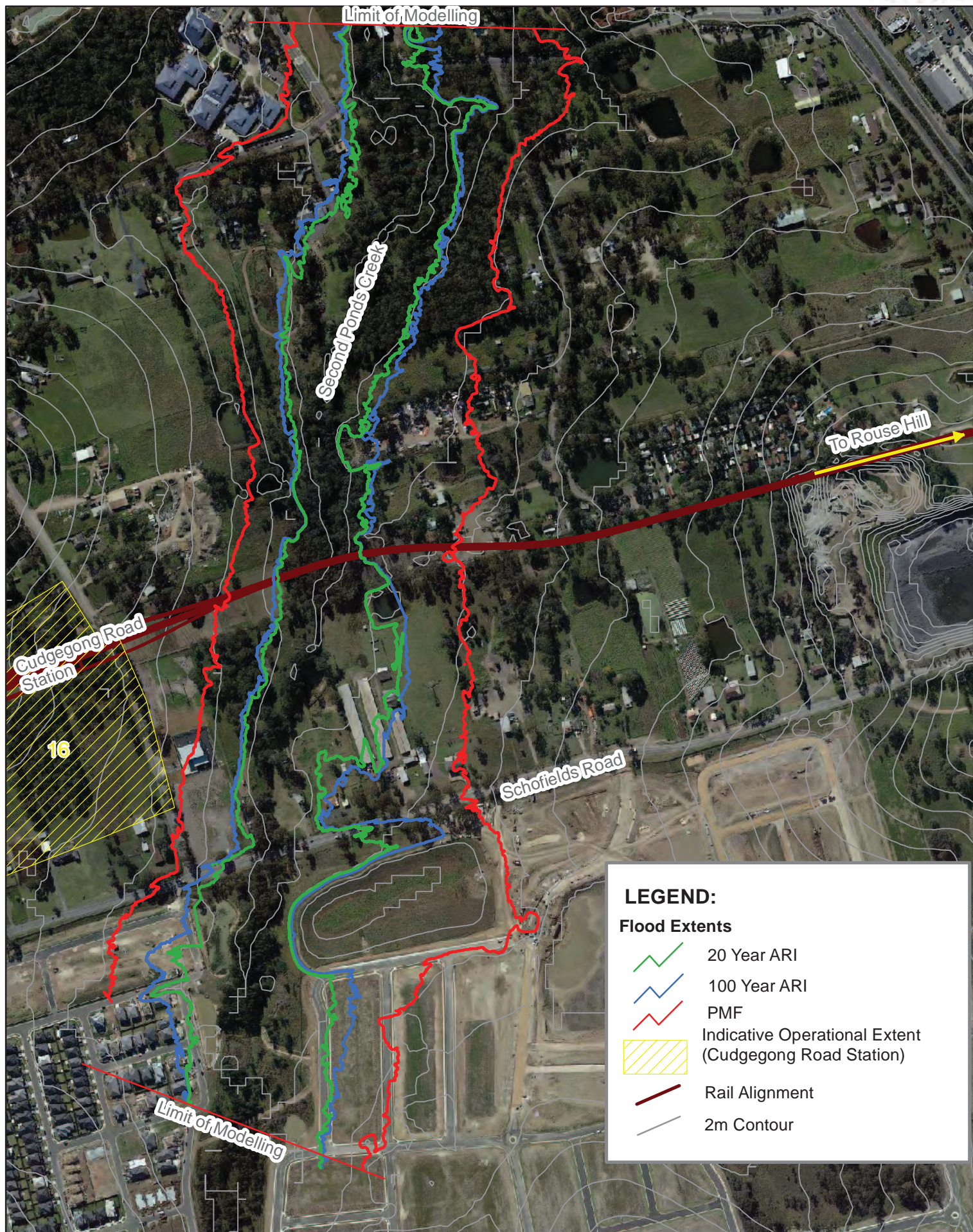
Flood extent mapping for Second Ponds Creek is provided in Figure 12 for the 20 and 100 year ARI events, as well as the PMF. Site 16 is located to the east of Second Ponds Creek and is not located within the defined flood extents.

4.1.4.2 First Ponds Creek – Cudgegong Road and Tallawong Stabling Facility (Site 17)

The western edge of Site 17 borders a tributary of First Ponds Creek. The tributary drains a catchment area of approximately 55 hectares to the Project corridor. The junction with First Ponds Creek is approximately 150m further downstream (to the north) at which location the catchment area draining to First Ponds Creek is approximately 300 hectares.

The First Ponds Creek catchment is currently largely undeveloped, consisting of rural residential development. Future urbanisation is proposed as part of the Alex Avenue Precinct.

Flood extent mapping for First Ponds Creek is provided in Figure 13 for the 20 and 100 year ARI events and the PMF. The western edge of the Site 17 bordering the First Ponds Creek tributary is partially flood affected.



North West Rail Link EIS

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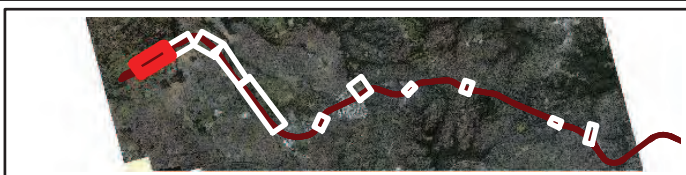
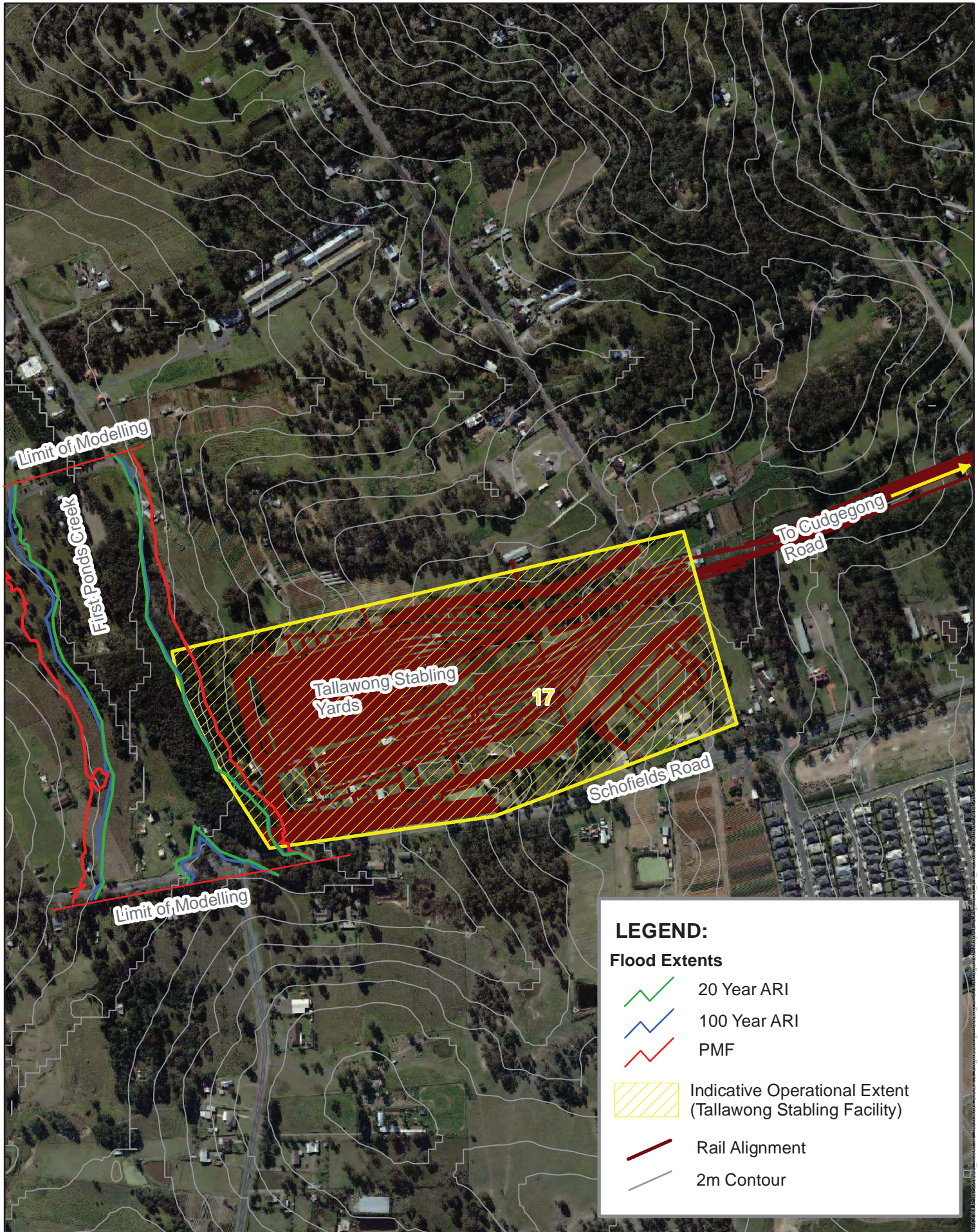
Site 16

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Source: AECOM

0 0.02250.045 0.09 km

Fig. 12



4.2 Water Quality

4.2.1 General

A considerable amount of water quality monitoring has been undertaken within the catchments traversed by the project. Local Councils within the area (namely Hornsby Shire Council, The Hills Shire Council and Blacktown City Council) have extensive water quality monitoring and reporting programmes. Water quality monitoring data is or has previously been collected by various government agencies including Sydney Water, the former Department of Land and Water Conservation (DLWC), the Environment Protection Authority, the Sydney Catchment Authority and the Hawkesbury Nepean Catchment Management Trust.

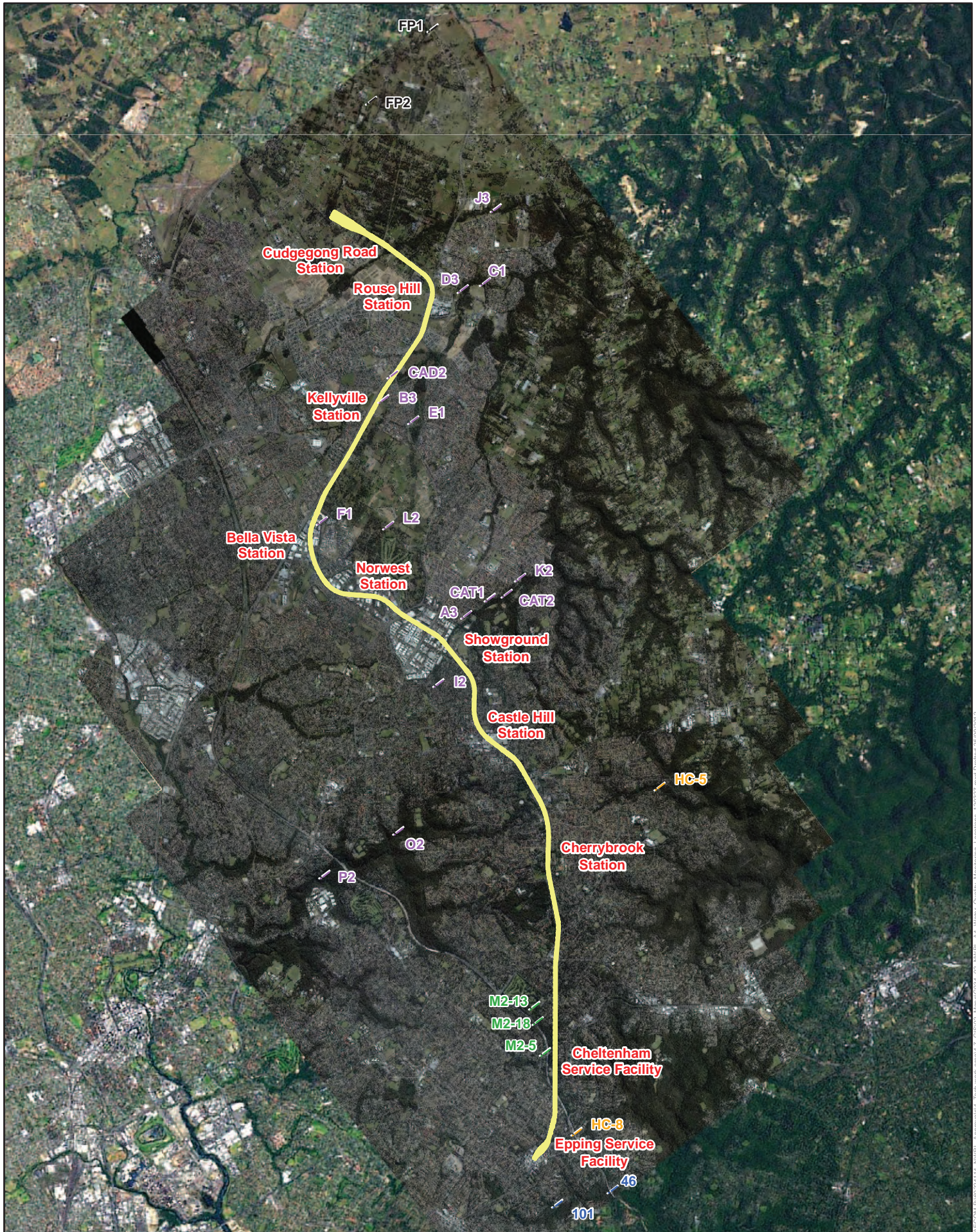
As part of the original approval conditions for the M2 Motorway a water quality monitoring program was established in 1997-98 following the commencement of operation in May 1997. The aim of the program was to monitor water quality in the receiving systems to check for conformance with recommended quality limits and identify any long term impacts associated with the M2 Motorway. Since that time, water quality data has been collected and analysed by HLA-Envirosciences at 16 locations on waterways upstream and downstream of the M2 Motorway corridor. Four of these sites are relevant to the NWRL Project. These are located on Devlins Creek in the vicinity of the Epping Service Facility (Site 1) and Cheltenham Services Facility (Site 3).

Hornsby Shire Council established a water quality monitoring program in 1994 to assess the impact of land use on waterways within the Council area and assess the performance of Council's Catchments Remediation Rate program. Hornsby Shire Council publishes an annual water quality report, which is made available to the community and interested authorities through the Council's web site. Monitoring includes Devlins Creek and Pyes Creek.

The Hills Shire Council's Health and Environmental Protection Team routinely monitors the water quality of major creek systems in the Council area. This includes monitoring sites upstream and downstream of the Project Area within:

- Cattai Creek
- Strangers Creek
- Elizabeth Macarthur Creek
- Caddies Creek
- Second Ponds Creek

These monitoring locations are presented in Figure 14. At each location Council officers test water samples for a range of parameters including Dissolved Oxygen (DO), temperature, pH and conductivity. Samples are also collected at each site and sent to a National Association of Testing Authorities (NATA) accredited laboratory for analysis of Faecal Coli forms, E.coli, Total Nitrogen, Total Phosphorous, Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS). Caddies Creek, being situated downstream of a former landfill site, is also tested for heavy metals. All results are compared to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).



- Water monitoring locations by council
- ! Baulkham Hill Council
 - ! Blacktown Council
 - ! Hornsby Council
 - ! M2 Locations
 - ! Ryde City Council

Blacktown City Council has an ongoing water quality monitoring program that was established in 2008 covering significant watercourses in the Council area. While monitoring sites are located on First Ponds Creek, they are situated at Riverstone Road and Windsor Road and therefore are not directly applicable to the project area.

4.2.2 Epping Station to Bella Vista Station

4.2.2.1 Devlins Creek (including Beecroft Road Tributary) – Sites 1 and 3

Hornsby Shire Council has established a monitoring station on Devlins Creek, approximately 200m downstream of the Cheltenham Services Facility. The monitoring station is shown on Figure 14 (referred to as location HC-8) and is adjacent to Sutherland Road at Cheltenham. The catchment draining to this monitoring site is approximately 823 hectares with about 8% falling in the Parramatta City Council area. Approximately 77% of the catchment is zoned residential with the remaining area consisting of a mix of special uses and open space, with a smaller proportion of commercial/industrial and business. Monitoring commenced in October 1994. Results of Council's monitoring are presented in Hornsby Shire Council (2009 and 2010).

At location HC-8 occasional high levels of faecal coliforms have been encountered, particularly after storms. The source of elevated levels is reported to be from stormwater runoff and/or sewer pipe overflows. Results exceeded the ANZECC Guidelines for Ammonium Nitrogen (NH₃) and phosphorous concentrations in the majority of samples taken. However, because faecal coliforms were low sewer leaks were not suspected. The levels of turbidity and suspended solids in urban sites were generally acceptable. Test results showed typically low DO levels, especially at low flow conditions when the pools tend to turn black.

The M2 Motorway monitoring sites for Devlins Creek sites are labelled M2-13, M2-18, M2-5 and M2-8 on Figure 14. These sites are located upstream of the Cheltenham Services Facility. Samples are collected following storm events where rainfall is greater than 10mm in the 24 hour period prior to sampling and are analysed for Total Suspended Solids (TSS). Suspended solids loadings are used as an important indicator in relation to nutrient transport and aesthetic appearance. AECOM (2011) tabulated the sampling data obtained for numerous events dating from January 1998 for the M2 project. The calculated long term average and median values for each of the sites are also included.

Comparison of the M2 Motorway monitoring results for pre and post construction of the Motorway indicates that construction of the existing motorway has not had any significant impact on the water quality of the downstream receiving systems.

4.2.2.2 Pyes Creek – Site 4

Hornsby monitoring location HC-5 is located on Pyes Creek at Cherrybrook (refer Figure 14). The catchment draining to the monitoring site is approximately 380 hectares of which 79% is zoned residential. The monitoring site is located in a section of creek that has extensive patches of exposed bedrock. Monitoring by Hornsby Shire Council commenced in October 1994.

The monitoring site is located approximately 3km downstream of Cherrybrook Station and is therefore not suitable to provide a direct analysis of potential changes in runoff quality from the Project. However, results do provide a useful background to the nature of the broader downstream receiving system.

Monitoring results exceeded the ANZECC guidelines for Ammonium Nitrogen (NH₃) and phosphorous concentrations in the majority of samples taken. The levels of turbidity and suspended solids in Pyes Creek were generally acceptable. Sewer leaks were not suspected due to low faecal coliform readings.

4.2.2.3 Cattai Creek – Sites 5 and 6

The Hills Shire Council operates three monitoring locations on Cattai Creek (referred to as locations A3, I2 and K3) as shown on Figure 14. Location I2 is located upstream of the Showground Station (Site 6), location A3 is approximately 200m downstream of the site on Showground Road and location K2 is a further 1.2km downstream. Additional monitoring locations have previously been operated by the EPA, SCA, Sydney Water, DLWC and the Hawkesbury Nepean Catchment Management Trust.

In general, *E. coli* and nutrients Total Nitrogen and Total Phosphorous were found to be above the ANZECC guidelines in over half the samples, with dissolved oxygen readings below recommended guidelines.

4.2.2.4 Strangers Creek – Site 7

The Hills Shire Council operates two monitoring locations on Strangers Creek (referred to as locations E1 and L2) as shown on Figure 14. Location L2 is approximately 1.5km downstream of the Norwest Station (Site 7). Location E1 is a further 2.5km downstream and is therefore not suitable to provide a direct analysis of runoff quality from the Project.

Results of monitoring at location L2 indicate nutrient levels below ANZECC guidelines, with dissolved oxygen readings below recommended guidelines.

4.2.3 Bella Vista Station to Rouse Hill Station

4.2.3.1 Elizabeth Macarthur Creek – Sites 8 to 11

Two monitoring sites operated by The Hills Shire Council are located on Elizabeth Macarthur Creek (locations F1 and B3 in Figure 14). Sampling location F1 is off Celebration Drive upstream of the proposed Bella Vista Station. Location B3 is off Clovelly Crescent, upstream of the confluence with Caddies Creek.

Location F1 has generally shown readings within acceptable limits for secondary contact recreation under the ANZECC guidelines. Slightly more than half the samples showed elevated Total Nitrogen levels. Results at the downstream monitoring site (location B3) indicate poorer quality, with elevated levels of Total Nitrogen and Total Phosphorous in nearly all the samples taken, along with elevated *E. coli* in approximately half the samples. Dissolved Oxygen at this location was below recommended levels within the ANZECC guidelines.

4.2.3.2 Caddies Creek (including Tributaries 3, 4 and 5) – Sites 12 to 15

The Hills Shire Council's Health and Environmental Protection Team operate two monitoring sites on Caddies Creek (Hills D3 and Hills C1 on Figure 14). Hills D3 is located approximately 1km downstream of the proposed Rouse Hill Station, with Hills C1 located a further 500m downstream.

Results from both sites indicate E. coli and nutrients Total Nitrogen and Total Phosphorous are above the ANZECC guidelines in over half the samples, with dissolved oxygen readings below recommended guidelines.

4.2.4 Rouse Hill Station to Tallawong Stabling Facility

4.2.4.1 Second Ponds Creek – Site 16

The Hills Shire Council's Health and Environmental Protection Team operate one monitoring site on Second Ponds Creek (Hills J3 on Figure 14). Hills J3 is located approximately 2.5km downstream of the Project corridor and therefore not suitable to provide a direct indication of the existing runoff quality relevant to the Project.

4.2.4.2 First Ponds Creek – Site 17

Blacktown City Council has two water quality monitoring sites in First Ponds Creek. The nearest of these is approximately 2.3km downstream of the Project and is therefore not suitable for use as a monitoring location.

5.0 Impacts

5.1 Flooding

5.1.1 General

Flooding of the creeks and waterways which traverse the project corridor has the potential to inundate the rail infrastructure, station precincts and ancillary facilities during the construction and life of the project, cause damage to the rail infrastructure and precincts and pose a safety risk to the public and rail workers. Furthermore, any proposed works within the floodplain have the potential to change existing flood behaviour and adversely impact on the surrounding environment. It is therefore necessary to manage the nature and extent of works within the floodplain in order to minimise the flood risk to the Project and surrounding environment.

Assessment has been made of flood risks and impacts relating to the construction and operation of the stations, rail infrastructure and systems defined under the scope of EIS 2. Each key component is described in the following sections in the context of potential flood impacts.

Construction impacts of the major civil works and operational impacts of major civil structures (bridges and viaducts) are addressed in the EIS 1. In assessing impacts on the surrounding environment consideration has been made to the cumulative impacts of EIS 1 and EIS 2 works. Refer to Section 5.1.3.

5.1.2 Impacts on Project Works

5.1.2.1 Station Precincts (Sites 4 to 8, 11, 14 and 16)

Each station will include a surrounding precinct that consists of a range of existing and future facilities including:

- Commercial/retail space.
- Transport interchanges/drop off/taxi facilities.
- Car and bicycle parking.
- Public domains and station plazas.
- Station access for emergency, delivery and maintenance vehicles.
- Pedestrian access.

As a minimum, railway stations are required to have 100 year ARI flood immunity. However, in accordance with the principles of the NSW Floodplain Development Manual (2005) a higher level of protection is needed where flows in excess of 100 year ARI have the potential to cause significant damage and/or risk to life. This is particularly relevant to underground stations where ingress of floodwaters has the potential to cause significant damage to critical services/infrastructure and where safe evacuation of rail users and staff may be difficult, particularly where there may be limited warning.

Underground stations are to be located at Cherrybrook, Castle Hill, Showground, Norwest and Bella Vista. Due to the potential consequences of flooding to these stations a PMF flood standard will be required against mainstream and significant overland flooding.

Based on the current concept design each station has been located above the PMF level of mainstream flooding. For above ground stations it is possible to adopt a lesser (100 year ARI) standard providing a flood risk assessment and flood evacuation plan is developed to identify how flood risks are managed for events greater than the 100 year ARI. Above ground stations are to be located at Kellyville, Rouse Hill and Cudgegong Road.

A summary of flooding potential at each station precinct, including PMF levels adopted for the Concept Design is provided in Table 4. Flood levels provided relate to mainstream flooding. At some stations, drainage collection systems will be required to manage the potential for local stormwater runoff to enter the stations. This is particularly relevant to Cherrybrook and Bella Vista Stations. Local issues and potential impacts relevant to each station are identified in Table 4 which also outlines mitigation measures to reduce the potential flood impacts.

The planning approach being adopted for the NWRL recognises that development in the precincts around the stations would occur over time, but that measures must be taken now to provide a robust framework within which this development can occur. In this context, the key flooding constraints and opportunities relevant to the broader station precincts have been assessed and key floodplain management requirements are summarised in Table 4.

Table 4 Potential Flood Impacts and Mitigation Measures at Station Precincts

Station Precinct	Type	Flooding Potential From	PMF Level (mAHD)	Potential Impacts	Mitigation Measures	
					Station	Broader Precinct
Cherrybrook	Below ground open box	Local overland flow only.	N/A (Local overland flow only)	<p>The station and broader precinct is not affected by mainstream flooding. However, a local overland flowpath runs south to north across the site. Refer to Figure 5 for peak overland flows.</p> <p>Castle Hill Road lies to the south of the site. Flows in excess of the road drainage system capacity will collect at the low point adjacent to Glenhope Road. Some of these flows will enter the station precinct and travel south along the existing depression that runs through the centre of the site.</p> <p>Overland flow through the site in the PMF is estimated to be 1.7m³/s.</p> <p>Without appropriate site grading and drainage measures there is the potential for overflows from Castle Hill Road to enter the precinct and flood the station.</p>	<p>Design of site grading and local drainage system within the station precinct to provide for the diversion of overland flows around the station opening.</p> <p>System to be designed to convey the PMF without ingress into the station, with appropriate allowance for drainage system blockage.</p> <p>Runoff draining to and through the site will be discharged into the natural depression at the north west corner of the site. This will be incorporated into the precinct design.</p>	<p>Site grading and precinct layout designed to manage overland flows along roadways and landscaped areas.</p>
Castle Hill	Below ground	Local overland flow only.	N/A (Local overland flow only)	<p>Station is located at the top of the catchment and therefore flood impacts are not anticipated.</p>	<p>Apart from appropriate drainage design, no additional flood mitigation measures are required.</p> <p>Appropriate drainage design shall include setting of station entries a minimum 0.3m above local ground elevations.</p>	<p>Apart from appropriate drainage design and surface grading to cater for local overland flows no additional floodplain management measures are required.</p>

Station Precinct	Type	Flooding Potential From	PMF Level (mAHD)	Potential Impacts	Mitigation Measures	
					Station	Broader Precinct
Showground	Below ground	Cattai Creek	84.2	Station has been located above the PMF level for Cattai Creek flooding. The broader precinct is located outside the 100 year ARI flood extent. However, the southwest corner of the precinct is flood affected in the PMF. The area affected is confined to an access road and a small section of the multi-level carpark building. Access to the station off Carrington Road is outside the PMF extent. Refer Figure 7 for flood extent mapping.	Station located outside the PMF extent. Appropriate drainage design shall include setting of station entries a minimum 0.3m above local ground elevations.	Western access road, adjacent to Cattai Creek, to be designed to manage flood impacts on Carrington Road and surrounding development.
Norwest	Below ground	Strangers Creek	81 (refer comments under 'Potential Impacts')	Station precinct is located adjacent to Norwest Boulevard, west of Strangers Creek. Preliminary hydraulic assessment has been carried out to determine the PMF level in Strangers Creek at Norwest Boulevard based on the conservative assumption of all runoff in the PMF flowing overland across the road. The station is located above the PMF level for Strangers Creek flooding. However, a minor tributary to Strangers Creek runs north along Brookhollow Avenue (along the western boundary to the station site). The PMF flow along Brookhollow Avenue is estimated to be 9.1m ³ /s with a depth of 0.5m above kerb level. Refer Figure 8 for precinct location and peak overland flows.	Station located outside the PMF extent for mainstream flooding. Local overland flows along Brookhollow Avenue to be managed by elevating western entry points to the station a minimum 0.5m above kerb level or providing surface grading to cater for overland flows in the PMF. Otherwise, station entries shall generally be set a minimum 0.3m above local ground elevations.	Buildings and entry points to station to be located 0.5m above kerb level in Brookhollow Avenue or surface grading within precinct designed to manage overland flows through the site.

Station Precinct	Type	Flooding Potential From	PMF Level (mAHD)	Potential Impacts	Mitigation Measures	
					Station	Broader Precinct
Bella Vista	Below ground open cut	Elizabeth Macarthur Creek	71.0	The station and broader precinct is located above the PMF level for Elizabeth Macarthur Creek flooding. Immediately north of Bella Vista Station is a 700m long cutting that falls to a low point away from the station thus presents minimal risk of overland flows entering the station.	Station located outside the PMF extent. Appropriate drainage design shall include setting of station entries a minimum 0.3m above local ground elevations.	Apart from appropriate drainage design and surface grading to cater for local overland flows no additional floodplain management measures are required.
Kellyville	Above ground	Elizabeth Macarthur Creek	48.6	The station itself is located above the PMF level for Elizabeth Macarthur Creek flooding. A small proportion of broader precinct along the eastern edge is affected by 100 year ARI flooding. The area affected is largely confined to proposed access road. A larger proportion of precinct, including area of carpark north of Samantha Riley Drive, is located within the PMF extent. Access to station from Old Windsor Road is outside the PMF extent. Refer Figure 9 for flood extent mapping.	The station itself is located outside the PMF extent and so, apart from appropriate drainage design, no additional flood mitigation measures are required.	Any filling within the floodplain associated with the construction of access roads or carparking to be designed to manage impacts on the surrounding development.

Station Precinct	Type	Flooding Potential From	PMF Level (mAHD)	Potential Impacts	Mitigation Measures	
					Station	Broader Precinct
Rouse Hill	Above ground	Caddies Creek Tributary 3	49.7	Under the current viaduct design Rouse Hill Station is an elevated scheme, located above the PMF level. Located north of Caddies Creek Tributary 3 the precinct would be susceptible to inundation from flows that overtop Windsor Road at the Tributary 3 culverts. Previous hydraulic studies undertaken for the Windsor Road Transitway Project (Maunsell 2005a and 2005b) show that the Tributary 3 culvert crossing has in excess of a 100 year ARI capacity. Consequently, aside from runoff from the local drainage network, the precinct is not expected to be affected by flooding up to the 100 year ARI event. Access to station off Windsor Road is located outside the PMF extent. However, the rail service facility is located within the PMF extent.	Station is located outside the PMF extent and so, apart from appropriate drainage design, no additional flood mitigation measures are required.	Critical infrastructure within the facility to be designed above the PMF level. Precinct works within the floodplain to be designed to manage impacts on Windsor Road.
Cudgegong Road	Above ground (within cutting)	Second Ponds Creek	48.4	Station is located above the PMF level and so the risk of flooding from Second Ponds Creek is low. Located outside the PMF flood extent for Second Ponds Creek. The existing site is largely undeveloped and contains a number of drainage lines and depressions that currently convey overland flows through the site. Refer to Figure 12 for precinct location and peak overland flows.	Station is located outside the PMF extent and so, apart from appropriate drainage design, no additional flood mitigation measures are required.	Apart from appropriate drainage design and surface grading to cater for local overland flows no additional floodplain management measures are required.

Notes

- Flood standard could be reduced to 100 year ARI providing flood risk assessment carried out to ascertain the risk to life and operational requirements during events in excess of the 100 year ARI and develop emergency management plan.

5.1.2.2 Tallawong Stabling Facility

Tallawong Stabling Facility is shown in Figure 13 and is to be located south of First Ponds Creek and west of Schofields Road.

A 100 year ARI flood standard is typically adopted for stabling facilities to provide a suitable level of flood immunity. However, any critical facilities located within the stabling facility may require a higher standard (refer to Section 5.1.2.6).

Based on the current concept design the stabling facility at Tallawong Road is outside the 100 year ARI flood extent (as shown in Figure 13) and buildings are located outside the PMF. Consequently, subject to future design development, the flood risk to the stabling facility is expected to be minor.

The broader stabling facility footprint does encroach on the First Ponds Creek PMF extent and therefore filling in this area will need to manage impacts on Schofields Road.

5.1.2.3 Tunnels

Twin underground rail tunnels extend from Epping Station for 15.5km to a tunnel portal at Bella Vista station.

Flooding of the tunnels has the potential to pose a risk to life of rail users and staff and lead to damage to critical services and infrastructure. Consequently, under the current concept design entries to the tunnels have been set at or above the Probable Maximum Flood (PMF) level to minimise the potential for floodwaters entering the tunnel. Tunnel entries include the tunnel portal at Bella Vista as well as access points to below ground stations and service facilities. The PMF flood level applicable to the tunnel portal is provided in Table 5. Refer to Table 7 for below ground services facilities and below ground stations.

Table 5 Tunnel Portal Entry

Portal Location	Flooding Potential From	Chainage	PMF Flood Level (mAHD)	Potential Impacts	Mitigation Measures
North of Celebration Drive	Elizabeth Macarthur Creek	40.240km	72.0	<p>Tunnel portal is located above the PMF level and so the risk of mainstream flooding is low.</p> <p>Rail alignment north of the portal has been aligned along a ridgeline to minimise the potential for overland flows entering the portal and tunnel.</p>	Portal is located outside the PMF extent and so, apart from appropriate drainage design, no additional flood mitigation measures are required.

5.1.2.4 The Skytrain and Surface Tracks

From the tunnel portal at Celebration Drive the rail line would continue through to Tallawong Stabling Facility via a combination of skytrain (on viaduct) and surface tracks (in cut or on embankment).

Skytrain

The bridges and viaducts to support the skytrain will be constructed as part of the major civil and construction works that have been assessed as part of EIS 1.

The underside of bridges and viaducts spanning waterways have been set a minimum 500mm above the 100 year ARI flood level (including climate change allowances). This level of protection is designed to not only manage flood risks to the rail line but also help to minimise impacts on adjacent development. Managing impacts on the surrounding environment is discussed further in Section 5.1.3.

A summary of flood level estimates applicable to the bridge/viaduct waterway crossings is provided in Table 6. As a minimum, bridge/viaduct levels have been set at least 500mm above these values and thus flood impacts on the skytrain track are considered to be manageable.

Table 6 Bridge and Viaduct Waterway Crossings

Creek	Chainage	Crossing	Estimated 100 year ARI Flood Level (mAHD) ^{Note 1}
Confluence of Caddies, Elizabeth Macarthur and Caddies Tributary 5	42.700km 43.500km	Viaduct	45.0 ^{Note 2} 43.2 ^{Note 2}
Caddies Tributary 4	43.800km 44.200km	Viaduct	44.5 ^{Note 2} 43.0 ^{Note 2}
Caddies Tributary 3	45.250km	Viaduct	46.3
Second Ponds Creek	47.000km	Bridge/viaduct and embankment	46.2
First Ponds Creek	West of project limit – future bridge crossing		40.4

Notes

1. Includes allowance for climate change based on 10% increase in rainfall intensity.
2. Flood levels at the start and end chainages are listed due to the length of viaduct spanning the floodplain and the flood gradient variation.

Surface Tracks

The NWRL design includes at grade sections of track (including sections in cut or on fill embankment) from Bella Vista to north of Balmoral Road and from the western abutment of Second Ponds Creek through to Tallawong Stabling Facility.

As a minimum at grade sections of track are required to have 100 year ARI flood immunity in accordance with standard practice. Under the current concept design at grade sections of track have been located outside the 100 year ARI extent of mainstream flooding and are typically outside the PMF extent apart from some localised areas either side of Second Ponds Creek. Consequently, subject to future design development flood impacts on at grade sections of track are considered to be manageable.

5.1.2.5 Rail Services Facilities

Flooding to the service facilities would have the potential to inundate the tunnels and below ground infrastructure with the potential risk to life and damage to critical infrastructure. Consequently the facilities have been located to manage the risk of flooding up to the PMF. A summary of flood level estimates applicable to the current concept design locations for the services facilities is provided in Table 7.

Table 7 Services Facilities

Facility	Flooding Potential From	Chainage	PMF Flood Level (mAHD)	Potential Impacts	Mitigation Measures
Epping	Devilins Creek Beecroft Road Tributary	25.400km	78.8	Facility entry points are located above the PMF level and so the risk of mainstream flooding is low.	Facility is located outside the PMF extent and so, apart from appropriate drainage design, no additional flood mitigation measures are required.
Cheltenham	Local runoff only	26.800km	Not applicable – local drainage only	Facility is located outside the floodplain	Portal is located outside the PMF extent and so, apart from appropriate drainage design, no additional flood mitigation measures are required.

5.1.2.6 Rail System Infrastructure

The operation of the NWRL will require new traction substations at Epping West, Cherrybrook, Castle Hill, Showground, Norwest and Tallawong stabling facility. A sectioning hut would be required at the Cheltenham services facility. In addition, an off precinct traction substation would be required at Bella Vista and a sectioning hut at Rouse Hill.

Above ground traction stations and sectioning huts have been located a minimum 500mm above the 100 year ARI flood level in accordance with the NSW Floodplain Development Manual (2005) and past project practices such as South West Rail Link to manage impacts of flooding.

At below ground facilities (between Epping and Bella Vista) entry points have also been located above the PMF level due to the increased risk to life and infrastructure as a result of ingress of floodwaters into the below ground structure. Facilities that are identified as being critical to emergency response operations also require protection up to the PMF.

A summary of flood level estimates applicable to currently proposed locations for the traction stations and sectioning huts is provided in Table 8.

Table 8 Electricity Substations and Sectioning Huts

Chainage	Facility	Flooding Potential From	Design Standard	Preliminary Flood Level (mAHD)	
				100 year ARI	PMF
25.400km	Epping Traction Substation	Devlins Creek Tributary	Greater of 100 year ARI plus 500mm or PMF	76.2	78.7
26.800km	Cheltenham Sectioning Hut	Local drainage only	Greater of 100 year ARI plus 500mm or PMF	Not applicable - local drainage only	Not applicable - local drainage only
31.250km	Cherrybrook Traction Substation	Local drainage only	Greater of 100 year ARI plus 500mm or PMF	Not applicable - local drainage only	Not applicable - local drainage only
33.750km	Caste Hill Traction Substation	Local drainage only	Greater of 100 year ARI plus 500mm or PMF	Not applicable - local drainage only	Not applicable - local drainage only
36.250km	Showground Traction Substation	Cattai Creek	Greater of 100 year ARI plus 500mm or PMF	81.3	84.2
38.500km	Norwest Traction Substation and Bulk Supply Point	Local drainage only	Greater of 100 year ARI plus 500mm or PMF	Not applicable - local drainage only	Not applicable - local drainage only
40.700km	Bella Vista Sectioning Hut	Elizabeth Macarthur Creek	Greater of 100 year ARI plus 500mm or PMF	70.2	71.0

Chainage	Facility	Flooding Potential From	Design Standard	Preliminary Flood Level (mAHD)	
				100 year ARI	PMF
42.700km	Kellyville Traction Substation	Elizabeth Macarthur Creek	100 year ARI plus 500mm	51.1	52.0
47.200km	Tallawong Road Traction Substation and Bulk Supply Point	First Ponds Creek	100 year ARI plus 500mm	47.1	49.2

5.1.3 Impacts on the Surrounding Environment

The Project crosses a number of creeks and watercourses and their associated floodplains. Under the current design a range of works are required within these floodplains, including embankments, bridge piers /columns and abutments, viaduct piers/columns, station precinct works (including carparks and roads) and facility structures. Any works within the floodplain have the potential to change flood behaviour and adversely impact on the surrounding environment.

In accordance with the NSW Floodplain Development Manual the NWRL concept design has been developed to manage the extent of impacts on the surrounding environment.

The 100 year ARI event has generally been adopted for assessing impacts on surrounding properties. However, in accordance with the requirements of the Environmental Assessment consideration has also been given to the implications of flooding during events in excess of the 100 year ARI event. Detailed assessment of flood risks in events greater than the 100 year ARI flood is particularly relevant in the context of potential flood impacts on critical infrastructure adjoining the project, including key transport links (such as Windsor Road, Old Windsor Road and Schofields Road) and infrastructure that are integral to emergency response operations (such as electricity substations).

Potential impacts associated with the construction of the rail embankments, bridges and viaducts were assessed as part of the Major Civil and Construction Works under EIS 1. These elements, plus EIS 2 works within the floodplain, such as station precinct works, have been assessed in combination to identify cumulative impacts of the EIS 1 and EIS 2 works.

The following sections provide an outline of the main waterways traversed or bordered by the Project, the nature of works proposed, potential flood impacts on the surrounding environment and measures incorporated into the design to manage these impacts. For sites affected by overland flows, impacts on the surrounding environment would be managed through the provision of flow paths integrated with the design of the station precincts to control flows that currently discharge to and through the sites.

5.1.3.1 Devlins Creek Tributary (Epping Services Facility)

The Epping Services Facility is located adjacent to the Devlins Creek tributary (referred to herein as the Beecroft Road tributary) that runs parallel to and between Edensor Street and Beecroft Road before joining Devlins Creek downstream of the Beecroft Road and Kandy Avenue intersection. Refer to Figure 3 for a locality map of the creek, including flood extent mapping for the 20 and 100 year ARI and PMF events.

There is considerable existing development on the floodplain in the vicinity of the project corridor, consisting mainly of medium density residential development and commercial development. These areas of existing development would be sensitive to changes in flood behaviour.

Given the sensitive nature of the surrounding development the Epping Services Facility has been designed to locate works outside the 100 year ARI flood extent and therefore negate any potential flood impacts on adjacent development up to the 100 year ARI flood. However, part of the proposed services facility is located within the PMF extent. Flood modelling results show that in a PMF flood levels could increase by up to 0.3m along the tributary between the facility site and Raby Road. Under existing conditions the area experiences widespread flooding in the PMF with properties along the tributary, including Raby Road already flood affected. No new properties would be affected as a result of the proposed works. Consequently the increase in flood levels is not considered to be significant in the context of the nature of existing flooding in the PMF.

5.1.3.2 Cattai Creek (Showground Station)

During the development of the concept design the Showground Station has been relocated outside the PMF extent to reduce the risk of flooding to the station, and potential impacts on adjacent development.

The broader Showground Station precinct area is located outside the 100 year ARI flood extent. A portion of the western access road off Carrington Road would be located within the PMF extent. Due to the conceptual nature of the precinct layouts there is currently limited information on finished design levels. However, given the extent of encroachment on the floodplain it is expected that impacts on the surrounding environment, and particularly Carrington Road can be managed in future design development.

5.1.3.3 Strangers Creek (Norwest Station)

Norwest Station is located on Norwest Boulevard, west of Strangers Creek. Strangers Creek in the vicinity of Norwest Boulevard is a highly modified system consisting of a series of ponds interconnected with drainage culverts, draining a catchment area of approximately 36 hectares. In larger flood events the ponds would overtop and flows would travel across Norwest Boulevard.

Norwest Station is elevated above Strangers Creek and located outside an area of mainstream flooding. However, significant overland flow from a tributary to Strangers Creek would travel down Brookhollow Road and Norwest Boulevard in larger events (along the western and northern boundaries to the precinct).

Adverse impacts on the surrounding area can be minimised through the provision of overland flowpaths to manage local runoff around and through the site. Such measures would need to be incorporated into the layout of the station precinct during future design development.

5.1.3.4 Elizabeth Macarthur Creek (Bella Vista Station to Kellyville Station)

Between Bella Vista Station and Kellyville Station the rail alignment runs parallel and to the west of Elizabeth Macarthur Creek. A locality map of the creek including flood extents for the 20 and 100 year ARI and PMF events is shown in Figure 9.

Development in the upstream catchment (south of Celebration Drive) is well established, consisting of a mixture of residential and commercial development. The catchment draining to Elizabeth Macarthur Creek between Celebration Drive and Samantha Riley Drive is currently largely undeveloped. However, significant urbanisation for the area is underway and ongoing as part of the North West Growth Centres. A particular area of future development is the Balmoral Release area.

During the concept design development the rail alignment has been shifted between Bella Vista and Kellyville Stations to run immediately east of Old Windsor Road, and thus outside of the Elizabeth Macarthur Creek floodplain. Flood modelling indicates that the rail corridor is clear of the PMF extent and therefore, impacts on flooding are expected to be negligible.

The Bella Vista Station Precinct is located outside the PMF extent for Elizabeth Macarthur Creek and therefore is not expected to have any adverse impacts on flooding.

Parts of the Kellyville Station Precinct are affected by flooding from Elizabeth Macarthur Creek in the 100 year ARI and greater. Based on the current concept layout the area that encroaches on the floodplain consists of roads and future development. Due to the conceptual nature of the precinct layouts, there is currently limited information on finished design levels. Consequently, in order to determine an upper limit of potential impacts the extent of proposed works has been assumed to be elevated above existing flood levels. The modelled arrangement is shown in Figure 15.

Flood Level Impacts

Modelled flood level impacts are shown in Figure 16 and Figure 17 for the 100 year ARI and PMF events respectively. The model results show that based on full development of the assumed precinct footprint there would be some localised impacts on the properties on the opposite side of the creek that are currently sensitive to flooding. These results indicate that it will be necessary to ensure that the precinct works are designed to ensure that existing flood storage and conveyance are maintained to ensure that there are no adverse impacts on adjacent properties.

In the PMF the modelled precinct footprint would result in flood level impacts of up to 0.5m along the precinct boundary immediately upstream (south) of Samantha Riley Drive. Further upstream (south) of Samantha Riley Drive impacts would generally be in the order of 0.1 to 0.15m. Properties along Elizabeth Macarthur Creek, as well as Samantha Riley Drive would experience increases in flood level of up to 0.15m. However, these properties are already flooded in the PMF under existing conditions. While no additional properties will be affected

by the proposed works along Elizabeth Macarthur Creek, the intersection of Old Windsor Road and Samantha Riley Drive will be flooded.

Flow Velocity Impacts

Under existing conditions 100 year ARI peak flow velocities along the Elizabeth Macarthur Creek main channel are generally in the order of 1 – 1.5m/s but can be up to 3m/s in isolated locations (refer Figure 18). In overbank areas peak velocities are typically less than 1m/s. Peak flow velocities would be slightly higher in the PMF, especially around Samantha Riley Drive due to overtopping of the road (refer Figure 20).

The model results show that there would be no discernible changes to flow velocities in the 100 year ARI event (refer Figure 19). However, peak flow velocities in the PMF could increase significantly at some locations, particularly around Samantha Riley Drive (refer Figure 21). This is because the precinct arrangement assumed in the modelling would reduce the flow area by almost 50% near Samantha Riley Drive.

Conclusion

Overall, the model results show that it would not be feasible to raise the levels across the entire precinct above existing flood levels without having adverse impacts on the surrounding environment. During the development of the precinct layouts it will therefore be necessary to provide surface grading that maintains existing flood storage and conveyance.



North West Rail Link EIS
Modelled Kellyville Station Precinct
 Source: AECOM

25 SEP 2012
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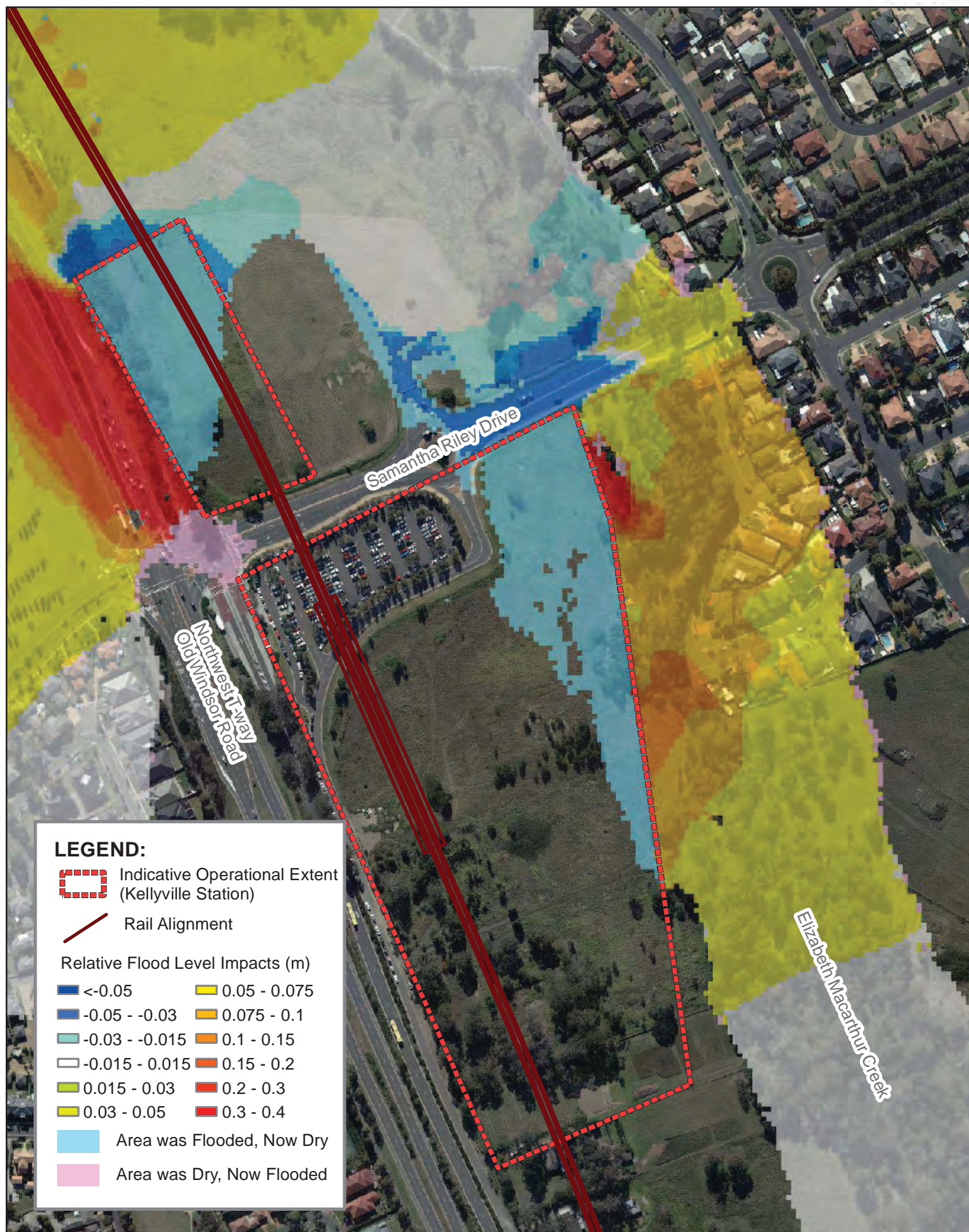
North West Rail Link EIS
 Relative Flood Level Impacts (100 Year ARI)
 Elizabeth Macarthur Creek
 Source: AECOM

25 SEP 2012

60224114

0 0.03 0.06 0.12 km

Fig. 16



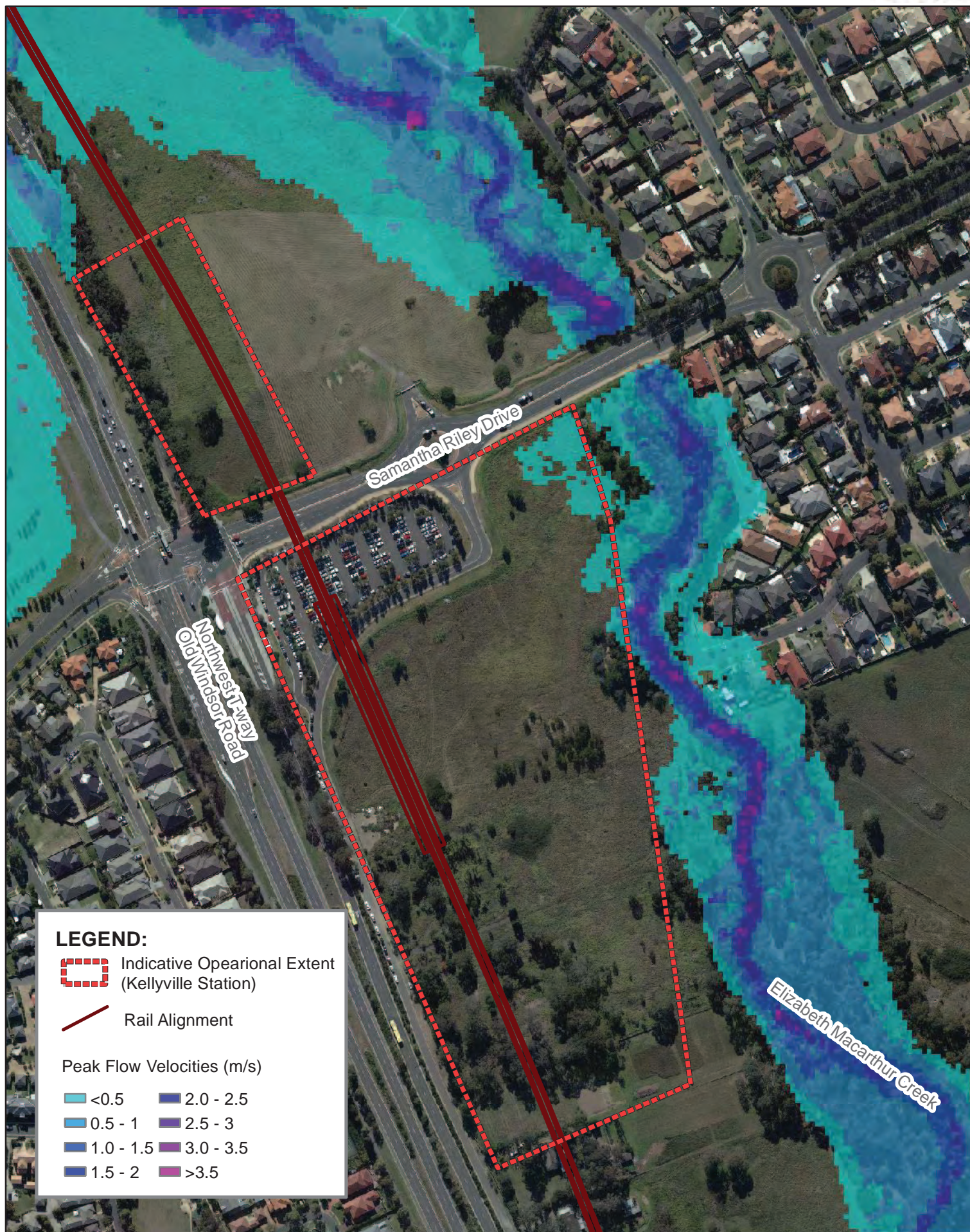
North West Rail Link EIS
Relative Flood Level Impacts (PMF)
Elizabeth Macarthur Creek
Source: AECOM

25 SEP 2012

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0 0.03 0.06 0.12 km

Fig. 17



North West Rail Link EIS
 Peak Flow Velocities - Existing (100 Year ARI)
 Elizabeth Macarthur Creek
 Source: AECOM

25 SEP 2012

60224114

0 0.03 0.06 0.12 km

Fig. 18