15. Hydrology and flooding

This chapter provides a summary of the hydrology and flooding impact assessment of the proposal. It describes the existing environment, assesses the impacts of construction and operation, and provides recommended mitigation measures. The full assessment report is provided as Technical Report 6.

15.1 Assessment approach

15.1.1 Methodology

Surface water and drainage infrastructure assessment

The surface water assessment involved:

- a review of background information relevant to the study area including previous studies, mapping, survey data, topography, and climatic data
- modelling of local catchment surface flow rates for the rail corridor
- a hydrologic analysis as described below
- identifying and assessing construction and operational activities that may impact on the surface water hydrology of watercourses within the proposal site
- identifying management and mitigation measures to manage potential impacts.

Flooding assessment

The hydrologic analysis involved identifying the existing structures to establish the base (existing) flooding conditions. For the existing base case condition, the geometry and form of each structure was analysed based on existing data. The local catchment area draining to each of the structure locations was determined.

Design rainfalls were applied to each local catchment to determine the peak rate of runoff from the catchments for a broad range of design rainfall durations. The predicted flood extent was mapped for a range of rainfall conditions. Hydrologic and hydraulic modelling was undertaken to examine the effect of the existing railway line on flooding, and enable the potential impact of the proposal to be assessed. Modelling considered the location and level of existing and proposed structures (mainly culverts) that enable water to flow through the rail formation and drain to downstream watercourses.

The proposal includes upgrading an existing rail corridor across floodplains. The proposal would be designed to convey flood flows in the same location as the existing rail corridor, to minimise changes to flow patterns. While culverts in the proposal site would be replaced the locations of culverts would not change from the existing scenario and flow patterns would be generally maintained. Therefore, changes to flow patterns have not been assessed. The flood management objectives for this assessment were considered in conjunction with the selection of the adopted rail level (top of the rail track).

Potential flood impacts were assessed by modelling the flooding behaviour of the existing rail corridor compared to the proposal. Flood modelling was undertaken for a range of design flood events, including the 50, 20, 10, five, two, and one per cent AEP events, and the probable maximum flood (PMF). The PMF is defined as an extreme flood deemed to be the maximum flood likely to occur in a particular catchment.

Flooding conditions for the 0.5 per cent and 0.2 per cent AEP events were also considered to represent climate change scenarios.

Flood modelling results were overlaid on aerial photography to identify potential impacts to land use, including built up areas, farm infrastructure, cropping areas, grazing, and forested areas, likely evacuation routes, and flood refuges. This allowed the magnitude of the predicted impacts to be identified for a range of flooding parameters.

The hydrologic analysis has only considered flood events resulting from rainfall on individual, and small groups of catchments immediately upstream of the existing rail corridor. The modelling of local (upstream) catchment flooding was considered to represent the conditions under which the new formation and track would have the greatest influence on flood levels. Downstream conditions were not assessed for the following reasons:

- the proposal site is already used for rail infrastructure, and culverts and bridge would be generally upgraded in their existing location. As a result, the pattern of flooding and drainage downstream of the rail corridor is expected to be largely unaffected
- if more extensive flood modelling was undertaken, broader flood processes (eg major river flooding, tailwater affects, etc) would dominate the results, rather than the impacts of the proposal
- increasing the extent of inundation upstream would result in a corresponding reduction in extent downstream
- by assuming that water would flow unimpeded through the culverts, the maximum potential flow velocities (that is, the worst case scenario) were estimated. This assisted in the identification of scour protection requirements without requiring downstream modelling.

While floodwaters from the Macquarie River spilling into Backwater Cowal or from the Macquarie River floodplain flowing onto into the Bogan River floodplain (Bradys Cowal) could impact the flooding conditions along the rail corridor the potential flow interaction of regional flood events with the local catchments was not considered during this assessment. During the detailed design further assessment would be undertaken to understand the interactions between Macquarie River, Backwater Cowal and the Bogan River.

Further information on the methodology is provided in Technical Report 6.

15.1.2 Legislative and policy context to the assessment

The following legislation, policies and guidelines were taken into consideration as part of the hydrology and flooding assessment:

- *Floodplain Development Manual: the management of flood liable land* (DIPNR, 2005)
- *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC, 2007)
- *Planning circular: New guideline and changes to section 117 direction and EP&A Regulation on flood prone land* (Department of Planning, 2007)
- *Flood Policy for Developments in Urban Floodplains*, Adopted February 2011 (Narromine Shire Council, 2011)
- *Parkes Shire Local Flood Plan* (SES, 2014a)
- *Narromine Shire Local Flood Plan* (SES, 2014b)
- *Lower Macquarie Groundwater Sources Water Sharing Plan*
- *Lachlan Regulated River Water Sharing Plan*
- *Lachlan Unregulated and Alluvial Water Sources Water Sharing Plan*
- *Macquarie Bogan Unregulated and Alluvial Water Sources Water Sharing Plan*
- *Macquarie and Cudgegong Regulated Rivers Water Sharing Plan.*

Water sharing plans for the Macquarie-Bogan and Lachlan river basins were also considered, with the Lachlan Unregulated and Alluvial Water Sources Water Sharing Plan and the Macquarie Bogan Unregulated and Alluvial Water Sources Water Sharing Plan most relevant in terms of the potential impacts of the proposal.

Flood evacuation planning in the study area is addressed in *Parkes Shire Local Flood Plan* (SES, 2014a) and the *Narromine Shire Local Flood Plan* (SES, 2014b). These documents identify the critical flood conditions in the two LGAs. Additionally, Narromine Shire Council has adopted the *Floodplain Risk Management Plan and Study* (Narromine Shire Council, 2009) and *Flood Policy* (Lyall & Associates, 2010) which guide floodplain risk management in the town of Narromine (to the north of the proposal site). No floodplain risk management study was publically available for the Parkes Shire Council.

15.2 Existing environment

15.2.1 Regional context – river and basin systems

The majority of the proposal site is located within the Macquarie-Bogan River basin. A small portion of the proposal site, between the southern end and about seven kilometres north-west of Parkes, is located within the Lachlan River basin. The location of the boundary between the two basins is shown on Figure 15.1.

At its closest point, the Macquarie River is about 900 metres north of the proposal site near Narromine. The Macquarie River starts south of Bathurst at the junction of the Campbells River and Davies Creek, and travels north-west past the towns of Wellington, Dubbo, and Narromine to the Macquarie Marshes. The Macquarie Marshes drain via the lower Barwon River into the Darling River and the Murray Darling Basin.

The Bogan River is the other major river located within the Macquarie-Bogan River basin. The Bogan River is located about 11 kilometres west of the proposal site, making it a receiving environment rather than a potential contributor to flooding. The Bogan River drains via the lower Barwon River into the Darling River and the Murray Darling Basin.

At its closest point, the Lachlan River is about 27 kilometres metres south of the proposal site. The Lachlan River starts as a chain of lakes formed by the confluence of the Hannans Creek and Mutmutbilly Creek catchments. Travelling west, the river system passes south of Parkes. Ridgey Creek, the closet significant tributary of the Lachlan River, is located about one kilometre east of the proposal site. Goobang Creek, which forms part of the Lachlan River basin, flows through Parkes.

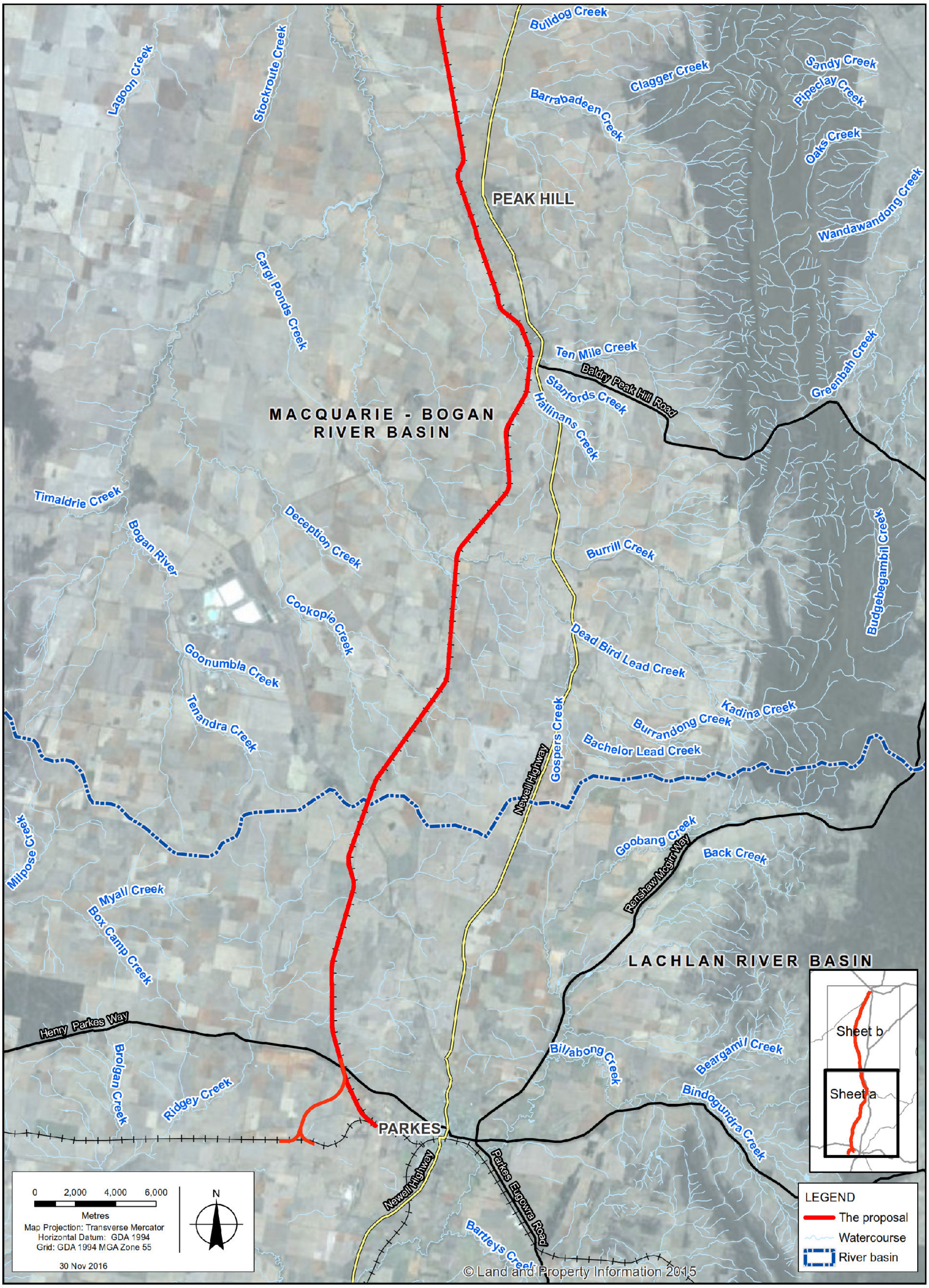
Except during major floods, the Lachlan River terminates in the west as a large, expansive system of wetlands known as the Great Cumbung Swamp. During major floods, the Lachlan River flows into the Murray Darling Basin.

15.2.2 Watercourses

Figure 15.1 shows the watercourses in the vicinity of the proposal site. A total of 15 watercourses of stream order three or above (based on the Strahler stream classification system) cross the proposal site. These are listed in Table 15.1. Further information on these watercourses is provided in Technical Report 6.

Most of these watercourses are in moderate to poor condition as a result of historical disturbances associated with agricultural practices. Reaches of the watercourses in poor condition are typically channelised to improve drainage and limit flood extents. These reaches can also display evidence of ongoing channel erosion.

The existing rail corridor and associated infrastructure has had minor localised impacts on watercourse form. This consists mainly of an increased propensity for scour and erosion immediately downstream of watercourse crossing structures.



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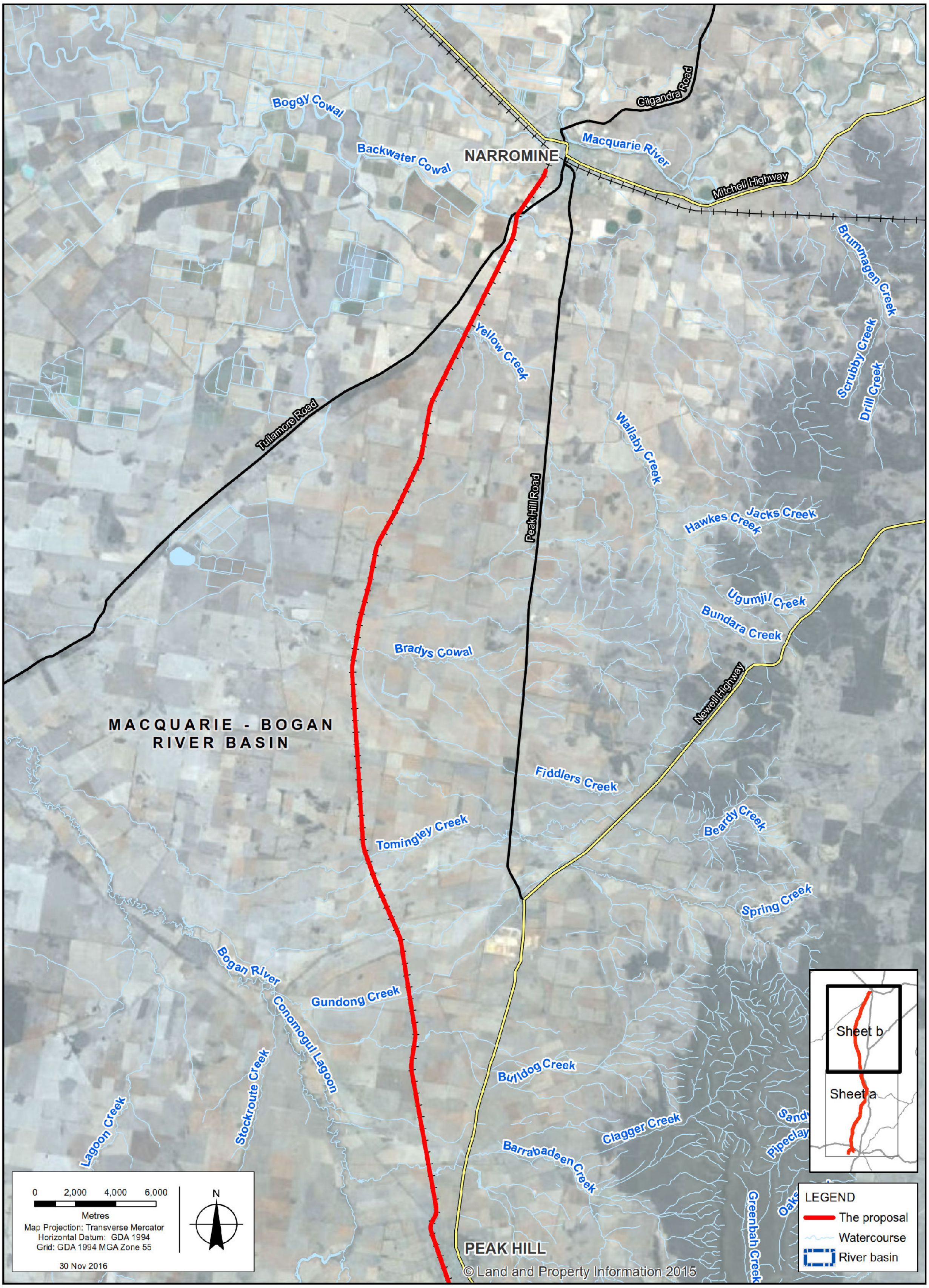
Data source: Commonwealth of Australia (Geoscience Australia), 250K Topographic Data Series 3, 2006. LPI, DCDB, 2012

Figure 15.1a

River basins and watercourses



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Data source: Commonwealth of Australia (Geoscience Australia), 250K Topographic Data Series 3, 2006. LPI, DCDB, 2012

Figure 15.1b

River basins and watercourses

Table 15.1 Watercourses crossing the proposal site

Catchment	Watercourse	Flow regime	Stream order	Style	Condition
Lachlan	Un-named	Ephemeral	3	Valley fill	Poor
Lachlan	Un-named	Ephemeral	3	Channelised fill	Moderate
Bogan	Un-named	Ephemeral	3	Channelised fill	Moderate
Bogan	Un-named	Ephemeral	3	Valley fill	Moderate
Bogan	Burrill Creek	Ephemeral	5	Low sinuosity fine grained	Good
Bogan	Stanfords Creek	Ephemeral	4	Channelised fill	Poor
Bogan	Ten Mile Creek	Ephemeral	4	Low sinuosity fine grained	Moderate
Bogan	Barrabadeen Creek	Ephemeral	5	Low sinuosity fine grained	Poor
Bogan	Bulldog Creek	Ephemeral	4	Valley fill	Moderate
Bogan	Un-named	Ephemeral	4	Valley fill	Poor
Bogan	Gundong Creek	Ephemeral	4	Channelised fill	Poor
Bogan	Tomingley Creek	Ephemeral	4	Valley fill	Good
Bogan	Brady's Cowal	Ephemeral	4	Low sinuosity fine grained	Moderate
Macquarie	Yellow Creek	Ephemeral	3	Valley fill	Moderate
Macquarie	Backwater Cowal	Ephemeral	5	Valley fill	Moderate

15.2.3 Groundwater

A total of 19 registered groundwater bores are located within 250 metres of the proposal site. The nearest bore is located 25 metres from the proposal site. A number of the identified bores had cancelled licences. Most of the bores (14) are registered for a combination of stock, domestic or irrigation use. Other bores are registered as town water supply (two bores), test bore (one bore), and two bores were unknown.

The majority of the bores are located in the vicinity of Narromine and intercept alluvial sediments associated with Macquarie River. Groundwater levels would be expected to rise and fall depending on rainfall.

To the south of Narromine, the study area is underlain by fractured rock associated with the Lachlan Fold Belt. Groundwater bores intercepting the fractured siltstone and sandstone rock aquifer are deeper than 70 metres below ground level. Groundwater in the fractured rock aquifer is not expected to be present in the vicinity of the ground surface.

Shallow alluvial sediments with a depth of less than 10 to 20 metres below ground level may be intercepted along watercourses. These perched shallow groundwater sources would be recharged by rainfall infiltration, with groundwater levels expected to rise following rainfall events.

15.2.4 Flooding

In general, the study area is characterised by relatively flat land. The existing rail corridor is subject to flooding, which in some locations overtops the rail track and does not comply with ARTC's design requirements for flood immunity. In the Parkes LGA, in which the Parkes north west connection is situated, flooding is reported as occurring in any season and is generally contained within the creek lines and adjacent flat areas.

A summary of the results of the flood modelling undertaken for the assessment is provided below. Further information and full modelling results are provided in Technical Report 6.

Flood planning in the urban area of Narromine is guided by Narromine Shire Council's *Flood Policy for Developments in Urban Floodplains*. This policy is not relevant to rural areas.

Location and extent of overtopping

Rail

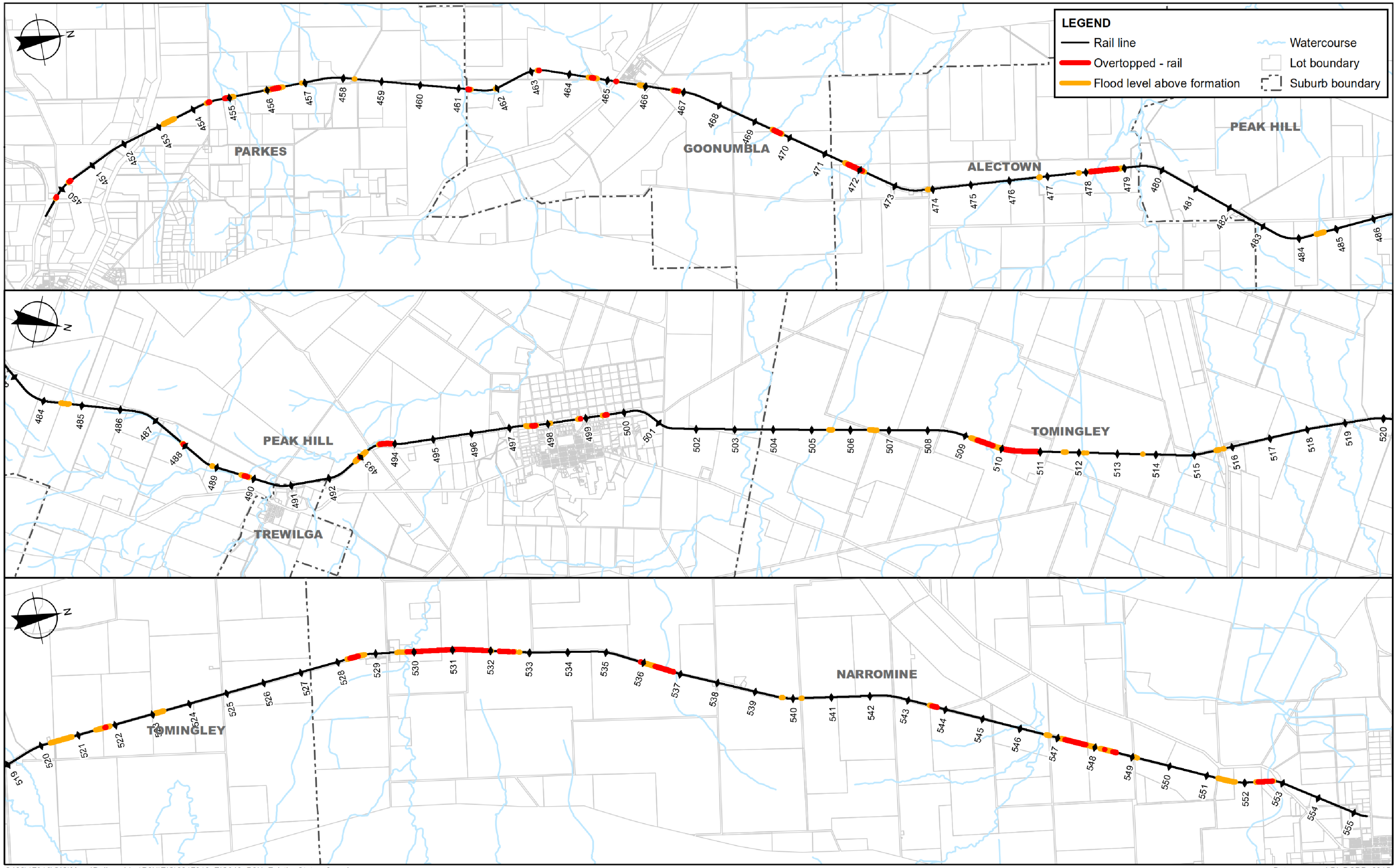
During the maximum modelled flood event, it is predicted that about 7.2 kilometres of the existing rail corridor would be overtopped, and the maximum water depth over the rail level would be 0.5 metres. The predicated overtopping locations along the existing rail corridor for the one per cent AEP event are shown in red on Figure 15.2.

Table 15.2 provides a summary of the length and maximum depth of rail overtopping (where floods rise above the rail level) for a range of modelled flood events. The maximum event modelled was the one per cent AEP flood event – a one per cent AEP means that there is a one in 100 probability of a flood event of that size occurring in any given year (equivalent to a 100 year ARI flood event).

Table 15.2 Summary of overtopping in flood events

Design event (% AEP)	Length of rail overtopping (km)	Maximum overtopping depth (m)
50	0.07	0.22
20	1.04	0.29
10	2.18	0.33
5	3.04	0.40
2	4.76	0.49
1	7.18	0.54

ARTC's technical requirements require that the ballast for the upgraded track needs to be above the modelled one per cent AEP local flood level. Table 15.3 lists the extent of compliance with ARTC's requirements using three different depths of ballast from the top of the rail level to the top of the formation. This is because the depth of the ballast of the existing rail corridor is not accurately known and varies along the length of the rail corridor.



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Data source: LPI, DCDB, 2015.

Figure 15.2
Predicted rail overtopping locations

Table 15.3 Summary of compliance with ARTC requirements

Design event (% AEP)	Length of rail overtopping (km)		
	Assumed 720 mm depth to top formation	Assumed 600 mm depth to top formation	Assumed 400 mm depth to top of formation
50	17.71	13.58	7.79
20	21.01	16.68	9.89
10	22.98	18.37	11.74
5	25.32	21.04	13.92
2	31.67	25.90	18.64
1	35.12	28.37	20.62

As is expected, smaller events result in less overtopping of the rail level, at fewer locations. For the maximum flood event the predicted length of non-compliance with ARTC's requirements ranges from 20.6 to 35.1 kilometres.

Level crossings

The flood modelling indicates that six public level crossings would be overtopped during flood events up to and including the one per cent AEP (listed in Table 15.4).

Table 15.4 Level crossing overtopping

Public level crossing	Level crossing overtopping (m)					
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Brolgan Road	0.01	0.04	0.04	0.13	0.24	0.29
Back Tradle Road	-	-	-	-	-	-0.03
Wyatts Lane	-	-	-	-	0.29	0.38
Bogan Road	0.04	0.19	0.20	0.21	0.22	0.23
Atwells Lane	-	-	-	0.04	0.08	0.11
Tullamore Road	-	-	-	0.02	0.02	0.02

Roads

Modelling was used to identify locations where public roads in the study area are predicted to be impacted by flooding. The results are summarised in Table 15.5. In total, 355 metres of existing roads are predicted to be flooded, and the maximum water depth is predicted to be about 0.8 metres at Tomingley Road.

These predicted closure locations are in close agreement with information provided by the local State Emergency Services (SES, 2014a and 2014b).

Table 15.5 Road overtopping – existing situation

Road	Maximum depth of overtopping (m)						Maximum length of overtopping (m)
	50% AEP	20 % AEP	10% AEP	5% AEP	2% AEP	1% AEP	
Alectown West Road	0	0.006	0.016	0.026	0.036	0.046	7
Bogan Road	0	0.095	0.105	0.115	0.125	0.135	2
Bulgandramine Road	0.017	0.073	0.083	0.093	0.103	0.113	61
Peak Hill Railway Road	0	0	0	0	0.085	0.085	40
Tomingley Road	0	0	0	0	0.468	0.782	80
Tomingley West Road	0	0	0	0	0.176	0.329	110
Wyanga Road	0	0	0	0.002	0.080	0.136	55
Total							355

Flooding upstream of the existing rail corridor

Flood extents

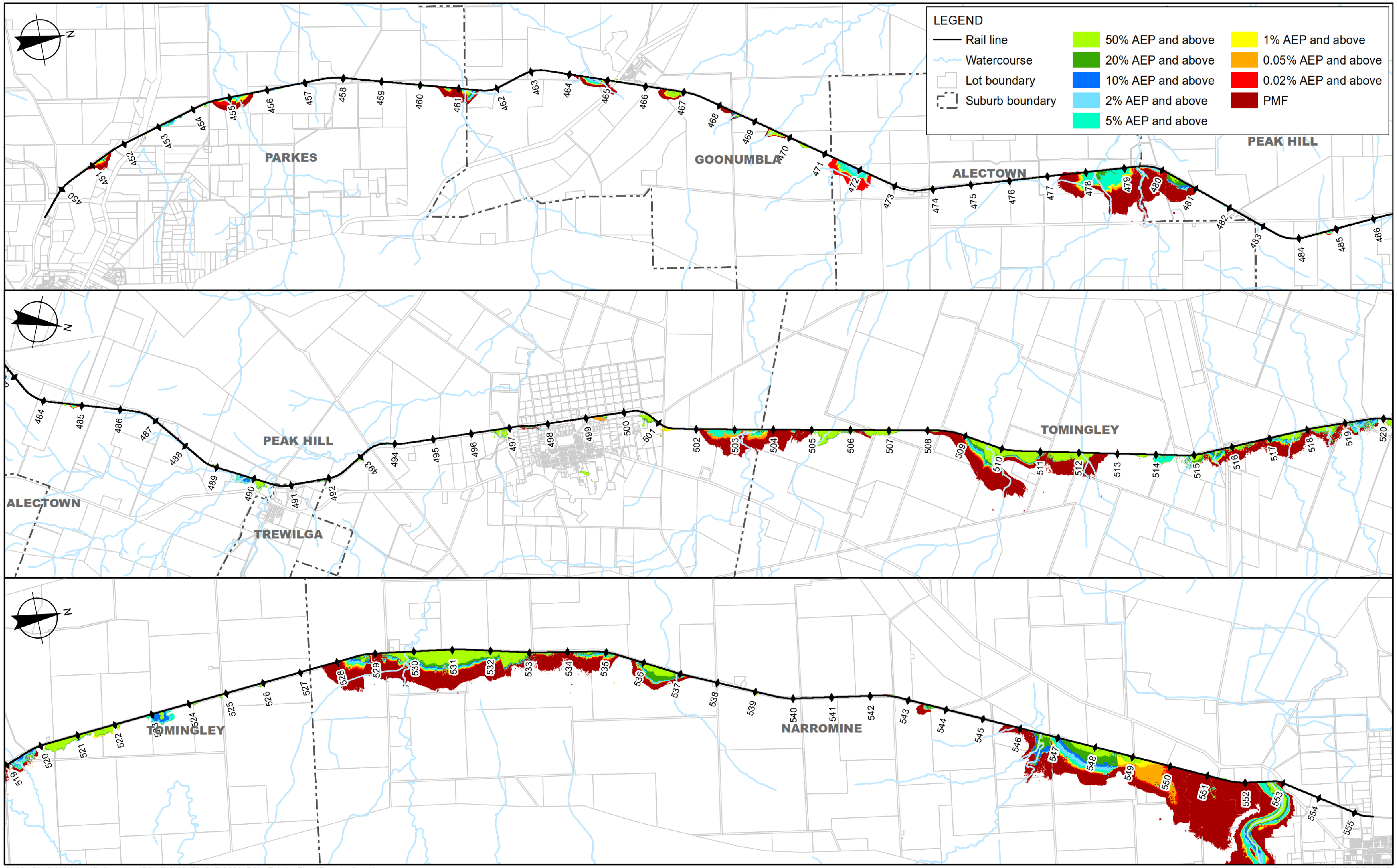
The predicted flood levels for the existing rail corridor were modelled for a range of events as described in section 15.1.1.

Figure 15.3 shows the extent of predicted floods upstream of the existing rail corridor.

Table 15.6 lists the areas of land that would be inundated by events up to the PMF.

Table 15.6 Areas of upstream flooding – existing rail corridor

Design event (% AEP)	Area of inundation (ha)
50	355.9
20	480.1
10	553.3
5	648.2
2	840.0
1	938.0
0.5	1,044.8
0.2	1,146.5
Probable maximum flood	2,720.8



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Data source: LPI, DCDB, 2015.

Figure 15.3
Existing flooding extents