Australian Government

BUILDING OUR FUTURE

NSW GOVERNMENT

Coffs Harbour Bypass

Environmental Impact Statement

September 2019

VOLUME 1C

Assessment of environmental impacts

RMS.19.1312

ISBN: 978-1-925891-58-4

CHAPTER

17

Chapter 17

Flooding and hydrology

17. Flooding and hydrology

This chapter provides an assessment of the potential impacts of the project relating to flooding and hydrology. **Table 17-1** lists the SEARs relating to flooding and hydrology, and where they are addressed in this chapter. The information in this chapter is supported by **Appendix O, Flooding and hydrology assessment**.

Table 17-1 Flooding and hydrology SEARs

Ref	Key Issue SEARs	Where addressed
11. Water - Hydrology		
1.	The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	Section 17.3 Section 17.4 **Chapter 10, Biodiversity** **Chapter 13, Agriculture** **Chapter 19, Surface water quality** **Chapter 20, Groundwater**
2.	The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	
	a) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge	Section 17.3 Section 17.4 **Chapter 10, Biodiversity** **Chapter 19, Surface water quality** **Chapter 20, Groundwater**
	d) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses	Section 17.5 Section 17.6 **Chapter 10, Biodiversity** **Chapter 19, Surface water quality**
	e) minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems	Section 17.5 Section 17.6 **Chapter 19, Surface water quality**
12. Flooding		
1.	The Proponent must assess and (model where required) the impact from the project on flood behaviour, in particular Coffs Creek, during the construction and operation for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including:	
	a) Any detrimental increases in the potential flood affectation of the project infrastructure and other properties, assets and infrastructure;	Section 17.5 Section 17.6

Ref	Key Issue SEARs	Where addressed
	b) Consistency (or inconsistency) with applicable Council floodplain risk management plans;	Section 17.1 Section 17.6
	c) Compatibility with the flood hazard of the land;	Section 17.6
	d) Compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;	Section 17.6
	e) Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, or adjacent to or downstream of the site;	Section 17.6
	f) Downstream velocity and scour potential;	Section 17.5 Section 17.6
	g) Impacts the project may have upon existing community emergency management arrangements for flooding, including Council's upper catchment detention basins. These matters must be discussed with the State Emergency Services and Coffs Harbour City Council	Section 17.6
	h) Any impacts the project may have on the social and economic costs to the community as consequence of flooding;	Section 17.6.7
	i) Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses; and	Section 17.5 Section 17.6 **Chapter 10, Biodiversity** **Chapter 18, Soils and contamination** **Chapter 19, Surface water quality**
	j) Any mitigation measures required to offset potential flood risks attributable to the project.	Section 17.5 Section 17.6 Section 17.7

17.1 Assessment methodology

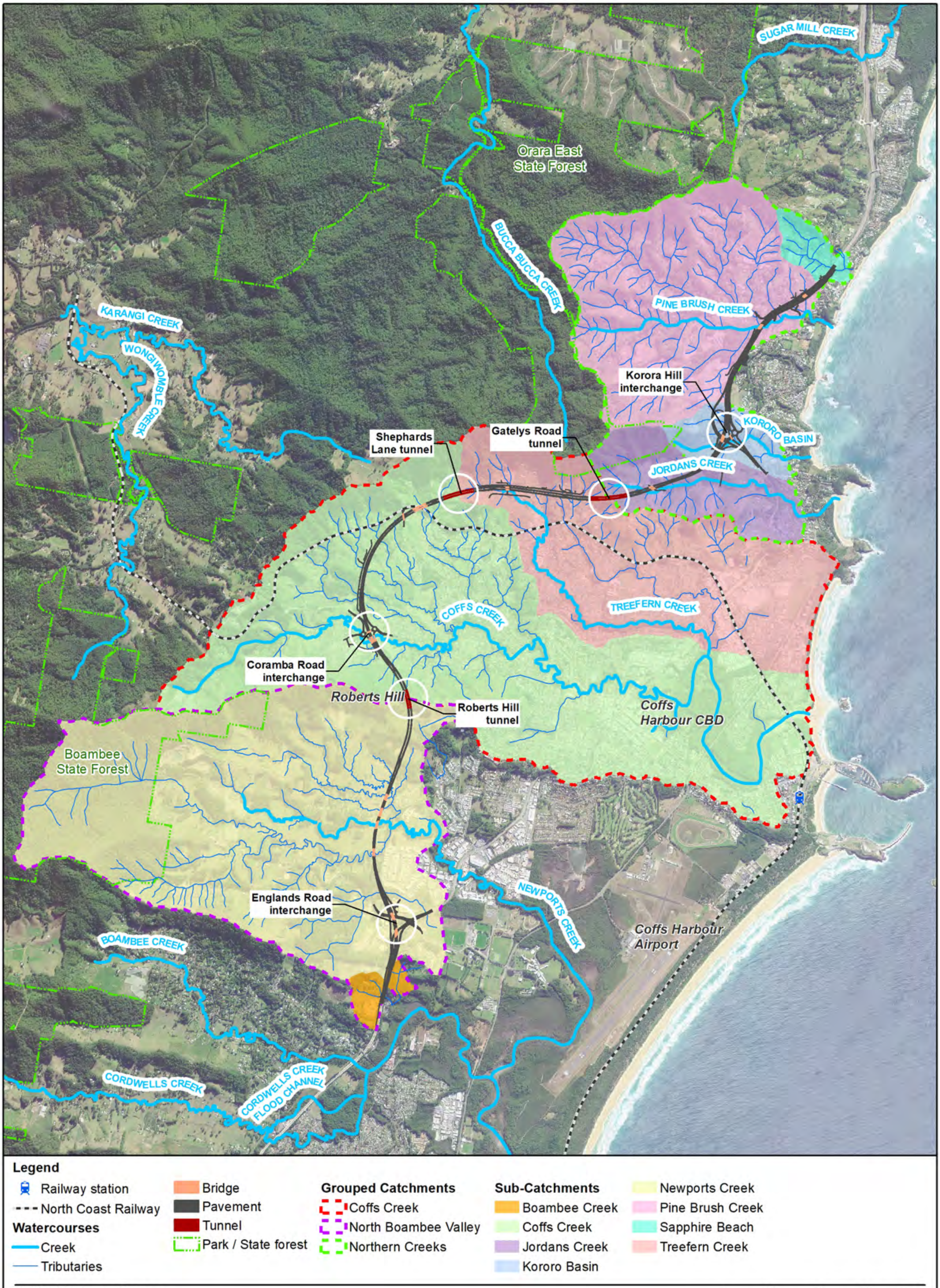
17.1.1 Study area

Coffs Harbour LGA covers several catchments which drain in a predominantly easterly direction from the steep ridges west of the project towards the ocean. The project interacts with several major and minor waterways and their catchment, see **Figure 17-1**. The catchments have been grouped by locality as listed below and are referred to throughout the chapter under North Boambee Valley, Coffs Creek and northern creeks. The localities and their catchments consist of:

- North Boambee Valley:
  - Tributary of Boambee Creek
  - Newports Creek.
- Coffs Creek:
  - Coffs Creek
  - Treefern Creek.

- Northern creeks:
  - Jordans Creek
  - Kororo Basin – this is not related to Korora, which is located in the upper catchment area of Pine Brush Creek. Kororo Basin is a separate catchment located south east of the Pine Brush Creek catchment
  - Pine Brush Creek
- Sapphire Beach – this relates to an unnamed waterway at this location.

Only the portion of the catchment that is relevant for the assessment of flooding conditions interacting with the project is shown in **Figure 17-1**. This is referred to as a study catchment. The study catchment is broken down further into sub-catchments as discussed in **Section 17.3.3**. **Figure 17-1** differs from the figure in **Chapter 19, Surface water quality**, which accounts for the full catchments and receiving environments that would possibly be impacted because of the project for the water quality assessment. For example, the hydraulic model boundary for the North Boambee Creek catchment was set at a suitable distance downstream of the project to adequately assess the potential flood impacts of the project, whereas for water quality, there could be potential impacts to the water quality that spreads downstream towards the coast.



Coffs Harbour Bypass
Study area
Figure 17-1

17.1.2 Study purpose

Flooding and hydrological modelling and impact assessment of the project were carried out to:

- Identify discharges and flood levels of major waterways to inform indicative sizing and configuration of cross-drainage structures (including bridges)
- Inform the sizing and design of operational water quality basins and channels
- Inform the structural bridge design for flood loading parameters
- Inform the vertical and horizontal alignment of the project to achieve the required design flood immunity for the project (as defined in Upgrading the Pacific Highway Design Guidelines (Roads and Maritime 2015f)) and to minimise potential flood impacts on the surrounding environment, communities and infrastructure
- Verify that any flood impacts are within the acceptable limits for a range of flood events (see **Section 17.1.4** for the suite of modelled design storm events)
- To assess the potential changes in surface water hydrology from the construction and operation of the project
- Undertake a sensitivity analysis to assess the impacts climate change may have on 'with project' and 'without project' scenarios.

17.1.3 Flooding terminology

The flooding and hydrology assessment has adopted the approach to design flood terminology as detailed in the latest version of Australian Rainfall and Runoff (Ball 2016). An extract of Figure 1.2.1 from Book 1 (see **Table 17-2**) details the relationship between average recurrence interval (ARI) and annual exceedance probability (AEP) for a range of design events.

Table 17-2 Event terminology (ARR 2016 Book 1)

Events per year (EY)	AEP (%)	AEP (1 in x)	ARI
0.69	50	2	1.44
0.5	39.35	2.54	2
0.22	20	5	4.48
0.2	18.13	5.52	5
0.11	10	10	9.49
0.05	5	20	20
0.02	2	50	50
0.01	1	100	100
0.005	0.5	200	200
0.002	0.2	500	500
0.0005	0.05	2000	2000

The difference between AEP and ARI is minimal for the 10-year ARI event and above. However, for the 2-year and 5-year ARI events the corresponding AEP percentages are 39.35 per cent and 18.13 per cent. In this range of events, the recurrence interval approach can be misleading where a strong seasonality is experienced. Typically, the Mid North Coast of NSW experiences a wet summer and dry winter rainfall regime.

All design events considered in this assessment are quoted in terms of AEP using percentage probability, which is consistent with recommendations in Australian Rainfall and Runoff (Ball 2016). The design events considered include:

- 18 per cent AEP
- 10 per cent AEP
- 5 per cent AEP
- 2 per cent AEP
- 1 per cent AEP
- Probable maximum flood (PMF).

17.1.4 Design criteria and objectives for flooding

Design criteria

The project infrastructure flood immunity objectives are provided in **Table 17-3**. Elements of the project design which help to achieve flood immunity include:

- **Road carriageways:** Design of carriageway levels to ensure inundation does not occur during the design flood event (refer to **Table 17-3**)
- **Embankments and batters:** Embankment levels and widths, and batter materials, should be designed to withstand flood inundation and protection against scour during a flood event
- **Cross drainage:** Culverts designed to convey flow under the roadway in the design flood event, ensuring the carriageway is free from inundation
- **Bridges:** The design flood immunity of all bridges in the project is greater than the 1 per cent AEP event flood immunity level of the carriageways. Specifically, the soffit level (underside) of these bridges would be greater than 0.5 metres above the 1 per cent AEP event flood level to allow debris to pass under the bridges and minimise the effects of debris blockage.

Floodplain management objectives

A series of floodplain management objectives have been developed to reduce potential flood impacts to a minimum. **Table 17-3** lists the criteria used to assess the tolerability of changes in flood behaviour such as changes in flood level and velocity, duration and direction because of the project.

The floodplain management objectives set out in **Table 17-3** are based on a number of local, State and national legislation, policies and guidelines, the project SEARs and similar Pacific Highway and other major Roads and Maritime projects.

The project has been assessed against the floodplain management objectives, noting that a merit-based approach has been adopted for the flood level objectives as outlined in **Table 17-3**.

Table 17-3 Project floodplain management objectives

Project infrastructure	
Alignment	1% AEP flood immunity for proposed main carriageway and 5% AEP for ramps and interchanges.
Tunnel portals	Above the PMF or the 1% AEP flood level +0.5 m (whichever is greater) where ingress of floodwaters would collect at the sag in the tunnel.
Waterway crossings	Bridge soffits >0.5 m above 1% AEP flood level. Appropriate scour protection designed for areas at risk of scour due to the project to ensure long term bed and bank stability.

Project infrastructure	
Construction	Potential impact of ancillary site locations is identified to ensure appropriate flood risk of vulnerable sites and to inform a future construction flood management plan.
External to construction footprint	
Level	A merit-based approach, considering the relative impact to peak flood level, hazard, extent and potential damages. In general, the following afflux criteria is applied for design events up to the 1% AEP: • < 10 mm for residential, commercial and industrial areas and buildings affected by finished floor level (FFL) inundation • < 50 mm for agricultural land • < 250 mm pastural, forest and recreational areas.
Scour	No adverse increase in peak flood velocity for design events (up to 1% AEP).
Access	All affected existing local and access roads are to be ultimately configured (where feasible during construction) such that the existing level of flood immunity, inundation duration and available evacuation time is maintained or improved (subject to CHCC and stakeholder consultation).
Direction	No change to the direction of watercourses or the direction of flood flows except for constriction into and expansion out of discrete openings (culverts and bridges) and constructed diversions.
Critical infrastructure	No adverse modifications to flood behaviour or hazard on critical or vulnerable infrastructure such as hospitals, nursing homes, childcare facilities and schools (up to PMF).
Emergency management	No adverse impact upon community flood emergency management plans - unless alternate risk mitigation is proposed.

Flood events assessed

A range of design storm events were modelled for the flood impact assessment. These are listed below:

- 18 per cent AEP design event
- 10 per cent AEP design event
- 5 per cent AEP design event
- 2 per cent AEP design event
- 1 per cent AEP design event
- PMF.

Climate change sensitivity tests were also carried out for:

- 2050 climate: 0.4m sea level rise and 10 per cent increase in rainfall intensity for the 1 per cent AEP event
- 2100 climate: 0.9m sea level rise and 30 per cent increase in rainfall intensity for the 1 per cent AEP event.

It is noted that the 2050 and 2100 climate change rainfall intensity increases are roughly aligned with the 0.5 and 0.1 per cent AEP events respectively.

17.2 Hydrology and flooding methodology

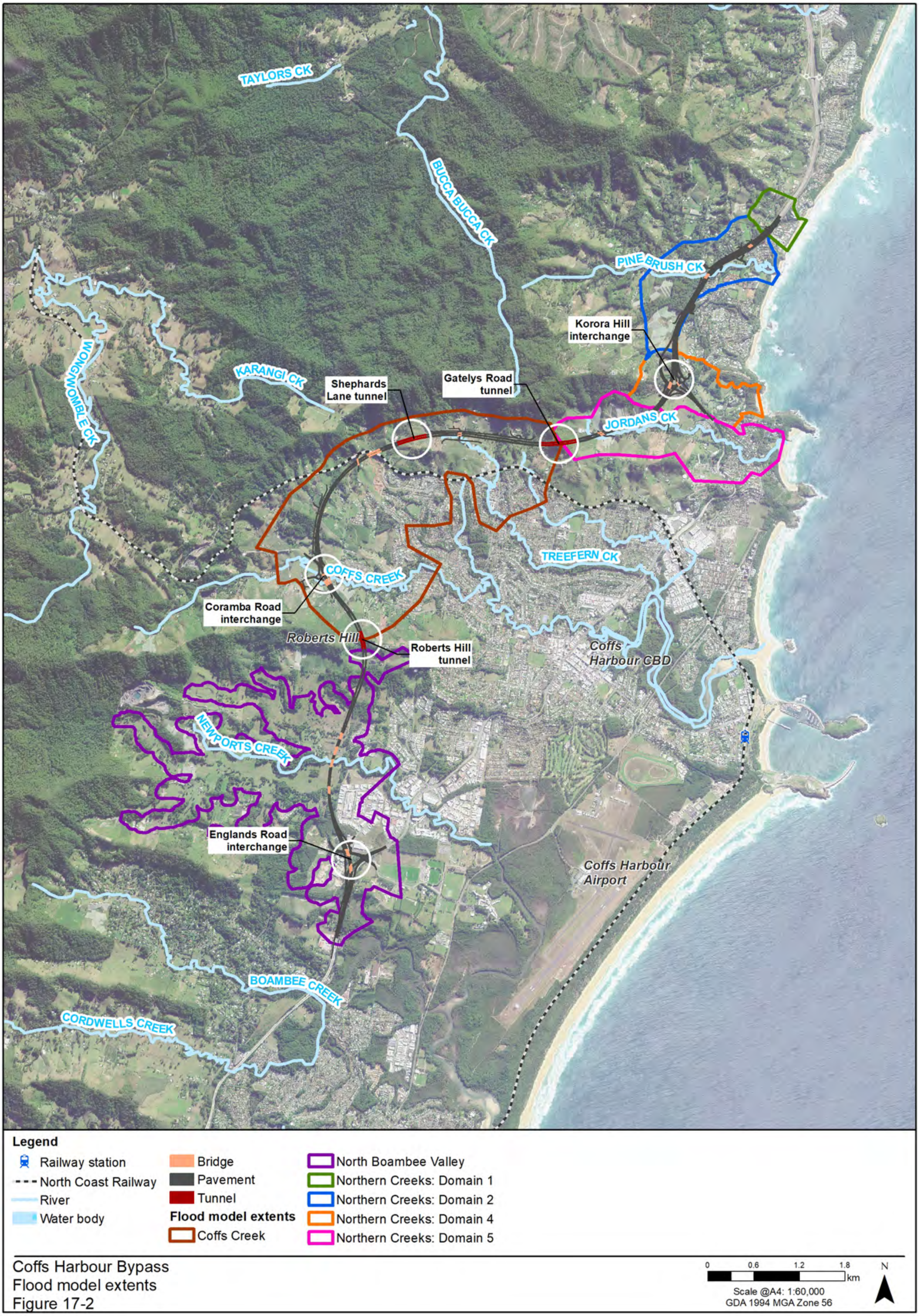
This assessment has been carried out in line with the NSW Floodplain Development Manual (DIPNR 2005) with reference to the Coffs Creek Floodplain Risk Management Plan (Bewsher Consulting Pty Ltd 2005) and the Boambee Newports Creek Floodplain Risk Management Plan (GHD 2016). The following process has been carried out for the assessment:

- Review all relevant information and data applicable to the project including availability of existing hydrological and hydraulic models, digital terrain data, aerial imagery, survey data, project design components and any other relevant information
- Review documentation in relation to applicable guidelines, floodplain risk management plans and establish project objectives and floodplain management objectives and design criteria for the project
- Review the flood risk of the existing environment for the study area, understanding the key flooding mechanisms, and reviewing information for historical flood events
- Refining and updating the existing flood models and developing new flood models for areas where no previous flood modelling had been undertaken
- Ensuring orographic rainfall effects were included in the flood models
- Carry out model validation for the new flood models and for those that had been refined and updated
- Simulate and establish the existing case scenario to understand the current flooding conditions for a range of rainfall events
- Consultation with NSW State Emergency Service (SES) and CHCC about flooding and the potential impacts of the project and proposed mitigation measures
- Assess the potential flooding impacts during construction of the project and identify environmental management measures to avoid, minimise and/or mitigate potential flood impacts on the project or because of the project
- Assess the potential operational impacts of the project and identify and recommend mitigation measures which have been incorporated into the design of the project to reduce and manage potential flood impacts
- Provide environmental management measures to manage residual operational impacts following the implementation of the flood mitigation measures.

17.2.1 Flood models

Hydrologic and hydraulic models were used to quantify and map the existing and developed case flooding conditions for this assessment. The flood model extents are shown in **Figure 17-2** and the hydraulic model boundaries were set at a suitable distance downstream of the project to adequately assess the potential flood impacts of the project.

A number of existing flood models were reviewed to determine their suitability for the flood impact assessment. A summary of the flood models used for the assessment is provided in the following sections. **Appendix O, Flooding and hydrology assessment** provides further information on the hydrological and hydraulic modelling methodology. Each model covers a separate waterway or basin which does not interact with each other. The combined flood model extents cover the entire project location for all waterway crossings.



Coffs Harbour Bypass
Flood model extents
Figure 17-2

North Boambee Valley

The hydrologic and hydraulic models adopted for this project were sourced from the Boambee Creek and Newports Creek Flood Study (Webb, Mckeown & Associates Pty Ltd. 2007), originally developed by Webb McKeown and Associates and later refined by de Groot & Benson (2013) as part of the North Boambee Valley (West) Flood Study for CHCC. The North Boambee Valley hydrologic model was set up in the Watershed Bounded Numerical Model (WBNM) software and the hydraulic model was a TUFLOW 'Classic' 1D/2D coupled model.

Time varying water levels at the model boundary were extracted from the GHD model developed for the Boambee Newports Creek Floodplain Risk Management Study (GHD 2016) to include the effects of tidal conditions on the flood model.

An additional hydrological model was created based on the existing North Boambee Valley hydrologic model, to capture additional sub-catchments affected by the project and the hydraulic model extents were extended to incorporate these additional sub-catchments.

The model topography has been constructed from a range of existing topographic survey datasets from 1996 to 2013, updated with LiDAR data taken in May 2016.

Coffs Creek

The Coffs Creek hydrologic model was set up in XP-RAFTS. The model parameters are described in detail in the Coffs Creek and Park Beach Flood Study report (CHCC 2016). The 1D/2D TUFLOW model developed by BMT WBM was used for the hydraulic modelling in the Coffs Creek catchment. The hydraulic model extents were extended to include additional sub-catchments affected by the project that were not included in the original model and were trimmed where appropriate.

The base topography of the model was updated with the LiDAR data taken in May 2016.

Northern creeks

A new hydrologic model was developed in XP-RAFTS for the four northern creeks. The model extents for the northern creeks are shown in **Figure 17-2.** The hydrologic model parameters used in the BMT WBM XP-RAFTS model for the adjacent Coffs Creek catchment were adopted for the northern creeks model. These parameters were used in lieu of any reliable flood data for calibration purposes.

Four new 1D/2D coupled TUFLOW models were developed for the northern creeks. The model topographies were based on LiDAR data taken in May 2016.

17.3 Existing environment

17.3.1 Historic floods

Coffs Harbour has a long history of flooding with significant events occurring in 1917, 1938, 1950, 1963, 1974, 1977, 1989, 1996, 2001, March/April 2009 and November 2009 (CHCC 2018a). Of these, the 1996 and March/April 2009 flood events were by far the largest. Coffs Harbour was declared a natural disaster zone following both these events which are detailed below.

March/April 2009 flood event

In late March 2009, during a three-day rain event, 440 mm of rain fell on Coffs Harbour in 24 hours, with 300 mm of rain falling in the hills west of Coffs Harbour (Rubinsztein-Dunlop 2009) and 286mm falling within four hours in the Coffs Harbour Creek catchment (Speer, Phillips & Hanstrum 2011). The rainfall intensity in the upper catchment was rarer than that of a 0.2 per cent AEP event with rainfall intensities at the Coffs Harbour Airport gauge being closer to a 2 per cent AEP for the 24-hour storm duration (BMT WBM 2018).

Several meteorological factors combined to produce the flooding and Coffs Harbour was declared a natural disaster zone (Speer, Phillips & Hanstrum 2011). Coffs Creek peaked at 5.1 m, isolating 3200 people (Speer, Phillips & Hanstrum 2011). The flood event severely affected key rail infrastructure, as shown **Figure 17-3,** causing landslides which washed away parts of the rail line just north of Coramba and closed the track between Kempsey and Casino.

Figure 17-3 Flooded tracks north-west of Coffs Harbour on April 1, 2009 (ABC North Coast NSW 2012)

1996 flood event

The most significant flood event in Coffs Harbour's history was the 1996 flood event which also resulted in Coffs Harbour being declared a natural disaster zone. About 500 mm of rainfall fell in six hours, with the most intense rainfall falling in the upper catchments (Maddocks & Rowe 2004).

The flood affected 800 properties, with inundation above floor level of over 250 residential properties and 210 commercial and public properties, as shown in **Figure 17-4** (CHCC 2018a). The flood level in Coffs Harbour Creek peaked at a record maximum 5.4 m (Speer, Phillips & Hanstrum 2011) and the average flood level was approximately one metre greater than the predicted 1 per cent AEP event causing $31 million in insurance claims.

The 1996 flood event resulted in CHCC commissioning a revised study which looked at the impact of orographic floods (resulting from the effects of mountains forcing moist air to rise). This resulted in an increase of flood levels by 0.5 metres or more in many places (Maddocks & Rowe 2004). Orographic rainfall effects have since been incorporated by multiple studies including the Coffs Creek and Park Beach Flood Study (2016) (CHCC 2016) which contribute to flooding analysis within the Coffs Harbour region. As such, orographic rainfall effects have been included in the methodology for assessing the flood impacts of the project.

Figure 17-4 Flooded commercial areas of Coffs Harbour in 1996 flood (Maddocks & Rowe 2004)

17.3.2 Flood protection

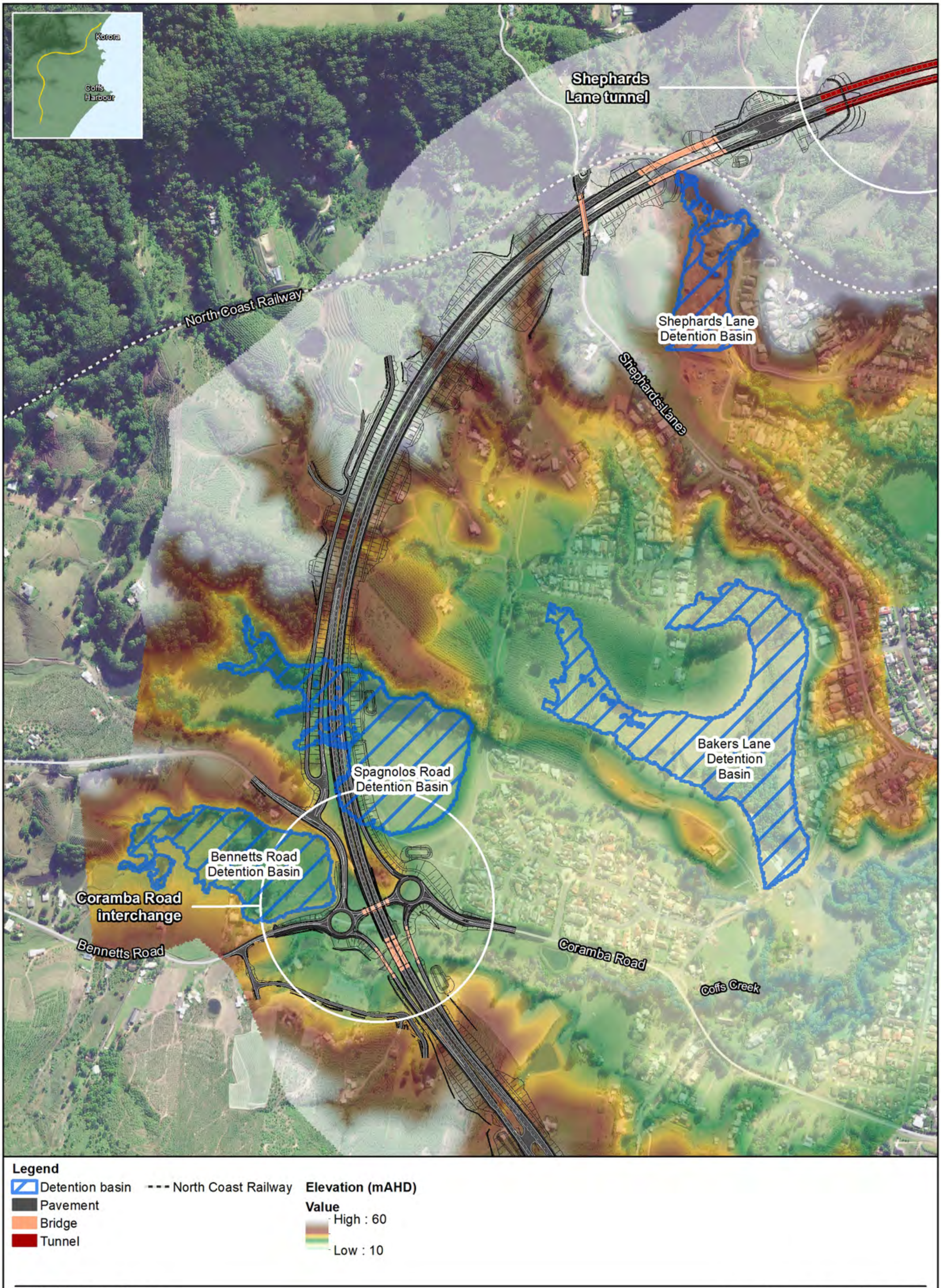
Several detention basins have been constructed in the Coffs Harbour LGA to mitigate the risk to the community in extreme flood events. These detentions basins include:

- The basin near Goodenough Terrace in the upper tributaries of Coffs Creek
- The basin next to Isles Drive in North Boambee Valley (Webb, Mckeown & Associates Pty Ltd. 2007)
- Several small basins located in the upper regions of the Coffs Harbour LGA. These are assumed to be at full capacity already as a conservative measure and only for agricultural use.

Additionally, four detention basins were designed as part of the CHCC Flood Mitigation Programme (CHCC 2018a) to provide flood protection for a 1 per cent AEP event. These basins were designed to alleviate the downstream flooding in the Coffs Creek catchment. The four basins are shown in **Figure 17-5** and comprise:

- Bakers Road detention basin at William Sharpe Drive, West Coffs
- Bennetts Road detention basin
- Spagnolos Road detention basin
- Shephards Lane detention basin.

The four detention bases were constructed and are fully operational. The project would affect the Bennetts Road and Spagnolos Road detention basins at the Coramba Road interchange as shown in **Figure 17-5**. The Shephards Lane detention basin is potentially affected by the bridge over the North Coast Railway (BR12) and the Bakers Lane detention basin is downstream of the project.



Coffs Harbour Bypass
Figure 17-5
Operational detention basins

17.3.3 Waterways and catchments interacting with the project

The project would interact with the following catchments:

- North Boambee Valley
- Coffs Creek
- Northern creeks.

Each catchment consists of unique topography with several sub-catchments, major waterways and tributaries.

North Boambee Valley

The Boambee Creek and Newports Creek catchment covers an area of about 50 km^2 and drains directly to the Pacific Ocean (WMA 2011). There are several small, unnamed tributaries draining into Newports Creek and Boambee Creek. The upper catchment area is primarily steep and densely vegetated, draining from west to east. The middle and lower reaches are characterised by a large floodplain and become more urbanised towards the coastline.

A smaller portion of the total catchment has been defined as the study catchment, see **Figure 17-1**. This is the area of the catchment where flooding interacts with the project.

Boambee Creek and Newports Creek are crossed by several transport corridors, including the Pacific Highway and Hogbin Drive. The Boambee Newports Floodplain Risk Management Study (GHD 2016) reported that the Pacific Highway would be overtopped in the 1 per cent AEP event at several locations including at Newports Creek near Cunninghams Store, the Coffs Harbour Health Campus and at Cook Drive. Hogbin Drive was reported to be overtopped at Coffs Harbour Airport, Southern Cross University, John Paul College, Boambee Creek, and south of Hi-tech Estate. North Boambee Road (opposite Mansbridge Drive) was also reported to be overtopped in the 18 per cent AEP event.

Coffs Creek

The Coffs Creek catchment area, shown in **Figure 17-1** is about 25 km^2 and consists of a flat coastal floodplain in the east rising to a steep escarpment on the west (BMT WBM 2018). This terrain is conducive to extreme weather events, some of which were discussed in **Section 17.3.1**. Elevations range from 10 mAHD to over 490 mAHD within a few kilometres (BMT WBM 2018). Around 23 per cent of the catchment is densely vegetated, 33 per cent is grazing and farmland, and 44 per cent is urbanised (GeoLINK 2015). A majority of the urbanised area is located in the low-lying coastal region of the catchment, while the upper catchment consists primarily of agricultural land and densely vegetated areas.

The Coffs Creek catchment drains through three main creek lines including Coffs Creek and two northern tributaries: Treefern Creek and an unnamed creek which flows parallel to Bray Street (GeoLINK 2015). At the coast, Coffs Creek forms an estuary which is a key recreational and environmental resource. West of the existing Pacific Highway the creek then splits into two smaller tributaries and then into a series of minor watercourses that divide the adjacent hillsides (GeoLINK 2015).

Northern creeks

Topography in the northern creeks catchment consists of steep upper ridges covered by dense bushland with tributaries draining into low-lying terrain on the western side of the existing Pacific Highway. Korora Basin, Jordans Creek, Pine Brush Creek and the unnamed waterway at Sapphire Beach are the main waterways within the northern creeks catchment and define the four small sub-catchments.

These sub-catchments and their approximate total area are shown in **Table 17-4**. All four sub-catchments flow from the steep ridges on the west through the upper tributaries in an easterly direction towards the coastline (**Figure 17-1**). Land use within the northern creeks catchment area consist of about 40 per cent dense bushland, 50 per cent grazing land and 10 per cent is urban. The urban area is primarily in the lower regions of the catchment and consists of residential houses, apartments, a conference centre and golf course, and beach front resorts.

The resorts within this area of Coffs Harbour are located at very low elevations adjacent to waterways and the ocean. The upper reaches of the northern catchments are about 300 mAHD.

Table 17-4 Northern creeks sub-catchments

Sub-catchment	Total area (km^2)
Jordans Creek	2.7
Kororo Basin	1.4
Pine Brush	8.4
Sapphire Beach	0.5

Jordans Creek sub-catchment drains from a small unnamed tributary under the existing Pacific Highway and through a small creek alongside beachfront villas which is susceptible to frequent flooding.

Pine Brush Creek sub-catchment is drained through several upper tributaries that flow into one larger section of Pine Brush creek under the existing Pacific Highway and into the ocean.

Rainfall within the Kororo Basin is governed by steep small upper tributaries that drain into the waterways which surround sections of the Pacific Bay Resort and golf course.

17.4 Existing case flooding

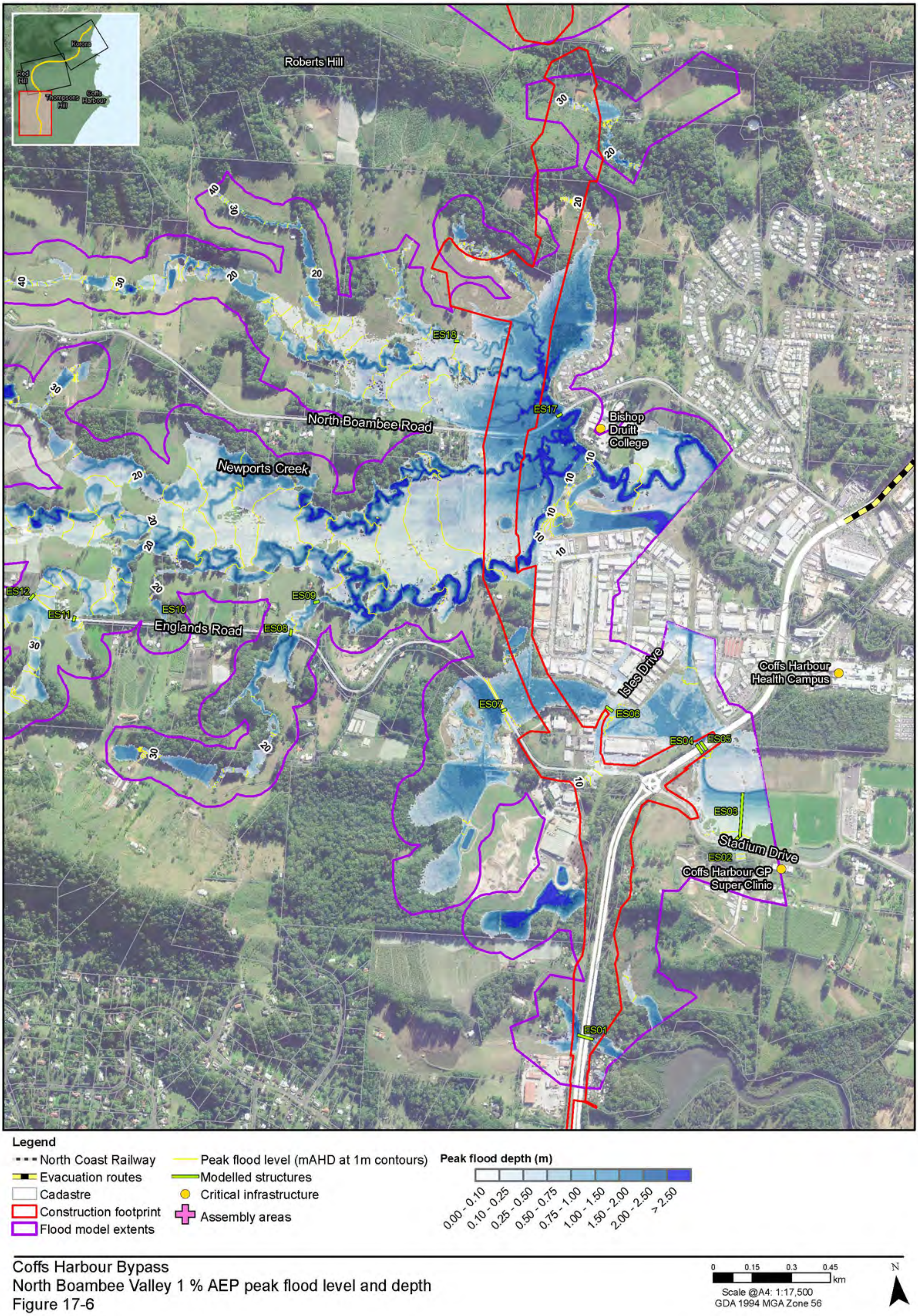
The flood models were simulated for the existing case for the range of flood events listed in **Section 17.1.4**.

Flooding in the study area differs in extent and timing due to the varying catchment sizes upstream of the project. The following sections provide more detail on the modelled existing case flooding conditions in each catchment.

17.4.1 North Boambee Valley

The 1 per cent AEP event peak flood level and depth is shown in **Figure 17-6** with the range of modelled storm events shown in **Appendix O, Flooding and hydrology assessment**. The following observations are noted:

- The project is located within the lower floodplain of Newports Creek and flooding is characterised by relatively low velocity flows outside the main creek channels
- North Boambee Road is overtopped during an 18 per cent AEP event with a peak flood depth of 780 mm
- Several rural properties on North Boambee Road and the northern extent of Highlander Drive are affected by the 18 per cent AEP event. However, no existing structures are affected by high hazard flooding during the 1 per cent AEP event
- Englands Road and Isles Drive overtop during the 18 per cent AEP, with predicted peak depths of less than 130 mm and 570 mm respectively. There is minor inundation of the upstream Pacific Highway shoulder during the 1 per cent AEP event
- Inundation of the road network and the north-west lots of Isles Drive industrial area occurs during the five per cent AEP, with much of the remaining industrial lots flooded during the PMF
- Bishop Druitt College and Coffs Harbour GP Super Clinic are the only critical infrastructure within the model extents (refer to **Figure 17-6**) and are PMF immune. Other critical infrastructure just outside the model extents in this catchment include the Coffs Harbour Health Campus
- The North Boambee Valley (West) urban release area (URA) includes extensive high hazard PMF areas throughout the Newports Creek floodplain, as illustrated in **Appendix O, Flooding and hydrology assessment**.



Coffs Harbour Bypass

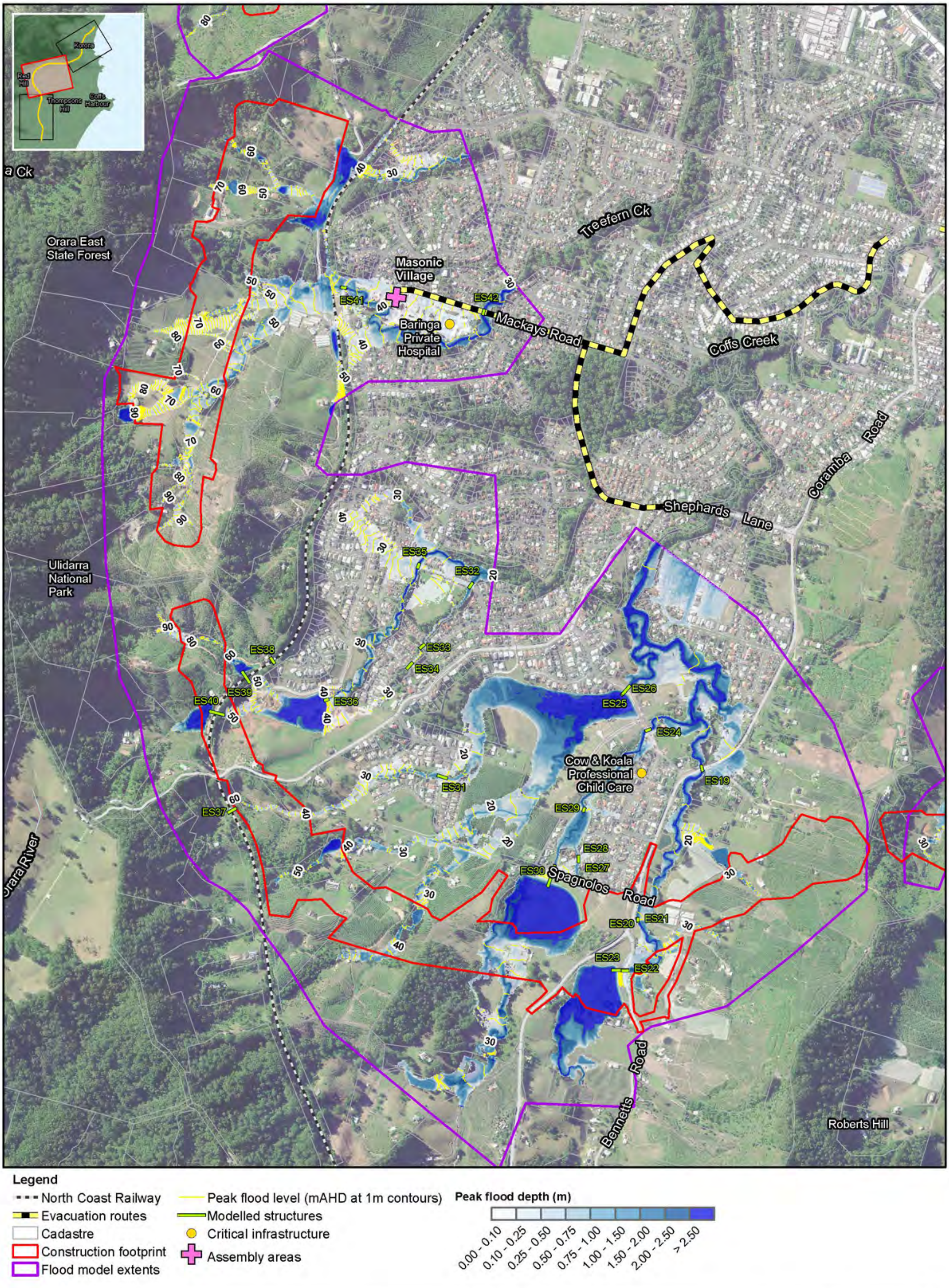
North Boambee Valley 1 % AEP peak flood level and depth

Figure 17-6

17.4.2 Coffs Creek

The Coffs Creek catchment is prone to severe flash flooding due to the steep upper ridges, a high level of urban development on the floodplain and the tendency for high rainfall (BMT WBM 2018). The existing case 1 per cent AEP event peak flood level and depth is shown in **Figure 17-7** with the range of modelled storm events shown in **Appendix O, Flooding and hydrology assessment**. The following observations are noted:

- Existing flooding through the project is characterised by high velocity flow paths generally contained to the established tributaries of the western escarpment
- The North Coast Railway is overtopped during the PMF event north of Brennan Court, with a peak overtopping depth of 900 mm
- 1 per cent AEP event inundation of existing structures (including residential buildings, sheds and other buildings) are noted in the following areas (generally outside of PMF high hazard):
  - Within Bennetts Road detention basin and Bennetts Road properties backing onto Coffs Creek
  - Several Coramba Road properties backing onto Coffs Creek
  - Immediately downstream of Spagnolos Road detention basin
  - Several properties around Roselands Drive and Coriedale Drive.
- The Cow & Koala Professional Child Care (critical infrastructure) is immune in the 1 per cent AEP flood event and inundated in the PMF event
- The CHCC Flood Mitigation Programme detention basins were designed to achieve efficient flood protection of downstream properties for a variety of storm events (CHCC 2018a). The design storm event for each basin potentially affected by the project is listed below:
  - Bennetts Road detention basin: 1 per cent AEP
  - Spagnolos Road detention basin: 1 per cent AEP
  - Bakers Road detention basin: PMF
  - Shephards Lane detention basin: 18 per cent AEP.



Coffs Harbour Bypass

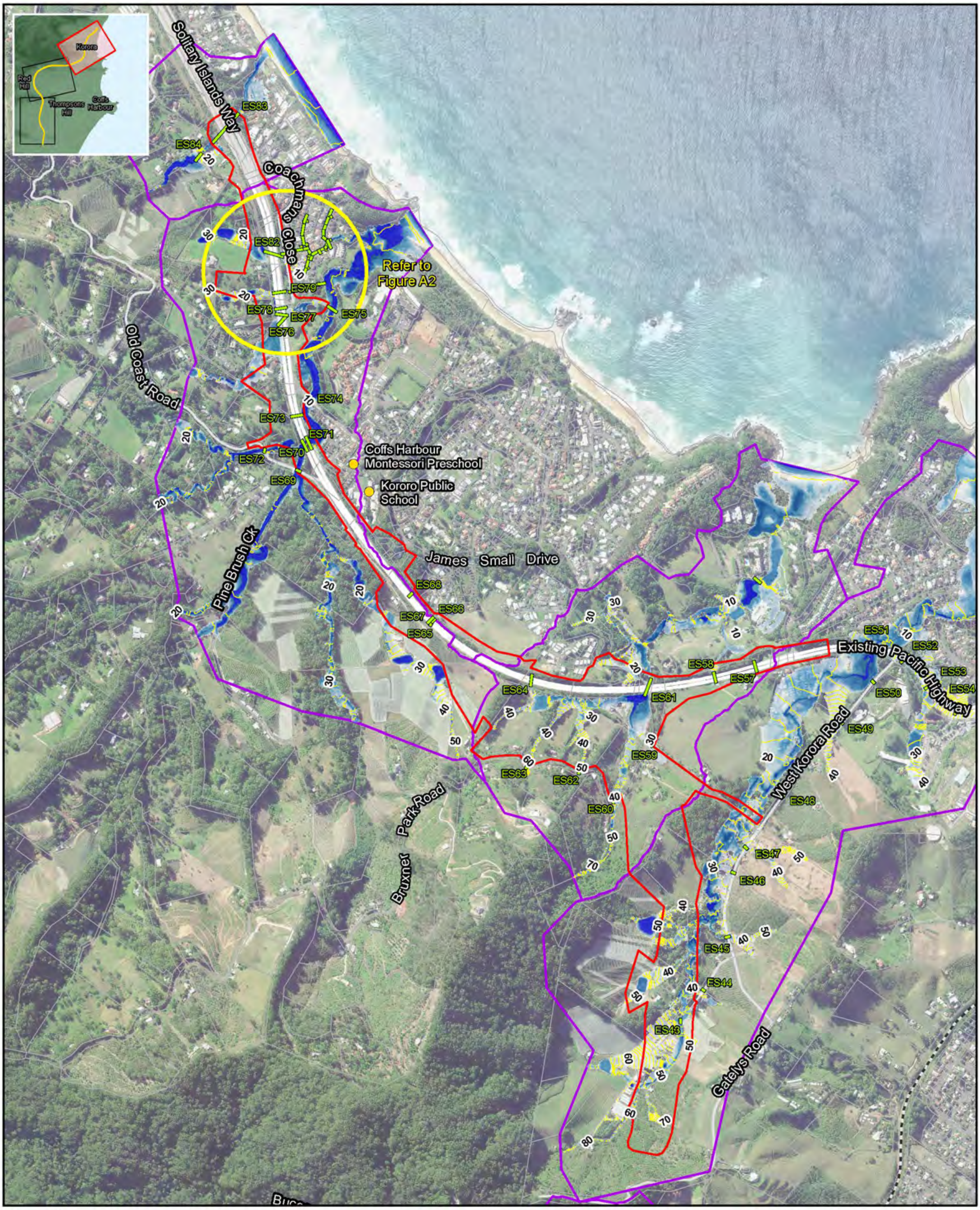
Coffs Creek 1 % AEP peak flood level and depth

Figure 17-7

17.4.3 Northern creeks

The existing peak flood level and depth for the 1 per cent AEP event for the northern creeks are shown in **Figure 17-8** with the range of modelled storm events shown in **Appendix O, Flooding and hydrology assessment**. The following observations are noted:

- Flooding is generally characterised by numerous, relatively small flow paths draining off the western hills, controlled by the existing Pacific Highway drainage structures
- Flows are constricted at the Pacific Highway / Bruxner Park Road intersection (ES61) resulting in upstream peak flood depths up to seven metres in the 1 per cent AEP event
- The existing Pacific Highway is above the 1 per cent AEP peak flood level, except for the Jordans Creek crossing (less than 18 per cent AEP immunity) and minor inundation of northbound lanes just west of Opal Boulevard
- There are several urban areas next to the project currently affected by 1 per cent AEP flooding. These are generally affected by PMF high hazard and include:
  - Nautilus Villas
  - Residential lots between Coachmans Close and Pine Brush Crescent
  - James Small Drive residential lots backing onto Pine Brush Creek
  - Banana Coast Caravan Park
  - Various rural lots immediately upstream of the project.
- Critical infrastructure in the flood model extents include Kororo Public School and Coffs Harbour Montessori Preschool. Both are PMF immune.



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical infrastructure
- Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Northern Creeks 1 % AEP peak flood level and depth
Figure 17-8

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

17.5 Assessment of construction impacts

The potential hydrology and flooding impact of the following construction activities has been assessed:

- Ancillary facilities
- Earthworks in floodplain areas
- Temporary waterway crossings
- Catchment drainage.

In addition to the above, the project has the potential to impact emergency response and evacuation routes during flood events because of changed road conditions. Consultation with SES indicates that SES would need unimpeded access during construction where an emergency response is required. As such, SES will be notified of any partial or total road closures needed for the construction of the project, during project construction. A Construction Flood Management Plan (CFMP) will be developed for the project (refer to **Section 17.7**), which will detail any impacts on existing flood conditions in relation to flood evacuation routes.

17.5.1 Ancillary facilities

The assessment of ancillary facilities considers potential facilities located within the 5 per cent AEP flood extent because these sites would have a higher risk of potential flood impacts than sites located outside the 5 per cent AEP flood extent. The peak flood extents for the 5 per cent AEP flood, 1 per cent AEP flood and PMF events (1 per cent AEP and PMF flood extents were used to provide an indication of the flood risks for the proposed ancillary facilities), and construction zones (including ancillary facilities) are shown in **Figure 17-9-01** to **Figure 17-9-03**.

Ten of the 14 potential sites for ancillary facilities identified for the project in **Chapter 6, Construction**, are located within potential flood hazard areas (areas within the 5 per cent AEP flood extent). These sites are subject to flooding in the 5 per cent AEP event. The flood extents and construction zones (including ancillary facilities) are shown in **Figure 17-9-01** to **Figure 17-9-03**.

An assessment has been carried out to identify the potential flood risk of each ancillary site considering the 5 and 1 per cent AEP, and PMF events. The assessment also considers the ancillary sites that are at risk of frequent (18 per cent AEP) high flood depths and velocities.

Locating ancillary facilities in areas of high flood risk or in areas subject to flood has the potential to impact on existing flooding and hydrology. Key ancillary site plant and facilities should be positioned to the least flood affected site areas to reduce potential impacts.

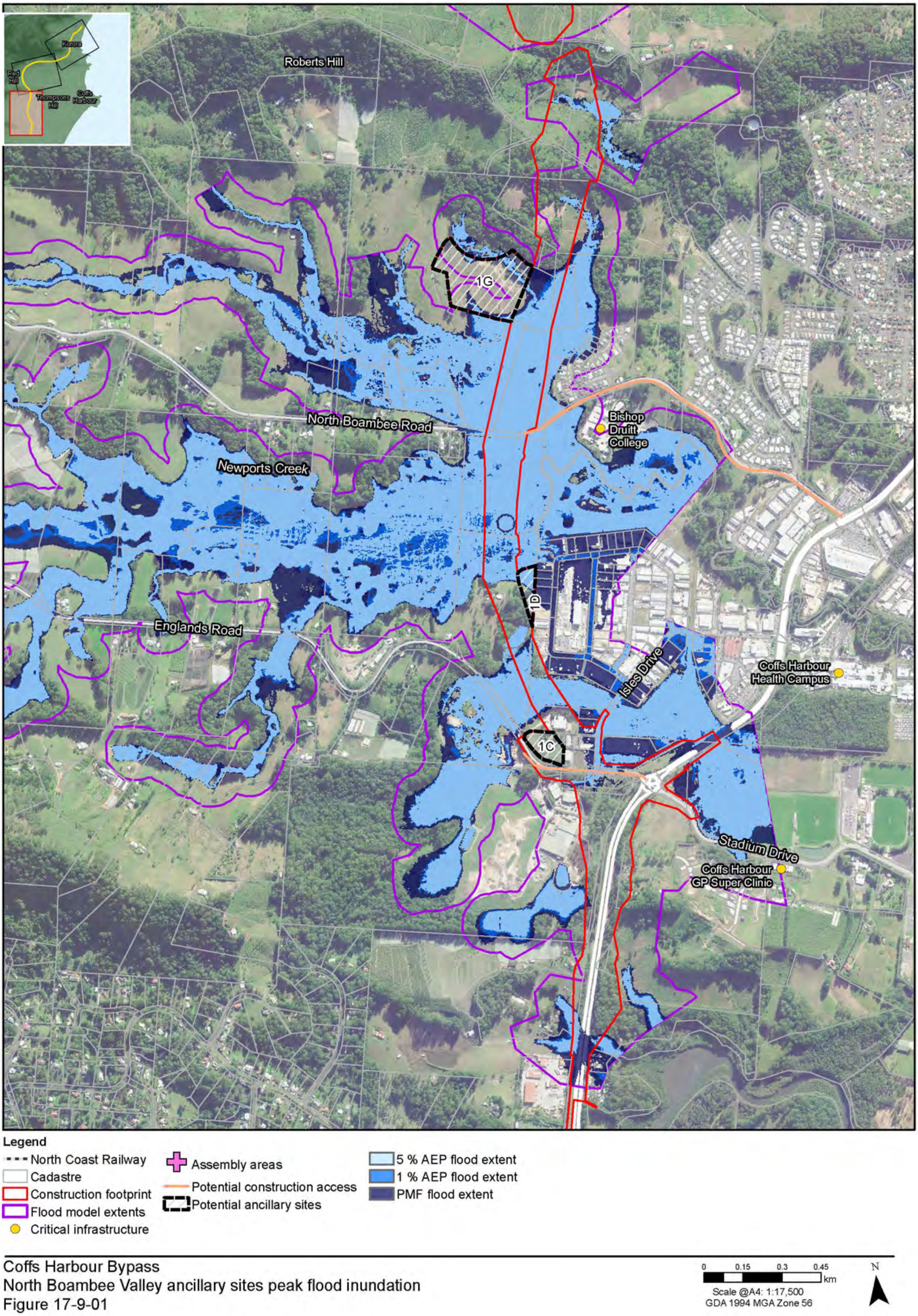
Table 17-5 presents the potential hydrology and flooding impacts of the proposed ancillary facility sites.

Table 17-5 Hydrology and flooding impacts of potential ancillary facilities

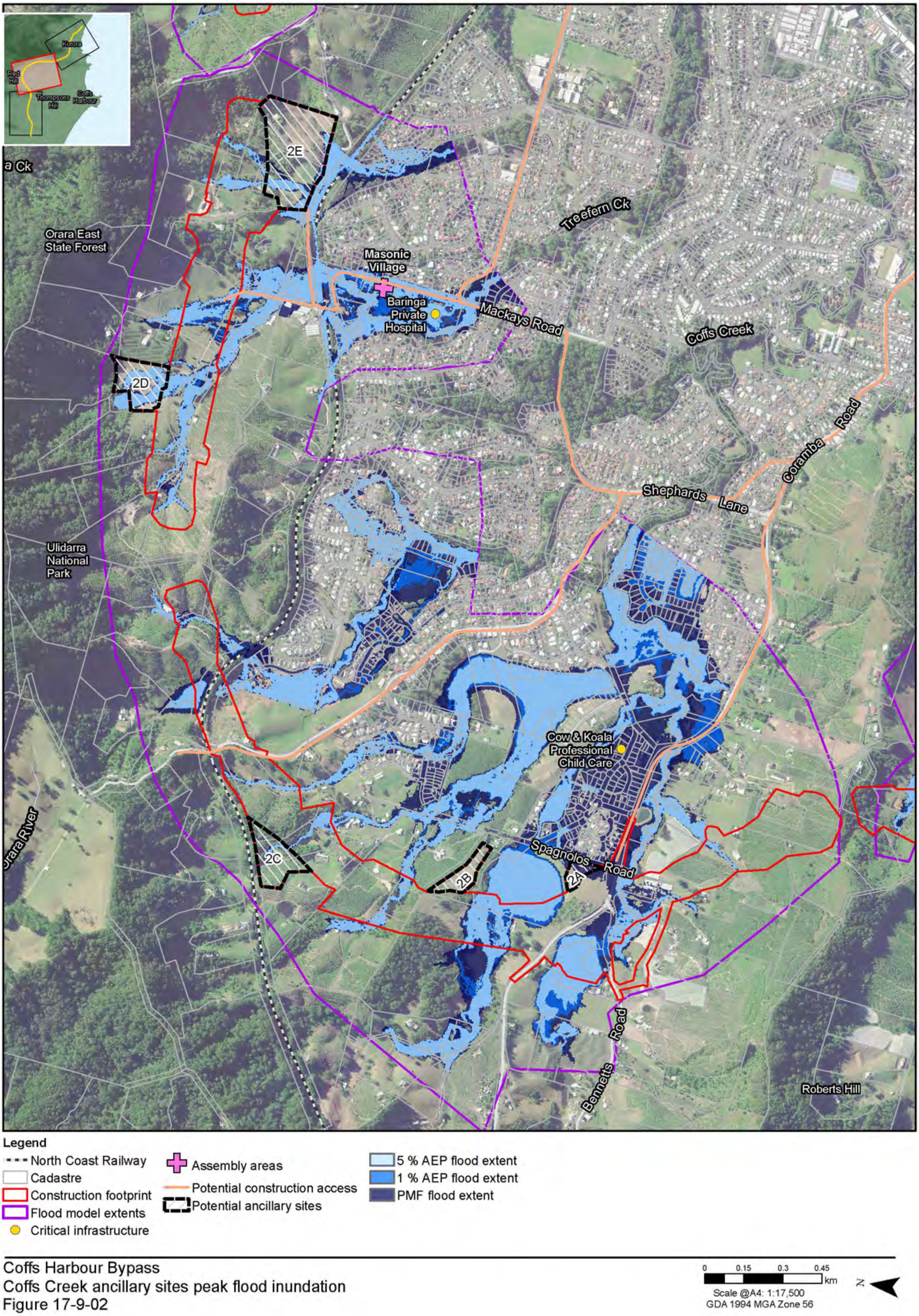
Site	Flood risk and potential impacts	Management measure
1D	The northern portion of this site is part of the Newport Creek floodplain, is within the 5 % AEP flood extent and at risk of frequent (18 % AEP) high flood depths and velocities. Because Isles Drive industrial area is immediately downstream of this site, locating site compounds or other facilities within the area of frequent impact could cause higher risk of impacts to Isles Drive.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area.

Site	Flood risk and potential impacts	Management measure
1G	This area is predominately flood immune apart from small areas in the north east and on the southern boundary which are part of the Newports Creek floodplain. The areas of risk are part of Newports Creek floodplain, so locating site compounds or other facilities within the areas of risk could cause displacement of existing flood storage / attenuation and have downstream impacts.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area.
2A	This site is predominately above 1 % AEP flood level and is subject to flooding during a PMF event. Use of this area for ancillary facilities has a relative low risk of potential impacts on flooding and hydrology. The consequence of inundation is high because of proximity of residential properties downstream of the site.	Management of the site uses outside of the PMF event are not required because of the low probability of flooding.
2C	This area is predominately flood immune apart from a tributary which originates in the site. The redirection of this tributary and its flows may cause previously flood free areas to be impacted, however, because the site is in the upper reaches of the catchment, potential impacts on flooding and hydrology are expected to be minimal.	A CFMP will be prepared to manage potential flood risk. Conveyance of existing small tributary within the site and its associated flows should be maintained.
2D	An existing farm dam upstream of the site controls inundation of this area and the site is impacted by the 5 % AEP flood event. Ancillary facilities may result in redirection of flows and may cause previously flood free areas to be impacted, however, because the site is in the upper reaches of the catchment, potential impacts on flooding and hydrology are expected to be minimal.	A CFMP will be prepared to manage potential flood risk. Inspection of the dam existing condition before construction activities. Inspection of the dam should also be carried out, after storm events during construction. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area.
2E	The southern portion of this site is in the upper reaches of Treefern Creek and is impacted in a 5% AEP flood event. Locating ancillary facilities in areas affected by flooding may result in redirection of flows and may cause previously flood free areas to be impacted, however, because the site is in the upper reaches of the catchment, potential impacts on flooding and hydrology are expected to be minimal. Because of the proximity of residences at Abel Tasman Drive, locating ancillary facilities within the areas of flood risk could cause higher risk of impacts to Abel Tasman Drive.	A CFMP will be prepared to manage potential flood risk and the higher risk of impacts to residences of Abel Tasman Drive. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area.
2G	Most of this site is within the 5 % AEP flood extents and is at risk of frequent (18 % AEP) high flood depths and velocities. Because of agricultural land uses and a residential property, locating ancillary facilities within the area of frequent flood impact could cause higher risk of impacts to these lands.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area.

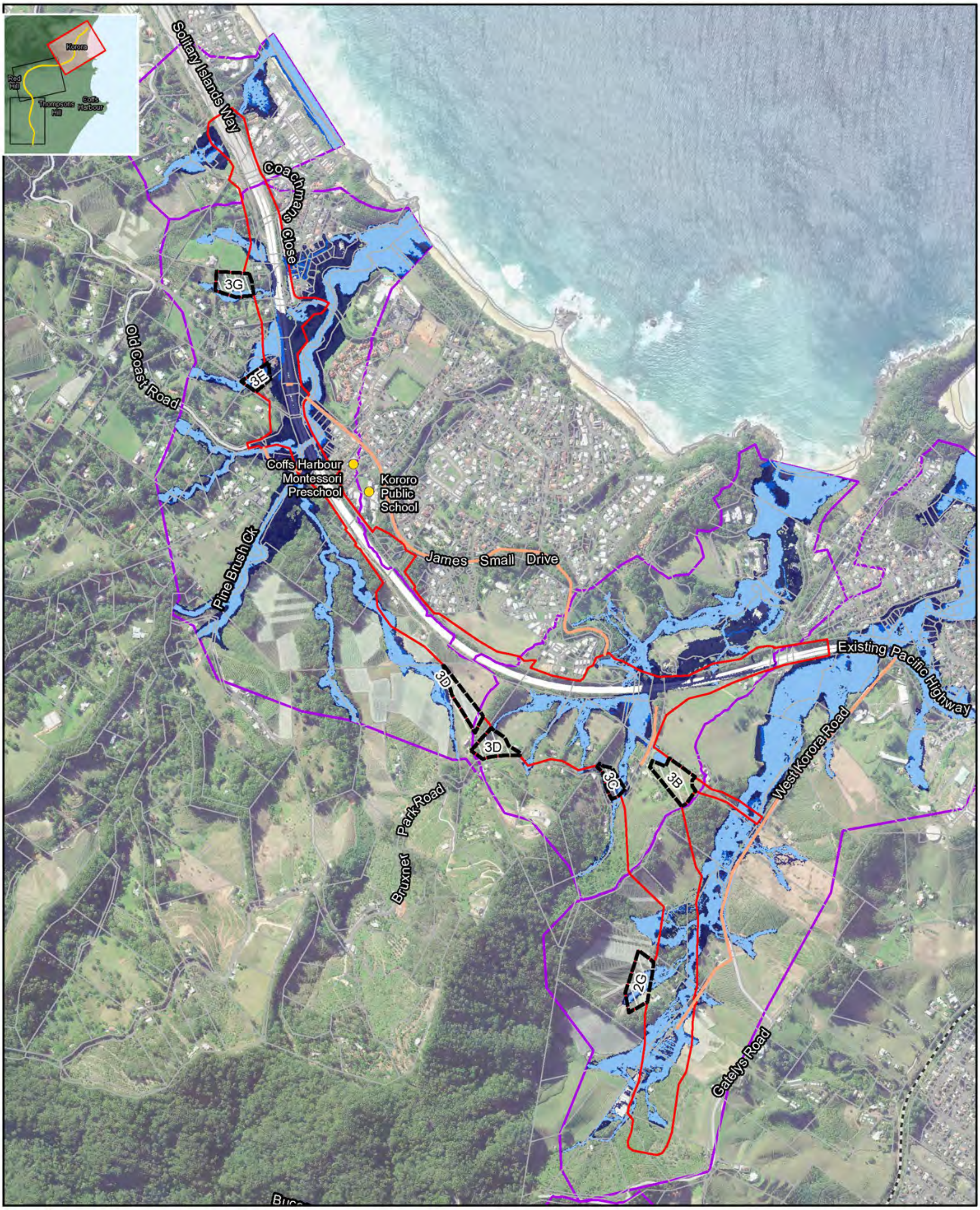
Site	Flood risk and potential impacts	Management measure
3C	The south eastern portion of the site contains a tributary discharging into Kororo Basin, which is within the 5 % AEP flood extents and is at risk of frequent (18 % AEP) high flood depths and velocities. The redirection of flows may cause previously flood free areas to be impacted and may increase flooding of upstream areas, with potential impacts on Bruxner Park Road.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area. The existing small tributary within the site and its associated flows should be maintained.
3E	Most of the site is within the 5 % AEP flood extent and is at risk of frequent (18% AEP) high flood depths and velocities. Consequence of inundation is potential high because of the relative proximity of properties.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area.
3G	Most of this site is flood free apart from an area along the southern boundary which is at risk of frequent (18 % AEP) high flood depths and velocities. Locating ancillary facilities in areas affected by flooding may result in redirection of flows and may cause previously flood free areas to be impacted, potentially impacting nearby residences.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area.



Coffs Harbour Bypass
North Boambee Valley ancillary sites peak flood inundation
Figure 17-9-01



Coffs Harbour Bypass
Coffs Creek ancillary sites peak flood inundation
Figure 17-9-02



Legend

- North Coast Railway
- Cadastre
- Construction footprint
- Flood model extents
- Critical infrastructure
- Assembly areas
- Potential construction access
- Potential ancillary sites
- 5 % AEP flood extent
- 1 % AEP flood extent
- PMF flood extent

Coffs Harbour Bypass
Northern Creeks ancillary sites peak flood inundation
Figure 17-9-03

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

17.5.2 Earthworks

Substantial earthworks would be required for the project including construction of road embankments and foundation drainage within all construction zones. The earthworks associated with the project would require temporary stockpiles or staged construction. Pre-loading of embankments is not anticipated for areas of soft soil.

The extent of these earthworks in flood affected areas are to be constrained to the operational conditions of the project to avoid potential adverse impact. As such, the flood impacts predicted would not be greater than those documented in the assessment of operational impacts in **Section 17.6**. If the detailed construction plan requires staging of additional earthworks within the floodplain, revised flood modelling will be carried out as part of the detailed design stage.

Where foundation drainage is capped during the construction phase, temporary drainage culverts or a suitable alternative drainage system would be implemented. This could include construction of diversion and catch drains along the formation and sedimentation control basins or swales (where required).

17.5.3 Temporary waterway crossings

Temporary crossing structures may be required to cross Newports Creek, Coffs Creek, Treefern Creek, Jordans Creek, Pine Brush Creek and other small unnamed drainage lines and watercourses to allow materials to be hauled within the construction footprint (rather than using the existing road network) while the adjacent culvert or bridge is being built. Temporary crossings have the potential to impact on the hydraulic function of the waterway, causing water levels to rise upstream of the crossing during a flood event. To avoid potential flood impacts of temporary creek crossings, the works will be designed, constructed and maintained in accordance with the following requirements:

- Watercourse crossings would be managed to avoid impact on any sensitive receiving environments (see **Chapter 19, Surface water quality**), including any hydrological changes
- Erosion and sediment control measures (including scour protection) would be installed upstream and downstream of culverts and disturbed stream/creek banks to avoid erosion of the watercourse
- Low-flow conditions would be maintained
- No additional flooding impacts would occur greater than those assessed for the operational phase
- Fish passage will be maintained in accordance with the its waterway classification and DPIE guideline Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (Fairfull & Witheridge 2003)
- Any material used will not result in fine sediment material entering the waterway
- Erosion and sediment controls will be included in accordance with Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004) and Volume 2 (A. Installation of Services; B. Waste Landfills; C. Unsealed Roads; D. Main Roads; E. Mines and Quarries) (DECC 2008)
- Any material used in the temporary creek crossing will be removed following construction and the site rehabilitated to its existing (or improved) condition.

17.5.4 Catchment drainage

Construction activities have the potential to impact on the volume and velocity of surface water discharged to adjacent waterways and hydrological processes during and after rainfall events.

Catch drains and cross-drainage structures would be built to divert overland flows away from the project and to convey overland flows under the project. Construction of the project would require diversion and management of overland flows to drain new works as they are being built.

These activities would have the potential to impact on flooding and hydrology, by:

- Changing the natural processes within waterways and floodplains, including the availability of water for ecological and agricultural purposes
- Potentially affecting erosion and sedimentation processes during construction.

Catchment drainage would be designed to divert overland flows from entering construction areas to support continuity of natural water courses and hydrological processes. This would reduce the effect of erosion from overland flows and reduce the subsequent extent of treatment needed for flows discharged from construction areas.

The construction of the catch drains and cross-drainage structures (including pits, pipes, culverts and open drains/swales) would occur progressively in conjunction with temporary, staged and permanent road drainage to enable continuity of natural watercourses and hydrological processes.

The potential impacts of changes in catchment drainage during construction have been assessed considering the differences between existing flow attributes and the predicted flow attributes with the project in place. The following flow attributes have been considered for the 1 per cent AEP flood event:

- Peak flow rates
- Peak flood levels and flow velocities
- Duration of inundation.

Peak flow rates

Peak flow rates are largely related to the size of the catchment area and the proportion of impervious areas within the catchment. A comparison of the proportion of impervious areas and the peak flow rates between the existing and developed case flood conditions at several points of interest (POI) downstream of the project, for the 1 per cent AEP flood event, is provided in **Table 17-6**.

Points of interest downstream of the project demonstrate the impact of the project on existing flow conditions. Points downstream of the project were selected to assess whether the impacts of the project would be localised to areas close to the construction footprint, or if there would be changes in the downstream flow conditions. The points of interest for each catchment are shown on **Figure 17-10**, **Figure 17-11** and **Figure 17-12**.

Table 17-6 Comparison of peak flows for the 1 per cent AEP flood event

Catchment	POI	Scenario	Impervious area (% of catchment)	Peak flow rate (m^3/s)
North Boambee Valley^	D	Existing	23.7	51.4
		Developed	23.7	52.2
		Difference	*0.0*	*1.7%*
	BA	Existing	1.6	239.9
		Developed	1.6	241.1
		Difference	*0.0*	*0.5%*
Coffs Creek	BB	Existing	4.1	84.1
		Developed	6.1	84.4
		Difference	*2.0*	*0.4%*

Catchment	POI	Scenario	Impervious area (% of catchment)	Peak flow rate (m^3/s)
	BC	Existing	16.9	46.7
		Developed	18.0	46.7
		Difference	*1.1*	*0.0%*
	AP	Existing	11.7	61.7
		Developed	16.4	58.6
		Difference	*4.7*	*5.0%*
	BD	Existing	13.3	18.6
		Developed	15.4	19.7
		Difference	*2.1*	*6.0%*
Northern creeks	P	Existing	0.2	76.9
		Developed	4.5	72.6
		Difference	*4.3*	*5.6%*
	Q	Existing	7.1	37.3
		Developed	21.3	44.5
		Difference	*14.2*	*19.1%*
	T	Existing	2.4	245.0
		Developed	4.3	244.7
		Difference	*1.9*	*0.1%*
	V	Existing	6.0	13.7
		Developed	8.5	14.1
		Difference	*2.5*	*2.9%*

^ *Existing hydrologic flows were adopted for the developed hydraulic analysis for the North Boambee Valley Catchment for the reasons listed below. This results in the per cent impervious areas in individual catchments being equal within the model:*

- The increase in impervious areas within the catchment because of the project would be relatively small (about 0.4 per cent)
- The response time for flows from the upper reaches of the catchment (where impervious areas would be unchanged because of the project) would be significantly longer (nine hours) when compared with the response time for flows from the project (ten minutes) (where the impervious areas would be increased). This means runoff from impervious areas of the project during a storm event would be discharged downstream long before flows from the upper reaches of the catchment reach the project, and as such would not affect peak flood levels.

The assessment is based on the comparison between the existing case and the developed case flood conditions. Conditions would change progressively during construction of the project. To be consistent with the floodplain management objectives outlined in **Section 17.1.4** for construction of the project, flood conditions during construction would be expected to be no worse than the developed case flood.

The assessment indicates peak flow rates in the developed case would generally be within five per cent of the existing flow rates downstream of the project. The exception would be at point of interest Q, which is downstream of the Korora Hill interchange. There would be a moderate increase in the peak flow rates at this location because of the increase in impervious areas from the proposed interchange (refer to **Section 17.6.3** for the assessment of operational impacts at this location).

No adverse impacts to natural processes within waterways and floodplains, including the availability of water for ecological or agricultural purposes (refer to **Chapter 13, Agriculture** for more information on potential agricultural impacts), would be expected. The minor changes in peak flow rates would not be anticipated to adversely impact on existing stormwater infrastructure.

No adverse impacts to the environmental availability of water or natural processes within the waterways would be expected. In addition, the minor changes would not be anticipated to adversely impact on the existing stormwater infrastructure.

If during detailed design construction impacts are predicted to be worse than the developed case flood impacts, mitigation measures will be developed in accordance with the flood plain management objectives and the CFMP.

Peak flood levels and flow velocities

Peak flood levels and flow velocities provide an indication of the potential change in natural processes within waterways. The locations where the most change would be expected is at the waterway crossings where flows would be constricted to pass beneath bridges at those locations. A comparison of the peak flood levels and flow velocities between the existing and developed case flood conditions at the major creek crossings, for the 1 per cent AEP flood event, is provided in **Table 17-7**.

Table 17-7 Predicted flood conditions of waterway crossings in 1 per cent AEP flood event

Waterway	Structure[1]	Peak flood level (mAHD)			Peak velocity (m/s)		
		Existing	Developed	Difference	Existing	Developed	Difference
Newports Creek and tributaries	BR03 (DS10)	10.88	10.86	*-0.02*	1.39	1.45	*0.06*
	BR23 (DS12)	10.32	10.55	*0.23*	0.53	0.90	*0.37*
	BR04 (DS13)	10.28	10.28	*0.00*	0.67	0.45	*-0.22*
	BR05 (DS14)	10.28	10.30	*0.02*	0.66	0.46	*-0.20*
Coffs Creek	BR06 (DS34)	21.44	21.50	*0.06*	0.74	0.75	*0.01*
	BR08 (DS35)	60.29	60.31	*0.02*	0.12	0.49	*0.37*
Jordans Creek	BR16 (DS66)	52.19	51.35	*-0.84*	0.53	0.92	*0.39*
Pine Brush Creek	BR21 (DS85)	11.63	11.67	*0.04*	2.54	2.48	*-0.06*

[1] *"DS" references are the design structures references shown on Figure 17-10, Figure 17-11 and Figure 17-12.*

The assessment is based on the comparison between the existing case and the developed case flood conditions. Conditions would change progressively during construction of the project. To be consistent with the floodplain management objectives outlined in **Section 17.1.4** for construction of the project, flood conditions during construction would be expected to be no worse than the developed case flood.

The differences in flood conditions between the existing and developed case shown in **Table 17-7** indicates there would be limited change in peak flood conditions at these waterway crossings. The exceptions are at BR23 over Newports Creek and BR16 near Jordans Creek where there would be a 230 mm flood level increase and an 840 mm flood level decrease respectively. The extent of flood level impacts at these two locations are shown on **Figure 17-10** and **Figure 17-12** respectively. These maps show these impacts would be localised.

Natural waterway processes would be maintained or improved following rehabilitation of the waterways affected by construction of the project, as outlined in **Section 5.3.9** of **Chapter 5, Project description** and the mitigation measures in **Section 17.7**.

If during detailed design construction impacts are predicted to be worse than the developed case flood impacts, mitigation measures will be developed in accordance with the flood plain management objectives and the CFMP.

Duration of inundation

The time of inundation for flood events may be increased immediately upstream of the project because of the location of the project in relation to the contributing catchments. An assessment of the predicted flood impacts has been carried out to identify the locations that would be most flood affected because of the project as these are the locations where the greatest change in time of inundation could be expected.

A comparison of the time of inundation between the existing and developed case flood conditions at these locations for the 1 per cent AEP flood event is provided in **Table 17-8**. The points of interest for each catchment are shown on **Figure 17-10** and **Figure 17-11**.

Table 17-8 Predicted change in time of inundation for the 1 per cent AEP flood event

Point of interest	Time of inundation (hr:min)		
	Existing	Developed	Difference
B	10:35	10:40	*0:05*
E	3:15	5:15	*2:00*
J	6:00	6:55	*0:55*

The assessment indicates the worst-case changes in time of inundation would be in the order of hours (at point of interest E), which would be unlikely to adversely impact the surrounding natural processes.

17.6 Assessment of operational impacts

Flood modelling was carried out during development of the design for the project to identify areas of impact and recommend mitigation measures which have been incorporated into the design of the project to reduce and manage potential flood impacts, which represents the developed case assessed in the following sections.

The flood models were simulated for the range of storm events listed in **Section 17.1.4** for the developed case (ie with the project) and compared to the existing case (ie without the project) flood conditions. The flood impacts were reviewed against the floodplain management objectives in **Section 17.1.4** and the outcomes are summarised in the following sections.

Afflux mapping for the 1 per cent AEP event is shown in the following sections (**Section 17.6.1**, **Section 17.6.2** and **Section 17.6.3**). Refer to **Appendix O, Flooding and hydrology assessment** for the full range of modelled storm events.

The afflux maps depict the 'difference' between the peak flood levels of the developed case and the existing case. The yellow to red colour range shows the increase in peak flood levels and the green to blue colour range shows the decrease in peak flood levels because of the project. Changes in flood levels of +/- 10 mm have been reported to be 'no impact', depicted in light grey, which is consistent with the accepted tolerance for TUFLOW modelling precision of +/-10 mm.

Changes to the flood extents are also shown, with areas that were previously 'wet' (in the existing case) but are now 'dry' (in the developed case) are shown in dark grey. Areas that were previously 'dry' but now 'wet' are shown in pink.

The predicted flood impacts resulting from the project would predominantly be related to increases in water levels and flood extents. In many areas, the project would hold back floodwater upstream of the project, which would result in reduced flood levels downstream of the project, improving flood conditions.

No adverse impacts to beneficial inundation of the floodplain environment are expected to occur because there would be negligible changes to the existing extent and period of inundation of areas sensitive to changes in hydrological regime (refer to **Chapter 10, Biodiversity**), ie there are no environmental areas sensitive to changes in hydrological regime previously inundated in the existing case that would be dry in the developed case.

Should detailed design result in flood impacts greater than those reported in **Section 17.6**, further flood modelling and assessment will be carried out, and reasonable and feasible management and mitigation measures would be implemented to ensure flood impacts are not greater than those reported in **Section 17.6**.

17.6.1 North Boambee Valley

Assessment of the potential operational impacts of the project on flooding and hydrology in the North Boambee Valley catchment against the design criteria and flooding objectives outlined in **Section 17.1.4** are outlined in the following sections.

Flood immunity of project infrastructure

The project was assessed against the flood immunity criteria shown in **Section 17.1.4**. The flood immunity outcomes of the project for North Boambee Valley is summarised in **Table 17-9** and the North Boambee Valley peak flood level is shown in **Figure 17-10**.

Table 17-9 Flood immunity outcomes of the project for North Boambee Valley

Design criteria	Performance against criteria
Flood immunity of 1% AEP for the highway targeted.	Flood immunity of the project is achieved within the North Boambee Valley catchment area.
Flood immunity of 5% AEP for ramps, service road and access road targeted.	Flood immunity of the project is achieved within the North Boambee Valley catchment area.
Tunnel portals above PMF or the 1% AEP flood level +0.5 m (whichever is the greater).	Roberts Hill tunnel meets the flood immunity criteria. Note the Roberts Hill tunnel does not contain a sag point where floodwaters would collect in the tunnel.
Waterway crossings – bridge soffits >0.5 m above 1% AEP flood level	All bridges in the North Boambee Valley catchment have bridge soffits at least 0.5 m above the 1% AEP flood level. Bridge abutments would be located to minimise scour velocities and would be subject to refinement during detailed design.

Flood impact of the project

Assessment of the potential operational flooding hydrology impacts of the project in the North Boambee Valley catchment against the floodplain management objectives outlined in **Section 17.1.4** is provided in the following sections. This includes an assessment of the following elements:

- Level
- Scour
- Access
- Direction
- Critical infrastructure
- Emergency management.

Key elements of the project relating to flooding and hydrology for North Boambee Valley catchment which have been incorporated into the design of the project include:

- Optimising the bridge locations to achieve conveyance for low and high flow events as well as for biodiversity objectives for fauna
- Appropriate sizing and positioning of longitudinal and transverse drainage culverts and channels
- Realignment of a northern tributary of Newports Creek (beneath bridge BR05) and addition of free draining storage areas beneath that bridge and the bridge over North Boambee Road (refer to **Table 5-3**, bridge BR04 and bridge BR05) to provide compensatory flood storage
- Optimisation of the road embankment design to minimise impact on floodplain storage while still providing noise mounds where required
- Provision of table drains along either side of North Boambee Road to provide sufficient drainage for low flow events.

Level

Peak flood levels for the 1 per cent AEP flood event in the North Boambee Valley catchment are shown in **Figure 17-10** and potential impacts of the project in terms of flood levels for representative points of interest (POI) in the catchment are summarised in **Table 17-10**. Note the existing structures and design structures identified in **Figure 17-10** are labelled with the prefix ES and DS respectively. The design structures consist of bridges or culverts. Where a design structure is a bridge, the corresponding bridge number (refer to **Section 5.3.4** of **Chapter 5, Project description**) is included in the table below.

Bridges, culverts and additional floodplain storage (north of North Boambee Road) have been incorporated into the project to mitigate potential flood impacts.

All areas external to the project in the North Boambee Valley catchment achieve required flood afflux criteria (as summarised in **Section 17.1.4**) except for at the Newports Creek floodplain upstream of the project (points of interest E and Z) because of the reduced flood conveyance and storage at this location. Point of interest B exceeds the afflux criteria, however this is on land owned Roads and Maritime (refer to **Table 17-10**).

Table 17-10 Predicted flood levels for the 1 per cent AEP flood event in the North Boambee Valley catchment and potential impacts

POI	Potential flood impacts	Mitigation measures incorporated into the project
A	The project widens the road embankment into the low-lying area currently drained by the existing culvert (ES01) and the driveway access of Lot 232 DP740659. Afflux up to 120 mm in the 1% AEP event is noted over the current dam.	The existing culvert (ES01) has been lengthened to match the width of the widened road embankment. A new culvert (DS02) has been included adjacent to ES01 to alleviate potential flood level increases upstream. New culverts (DS03) have also been included and raising of the affected driveway crest is proposed to maintain flood access.
B	The project has the potential to impact the tributary adjacent to Englands Road at point of interest B. Afflux up to 850 mm is predicted in the 1% AEP event which would be contained on land owned by Roads and Maritime between the project and Englands Road. The afflux is contained to the heavily vegetated floodplain with no impact to Englands Road flood immunity. Time of inundation is predicted to increase from 10 hours 35 minutes to 10 hours 40 minutes and as such this minor increase in duration is not expected impact environmental processes.	The approach of attenuating flood flows upstream of the project via the proposed culvert (DS09) results in peak flood level reductions to the downstream areas.
C	Stormwater drainage from the Englands Road interchange discharges to the existing drainage channel adjacent to the existing Pacific Highway, resulting in a change in flow distribution over Lot 61 DP1026815.	The proposed culvert (DS05) discharges directly into the downstream channel generally resulting in peak flood level reductions.
D	The tie-in with the existing Pacific Highway slightly modifies the road profile and embankment width affecting flood conveyance. There is a localised increase in flow velocities downstream of the culverts because of the project.	Extension of cross-drainage culverts have been included to match width of road embankment (DS07, DS08).
E	The project traverses the Newports Creek floodplain at this location and the project embankments affect flood storage and conveyance to the main creek channels Localised afflux of up to 0.5 m in the 1% AEP event is predicted immediately upstream of the project. Afflux reduces to around 0.2 m as the extent of flood depth increase extends upstream to: • The existing agricultural/forested areas, • The residential property adjacent to North Boambee Road (property is owned by Roads and Maritime). Flood depth increase by 0.2 m in the 1% AEP event • Towards North Boambee Road.	The proposed bridge and culvert structures (DS10 (BR03) to DS12(BR23)) have been included to provide for flood flow conveyance but do not eliminate afflux upstream.

POI	Potential flood impacts	Mitigation measures incorporated into the project
	There is no change to the PMF flood hazard category upstream of the project throughout the North Boambee Valley (West) URA.	
F / Z	The project traverses the Newports Creek floodplain. Embankments reduce floodplain storage in this area resulting afflux up to 35 mm in the 1% AEP event on the surrounding pastural/forested areas and the northern extent of Highlander Drive. Afflux of up to 18 mm is predicted at the residential property of Lot 1 DP711234 – on the north side of North Boambee Road near POI: Z	The proposed bridges (DS13 (BR04) and DS14 (BR05)) and excavation areas provide mitigating flood conveyance and provide compensatory flood storage. Excavation of the floodplain beneath the bridges increases flood storage and is needed to reduce predicted afflux.

Mitigation measures for residual impacts

The following design options will be investigated before construction of the project, to reduce the predicted afflux in those areas where afflux is forecast to be greater than the floodplain management objectives (refer to **Section 17.1.4**):

- **Increased bridge lengths:** This would provide increased conveyance and reduce the impact to floodplain storage by reducing the size of road embankments
- **Downstream channel works:** Minor modifications to the channel of Newports Creek downstream of the project could be considered in consultation with CHCC, to reduce predicted afflux
- **Additional storage areas:** Compensatory excavation of floodplain areas to mitigate the storage loss from embankments for the project. There is limited available area within the construction footprint and maintenance of free drainage of low-lying areas may be difficult
- **Cross-drainage:** Mitigation measures incorporated into the project would hold back flood waters upstream of the project (point of interest B), on heavily vegetated areas on land owned by Roads and Maritime. This would result in a decrease in the flood levels downstream of the project in the 1 per cent AEP flood event, improving flood conditions downstream of the project. Refinement of the cross-drainage design during detailed design could provide a better balance between holding water upstream of the project and managing downstream flood levels consistent with the floodplain management objectives in **Section 17.1.4**
- **Whole of government approach:** Through discussions with CHCC and DPIE (Environment, Energy and Science), a whole of government approach would be investigated which considers the relationship between the project and North Boambee Valley (West) URA and what reasonable and feasible options could be implemented to assist in managing potential flood impacts.

Investigation of the potential mitigation measures listed above would need to be carried out in consultation with CHCC and other relevant stakeholders.

Scour

Peak velocity difference maps are provided in **Appendix O, Flooding and hydrology assessment**. All culvert outlets and bridges would be designed with appropriate culvert outlet scour protection and treatments to dissipate high velocity flows. Scour protection and energy dissipation designs would be developed during detailed design to mitigate risks of erosion and bank stability because of high velocity flows.

The critical storm durations in the study area range from two-hour to nine-hour storms. The response of the catchments during an extreme flood event would therefore be rapid, with the resulting flood expected to pass relatively quickly meaning bridges would not be subject to prolonged flood discharges over the course of several days.

Potential impacts of the project on scour and flood velocity in the North Boambee Valley catchment include:

- The flow velocities upstream of proposed bridge structures DS12 (BR23), DS13 (BR04) and DS14 (BR05) would increase by about 0.8 m/s in the 1 per cent AEP flood event
- Flow velocities downstream of proposed culverts DS07, DS08 and DS20 would increase by 0.5 m/s in events above the 5 per cent AEP flood event
- There would be no significant peak velocity impacts and no notable adverse impacts to adjacent riparian vegetation would be expected.

Adequate revegetation and scour protection would be needed for the areas noted above where there is a predicted increase in flow velocities.

A waterway realignment is proposed within the North Boambee Valley floodplain (beneath DS13 (BR04) and DS14 (BR05)). Further detail is provided in **Section 17.6.8**.

Access

Potential flood impacts of the project on existing local and access roads in the North Boambee Valley catchment are summarised in **Table 17-11**. For this assessment, a road or access point is considered non-trafficable where there would be 100 mm or more water over the crest of the road or access point. There are some cases where there would be a minor increase or decrease in the depth of flooding with the project in place, however the predicted flood depth is greater than 100 mm. Despite a minor change in flood depth, access would be non-trafficable and would remain unchanged because there would be more than 100 mm over the road or access point.

Table 17-11 Potential flood impacts on existing and local roads in the North Boambee Valley catchment

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Description
		Existing immunity	Immunity with the project	
A	Lot 232 DP740659	<18% / 520	>1% / 0	Access would be improved with the project in place – to >1% AEP flood immunity.
B	Englands Road	<18% / 130	<18% / 130	No change to flood immunity. Note there would be a minor reduction in the time of inundation by 2 minutes from 1 hour 58 minutes to 2 hours.
D	Pacific Highway at Newports Creek	>1% / 0	>1% / 0	No change in flood immunity of the existing Pacific Highway.
W	Isles Drive	<18% / 570	<18% / 160	Access to Isles Drive would remain non-trafficable in the 18% AEP event, however the flood depth over Isles Drive would be lower (reduced to 160 mm) with the project in place.
X	Engineering Drive	2% / 110	2% / 110	No change in flood immunity with the project in place.

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Description
		Existing immunity	Immunity with the project	
Y	North Boambee Road[1]	<18% / 780	<18% / 780	No change in flood immunity with the project in place.
AA	Highlander Drive north	<18% / 540	<18% / 550	Access to Highlander Drive would remain non-trafficable in the 18% AEP event, however the flood depth would be 10 mm deeper with the project in place. Note there would be a minor reduction in the time of inundation.
AA	Glengyle Close	<18% / 510	<18% / 520	Access to Glengyle Close would remain non-trafficable in the 18% AEP event, however the flood depth would be 10 mm deeper with the project in place. Note there would be a minor reduction in the time of inundation.
Z	Lot 2 DP711234	<18% / 280	<18% / 280	No change in flood immunity with the project in place.
Z	Lot 100 DP1145073	<18% / 190	<18% / 200	Access would remain non-trafficable in the 18% AEP event, however the flood depth would be 10 mm deeper with the project in place.

*1 – Consultation with CHCC (refer to **Chapter 7, Consultation**) indicates North Boambee Road could be upgraded to improve its flood immunity. The project provides sufficient vertical clearance to North Boambee Road to enable it to be raised in the future.*

Table 17-11 demonstrates the project is not predicted to adversely impact currently flood affected access routes and no additional mitigation is required for access in the North Boambee Valley catchment.

Direction

There is minimal change to the direction of watercourses or the direction of flood flows because of the project, except for constriction into and expansion out of culverts and bridges needed for flood conveyance and constructed diversions.

Critical infrastructure

Flood impacts to critical infrastructure in the North Boambee Valley catchment are not expected because of the project. A summary is provided below:

- Bishop Druitt College: All buildings are outside the flood extents. A portion of the carpark and sporting fields are inundated under existing conditions and these are not expected to be impacted by the project. No change in flood immunity is anticipated
- Coffs Harbour GP Super Clinic: This critical infrastructure is located outside the flood extents for the North Boambee Valley catchment and is no change in flood immunity is anticipated because of the project.

Emergency management

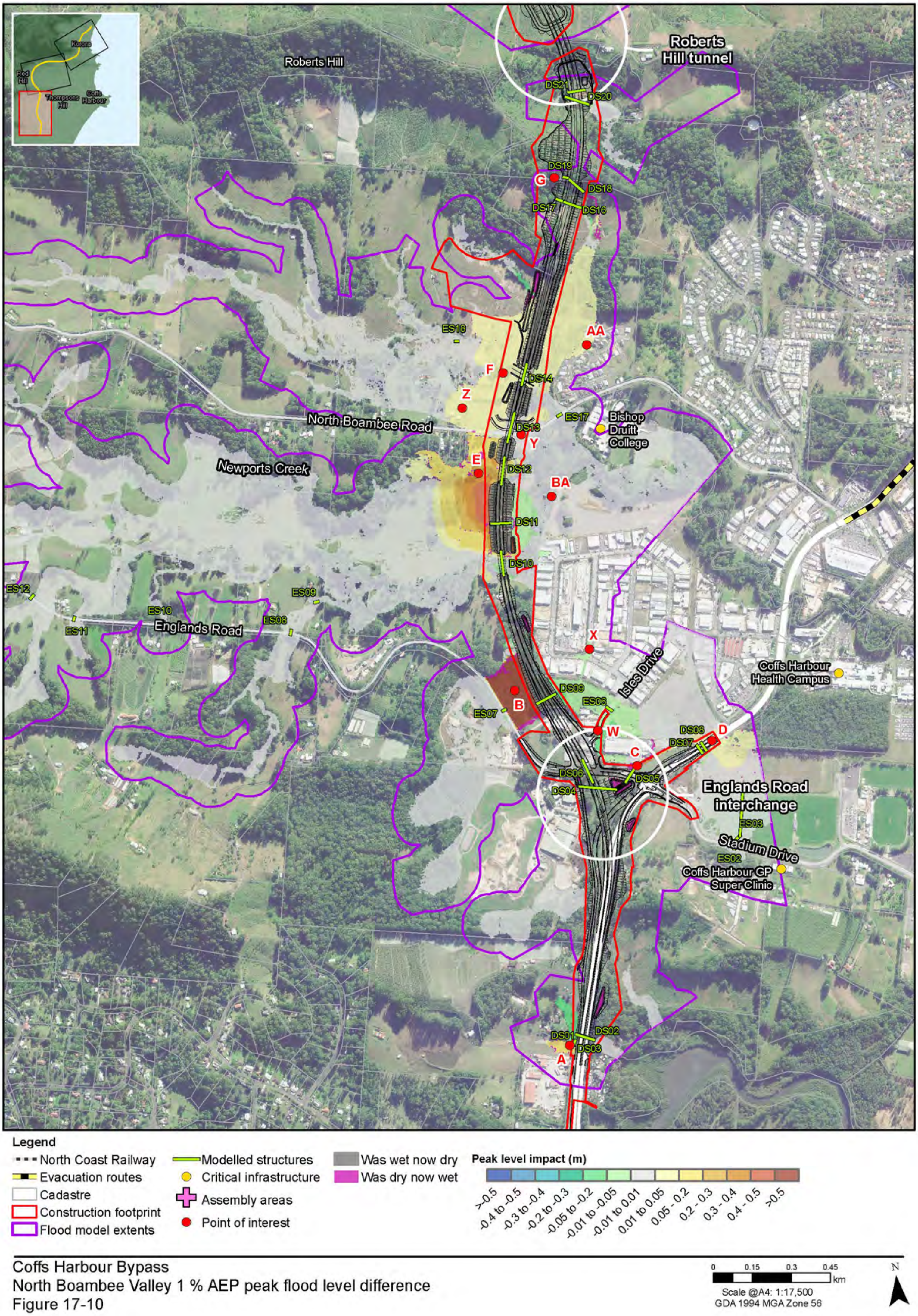
The existing flood emergency management plan (SES 2017) includes identified evacuation routes and assembly areas as illustrated in **Figure 17-10**. Peak flood level difference maps within **Appendix O, Flooding and hydrology assessment** indicates no adverse impact to these areas.

Consultation with SES and CHCC (refer to **Chapter 7, Consultation**) indicates flooding around Newports Creek and its tributaries, including areas adjacent to Coffs Harbour Health Campus are current flooding concerns. SES rely on an existing stream gauge adjacent to Isles Drive industrial area to monitor flood conditions.

Peak flood level difference maps provided in **Appendix O, Flooding and hydrology assessment** indicate no adverse impact to the identified evacuation routes and assembly areas surrounding the North Boambee Valley flood model. Access to the Coffs Harbour Health Campus from the south is maintained for events up to and including the 1 per cent AEP event.

The project provides additional routes and connections above predicted flood levels resulting in potentially more effective flood evacuation procedures. This includes improved access to the Coffs Harbour Health Campus from the north via the bypass (with the bypass accessed via the Coramba Road or Korora Hill interchanges), the Englands Road interchange and the section of the existing Pacific Highway north of the Englands Road interchange, for events up to and including the 1 per cent AEP event.

Consultation with SES and CHCC will be carried out during detailed design if there are any changes to the existing flood evacuation routes or associated roads which may be impacted during operation.



Coffs Harbour Bypass
North Boambee Valley 1 % AEP peak flood level difference
Figure 17-10

17.6.2 Coffs Creek

Assessment of the potential operational impacts of the project on flooding and hydrology in the Coffs Creek catchment against the design criteria and flooding objectives outlined in **Section 17.1.4** are outlined in the following sections.

Flood immunity of project infrastructure

The project was assessed against the flood immunity criteria and is shown in **Section 17.1.4**. The flood immunity outcomes of the project for Coffs Creek is summarised in **Table 17-12**.

Table 17-12 Flood immunity outcomes of the project for Coffs Creek catchment

Design Criteria	Performance against criteria
Flood immunity of 1% AEP for the highway targeted.	Flood immunity of the project is achieved within Coffs Creek catchment area.
Flood immunity of 5% AEP for ramps, service road and access road targeted.	Flood immunity of the project is achieved within Coffs Creek catchment area.
Tunnel portals above PMF or the 1% AEP flood level +0.5 m (whichever is the greater).	Roberts Hill, Shephards Lane and Gatelys Road tunnels meet the flood immunity criteria. Note the tunnels do not contain sag points where floodwaters would collect in the tunnels.
Waterway crossings – bridge soffits >0.5 m above 1% AEP flood level	All bridges in the Coffs Creek catchment have bridge soffits at least 0.5 m above the 1% AEP flood level. Bridge abutments would be located to minimise scour velocities and would be subject to refinement during detailed design.

Flood impact of the project

Assessment of the potential operational flooding hydrology impacts of the project in the Coffs Creek catchment against the floodplain management objectives outlined in **Section 17.1.4** is provided in the following sections. This includes an assessment of the following elements:

- Level
- Scour
- Access
- Direction
- Critical infrastructure
- Emergency management.

Key elements of the project relating to flooding and hydrology for Coffs Creek catchment which have been incorporated into the design of the project include:

- Optimising the bridge openings to achieve conveyance for low and high flow events, biodiversity objectives for fauna and constructability
- Appropriate sizing and positioning of longitudinal and transverse drainage culverts and channels
- Modification of the Bennetts Road detention basin and outlet arrangement. Excavation of the base of the Bennetts Road detention basin is proposed as part of this project to increase the storage of the basin by 26,600 m^3 while maintaining the existing low flow channel

- Mitigating adverse impacts by optimising the location of proposed water quality treatment basins to not impact on existing flow paths
- Provision of table drains and appropriate scour protection along either side of the project to capture flows and minimise the risk of adverse impacts on the existing waterway and bank stability.

Level

Peak flood levels for the 1 per cent AEP flood event in the Coffs Creek catchment are shown in **Figure 17-11** and potential impacts of the project in terms of flood levels for representative points of interest (POI) in the catchment are summarised in **Table 17-13**. Note the existing structures and design structures identified in **Figure 17-11** are labelled with the prefix ES and DS respectively. The design structures consist of bridges or culverts. Where a design structure is a bridge, the corresponding bridge number (refer to **Section 5.3.4** of **Chapter 5, Project description**) is included in the table below.

Bridges, culverts and additional flood storage (upstream of the project near Coramba Road and within the Bennetts Road detention basin) have been incorporated into the project to mitigate potential flood impacts.

All areas external to the project achieve required flood afflux criteria (as summarised in **Section 17.1.4**) except for Coffs Creek downstream of the Coramba Road interchange (points of interest I and AQ). This is because of impacts of the project on the outlet from the Bennetts Road detention basin and the increased pavement area resulting in more stormwater runoff entering the creek from the project.

Despite the mitigation works incorporated into the project (refer to **Table 17-13)**, downstream residential properties backing onto Coffs Creek (point of interest AQ) are predicted to experience peak flood level increases. It is unconfirmed if this predicted afflux would affect existing structures, as a finished floor level survey of these properties has not been conducted. A finished floor level survey of the properties identified at point of interest AQ will be carried out during detailed design to confirm whether predicted afflux would affect the existing structures.

Table 17-13 Predicted flood levels for the 1 per cent AEP flood event in the Coffs Creek catchment and potential impacts

POI	Potential flood impacts	Mitigation measures incorporated into the project
I	Predicted afflux in the 1% AEP flood event is 18 mm within the Bennetts Road detention basin because of the Coramba Road interchange immediately downstream of the basin and the impact this has on the outlet from the basin.	The basin outlet pipe has been extended to daylight (DS37), the spillway flows are routed through a proposed culvert (DS36) and the proposed bridges (DS32 to DS35 (bridges BR06, BR07 and BR08)) provide conveyance to Coffs Creek. Excavation of the basin floor is proposed to increase storage in the basin by about 26,600 m^3.
AQ	Predicted afflux in the 1% AEP flood event is 50 mm within Coffs Creek downstream of the project. The increase in flood level at this location is because of the increased area of impervious surfaces (the project pavement), resulting in additional stormwater runoff entering the creek.	Alignment drainage allows for a proportion of flood flows (10% AEP) to discharge at the various tributary crossings upstream of Coffs Creek to reduce the volume of stormwater runoff from the project, discharging directly to Coffs Creek. Excavation of the base of the Bennetts Road detention basin to increase the storage of the basin and balance the volume of flows downstream in Coffs Creek.

POI	Potential flood impacts	Mitigation measures incorporated into the project
J	The project extends into the existing Spagnolos Road detention basin, decreasing storage volume and attenuation effectiveness. Predicted afflux upstream of the project and the Spagnolos Road detention basin in the 1% AEP flood event would be greater than 500 mm. This afflux is contained to the heavily vegetated areas on land owned by Roads and Maritime. There would be a decrease in flood levels within the Spagnolos Road detention basin in the 1% AEP flood event.	The approach of attenuating flood flows upstream of the project via the proposed culvert (DS38) results in peak flood level reductions to the downstream areas.
M	Afflux of up to 400 mm during the 1% AEP flood event is predicted within the Treefern Creek area downstream of project near point of interest M. The concept design for the project includes measures to direct flows crossing the main carriageway (via a proposed culvert DS55) away from Mackays Road to improve local access and reduce potential scour effects. Afflux is contained to vegetated creek areas and the proposed design results in no adverse flood impact to access.	

Mitigation measures for residual impacts

The following design options will be investigated before construction of the project, to reduce the predicted afflux in those areas where afflux is forecast to be greater than the floodplain management objectives (refer to **Section 17.1.4**):

- **Main carriageway drainage:** The Coffs Creek crossing forms the longitudinal low point of the alignment between the Roberts Hill and Shephards Lane tunnels. The design of the main carriageway for the project in this area includes a drainage system which would collect stormwater from the main carriageway (up to the 10 per cent AEP event) and discharge the flows at the various tributary crossings north of Coramba Road interchange. For storm events greater than a 10 per cent AEP, stormwater collected on the main carriageway up to the 10 per cent AEP event flows would be collected in the drainage system, and the remaining flows would bypass the drainage system and discharge to Coffs Creek. Refinement of the drainage system to carry flows greater than the 10 per cent AEP event could reduce the total amount of runoff from the main carriageway entering Coffs Creek at Coramba Road interchange, and potentially reduce downstream impacts along Coffs Creek
- **Downstream channel works:** In the areas where afflux is predicted, modifications to the Coffs Creek channel may reduce potential impacts to adjacent properties and could be considered in consultation with CHCC. These works may however shift afflux further downstream and would impact existing established vegetation along the existing creek channel
- **Southern tributary:** The proposed culvert (DS27) could be modified to further hold back flood flows or a new detention storage could be included within the construction footprint to provide additional storage upstream of the project to reduce impacts downstream of the project and reduce flood levels at point of interest AQ
- **Cross-drainage:** The project as proposed would hold back flood waters upstream of the project (point of interest J), on heavily vegetated areas of land currently owned by Roads and Maritime.

This would cause the road formation to act as a detention basin and potentially result in a decrease in flood levels within the Spagnolos Road detention basin in the 1 per cent AEP flood event. While this would potentially improve flood conditions downstream of the project, there would be greater operational and management risks for the main carriageway as well as ongoing maintenance and management requirements for this location. Refinement of the cross-drainage design in this location will be carried out during detailed design in consultation with CHCC and DPIE (Environment, Energy and Science). Refinement of the cross-drainage design would aim to maintain the existing flooding / hydrological regime by providing a better balance between holding water upstream of the project and managing downstream flood levels consistent with the floodplain management objectives in **Section 17.1.4**

- **Local property mitigation:** There may be opportunities to carry out localised mitigation work on affected properties (point of interest AQ), including flood barriers / levees to protect existing structures and confine flows to the main channel. A finished floor level survey is required to confirm any adverse impacts to existing structures
- **Culvert duplication:** The culvert under Coramba Road (ES19) could be modified in consultation with CHCC to reduce the predicted afflux. Further investigation would be required to ensure afflux does not result further downstream.

Investigation of the potential mitigation measures listed above would need to be carried out in consultation with CHCC and other relevant stakeholders.

Scour

Peak velocity difference maps are provided in **Appendix O, Flooding and hydrology assessment**. All culvert outlets and bridges would be designed with appropriate culvert outlet scour protection and treatments to dissipate high velocity flows. Scour protection and energy dissipation designs would be developed during detailed design to mitigate risks of erosion and bank stability because of high velocity flows.

The critical storm durations in the study area range from one-hour to nine-hour storms. The response of the catchments during an extreme flood event would therefore be rapid, with the resulting flood expected to pass relatively quickly meaning bridges would not be subject to prolonged flood discharges over the course of several days.

Potential impacts of the project on scour and flood velocity in the Coffs Creek catchment include:

- Coffs Creek: Minor (up to +0.2 m/s) peak velocity increases are predicted within Coffs Creek downstream of Bennetts Road detention basin that may result in localised scour during peak events
- Treefern Creek: The proposed culvert (DS55), near point of interest M, redistributes flows away from Mackays Road and results in increased peak flood velocities (up to 0.5 m/s) in the vegetated area downstream of the project. Absolute velocities are still relatively low in the 18 per cent AEP flood event, increasing from 1.4 m/s in existing conditions to 2.1 m/s with the project in place
- Minor tributaries: Downstream of design culverts DS41 and DS61, increases of up to 0.3 m/s in events above the 5 per cent AEP are predicted.

There are no significant peak velocity impacts predicted and no notable adverse impacts to adjacent riparian vegetation are expected.

Adequate revegetation and scour protection would be needed for the areas noted above where there is a predicted increase in flow velocities.

Waterway realignments are proposed within the Coffs Creek catchment at Coffs Creek and in the upper reaches of Treefern Creek. Further detail is provided in **Section 17.6.8**.

Access

Potential flood impacts of the project on existing local and access roads in the Coffs Creek catchment are summarised in **Table 17-14**. For this assessment, a road or access point is considered non-trafficable where there would be 100 mm or more water over the crest of the road or access point. There are some cases where there would be a minor increase or decrease in the depth of flooding with the project in place, however the predicted flood depth is greater than 100 mm. Despite a minor change in flood depth, access would be non-trafficable and would remain unchanged because there would continue to be more than 100 mm over the road or access point.

Table 17-14 Potential flood impacts on existing and local roads in the Coffs Creek catchment

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Description
		Existing immunity	Immunity with the project	
AD	Lot 60 DP586574	<18% / 330	>1% / 50	Access would be improved with the project in place to >1% AEP flood immunity.
AD	Lot 730 DP1066743	<18% / 360	10% / 130	Access would be improved with the project in place to a 10% AEP event standard.
AE	William Sharp Drive west	<18% / 110	10% / 190	Access would be improved with the project in place to a 10% AEP event standard.
AF	Rosalee Close	<18% / 430	<18% / 410	Access to Rosalee Close would remain unchanged, with a reduction in flood depth of 20 mm with the project in place.
AK	Roselands Drive near Spagnolos Road	10% / 130	5% / 120	Access would be improved with the project in place to almost to a 5% AEP event standard.
AL	Roselands Drive near Barnet Street	5% / 140	5% / 110	Access to Roselands Drive would remain unchanged, with a reduction in flood depth of 30 mm with the project in place.
AM	Gillon Street	5% / 160	1% / 180	Access would be improved with the project in place to almost to a 1% AEP event standard.
AN	Polwarth Drive	<18% / 180	<18% / 160	Access would remain non-trafficable in the 18% AEP event and there would be a reduction in flood depth of 20 mm with the project in place. Note there would be a minor reduction in the time of inundation.
AG	Spagnolos Road	1% / 120	>1% / 20	Access would be improved with the project in place - to >1% AEP flood immunity.

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Description
		Existing immunity	Immunity with the project	
AI	Lot 5 DP1104404	<18% / 230	<18% / 210	Access would remain non-trafficable in the 18% AEP event and there would be a reduction in flood depth of 20 mm with the project in place. Note there would be a minor reduction in the time of inundation.
AH	Lot 102 DP1150637	<18% / 640	<18% / 600	Access would remain non-trafficable in the 18% AEP event and there would be a reduction in flood depth of 40 mm with the project in place. Note there would be a minor reduction in the time of inundation.
AJ	Lot 4 DP1157157	<18% / 590	<18% / 590	Access would remain unchanged.
M	Mackays Road Treefern Creek North	<18% / 520	<18% / 420	Access would remain non-trafficable in the 18% AEP event and there would be a reduction in flood depth of 100 mm with the project in place. Note there would be a minor reduction in the time of inundation.
AP	Mackays Road Treefern Creek South (Bray Street)	<18% / 260	<18% / 150	Access would remain non-trafficable in the 18% AEP event and there would be a reduction in flood depth of 110 mm with the project in place. Note there would be a minor increase in the time of inundation.

Table 17-14 demonstrates the project is not predicted to adversely impact currently flood affected access routes and in some cases, access is improved, no additional mitigation is required for access in the Coffs Creek catchment.

Direction

There is minimal change to the direction of watercourses or the direction of flood flows because of the project, except for constriction into and expansion out of culverts and bridges needed for flood conveyance and constructed diversions.

Critical infrastructure

Potential flood impacts of the project on critical infrastructure in the Coffs Creek catchment include:

- Baringa Private Hospital: A reduction in peak flood levels for all events except the PMF are predicted. A minor increase of 18 mm to a peak flood depth 954 mm is predicted in the PMF event with the project in place
- Cow & Koala Professional Child Care: Predicted to remain flood immune in flood events up to and including the 1 per cent AEP event. Peak flood levels are predicted to be lower, by 11 mm, in the PMF event.

Mitigation measures for residual impacts

The following measures will be investigated before construction of the project, to confirm potential impacts and reduce the predicted afflux if required:

- Additional survey data will be collected, including the existing culverts beneath the North Coast Railway, and incorporated into the flood models. Additional flood modelling will be carried out to confirm the potential impacts at Baringa Private Hospital
- If additional modelling indicates a potential impact at Baringa Private Hospital, finished floor level surveys will be carried out to confirm whether predicted afflux affects the existing structures. A finished floor level survey of the properties identified at point of interest R will be carried out during detailed design to confirm whether predicted afflux affects the existing structures. If required, there may be opportunities to incorporate additional mitigation measures within the construction footprint to reduce potential downstream impacts.

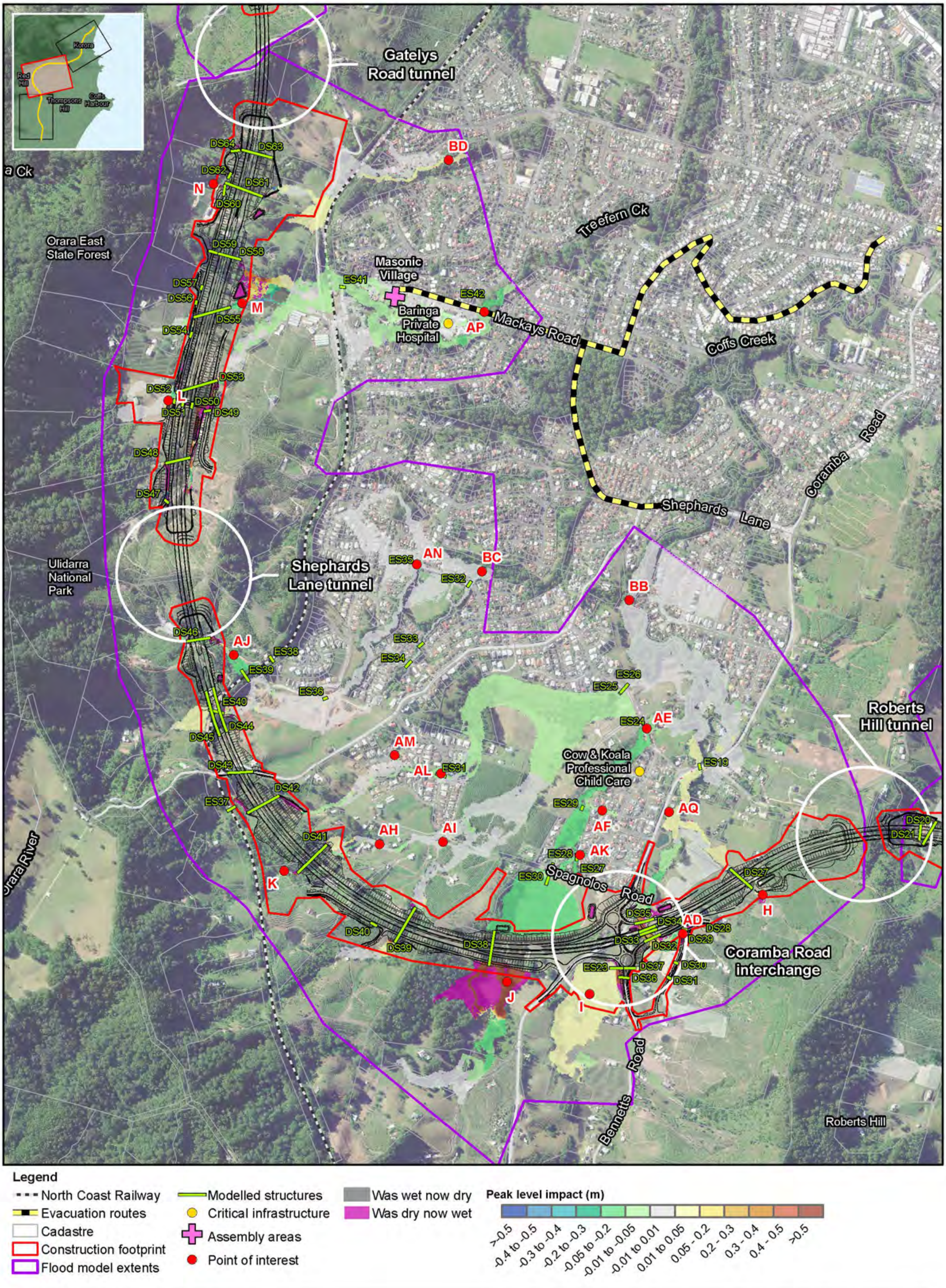
Investigation of the potential mitigation measures listed above would need to be carried out in consultation with CHCC, ARTC and other relevant stakeholders.

Emergency management

The existing flood emergency management plan (SES 2017) includes identified evacuation routes and assembly areas as illustrated in **Figure 17-11**. Peak flood level difference maps within **Appendix O, Flooding and hydrology assessment** indicate no adverse impact to these areas.

The project provides additional routes and connections above predicted flood levels resulting in potentially more effective flood evacuation procedures.

Consultation with SES and CHCC will be carried out during detailed design if there are any changes to the existing flood evacuation routes or associated roads which may be impacted during operation.



Coffs Harbour Bypass
Coffs Creek 1 % AEP peak flood level difference
Figure 17-11

17.6.3 Northern creeks

Assessment of the potential operational impacts of the project on flooding and hydrology in the northern creeks catchment against the design criteria and flooding objectives outlined in **Section 17.1.4** are outlined in the following sections.

Flood immunity of project infrastructure

The flood immunity outcomes of the project for the northern creeks is summarised in **Table 17-15**.

Table 17-15 Flood immunity outcomes of the project for the northern creeks

Design Criteria	Performance against criteria
Flood immunity of 1% AEP for the highway targeted.	Flood immunity of the project is achieved within the northern creeks catchment areas.
Flood immunity of 5% AEP for ramps, service road and access road targeted.	Flood immunity of the project is achieved within the northern creeks catchment area.
Tunnel portals above PMF or the 1% AEP flood level +0.5 m (whichever is the greater).	Gatelys Road tunnel meets the flood immunity criteria. Note the Gatelys Road tunnel does not contain a sag point where floodwaters would collect in the tunnel.
Waterway crossings – bridge soffits >0.5 m above 1% AEP flood level	All bridges in the northern creeks catchments have bridge soffits at least 0.5 m above the 1% AEP flood level. Bridge abutments would be located to minimise scour velocities and would be subject to refinement during detailed design.

Flood impact of the project

Assessment of the potential operational flooding hydrology impacts of the project in the northern creeks catchments against the floodplain management objectives outlined in **Section 17.1.4** is provided in the following sections. This includes an assessment of the following elements:

- Level
- Scour
- Access
- Direction
- Critical infrastructure
- Emergency management.

Key elements of the project relating to flooding and hydrology for northern creeks catchments which have been incorporated into the design of the project include:

- Optimising the bridge openings to achieve conveyance for low and high flow events as well as for biodiversity objectives for fauna
- Appropriate sizing and positioning of cross drainage culverts
- Managing overland flows from small steep upstream catchments to achieve the flood immunity objectives of the project within an urbanised environment
- Ensuring any increased stormwater runoff from the project did not adversely impact flood levels downstream of the project

- Mitigating adverse impacts by optimising the location of water quality treatment basins to not impact on existing flow paths
- Provision of table drains and appropriate scour protection to capture flows and minimise the risk of adverse impacts on the existing waterway and bank stability
- Design coordination and optimisation to ensure that the Korora Hill interchange road runoff catchments would be captured and outlet to manage downstream impacts.

Level

Peak flood levels for the 1 per cent AEP flood event in the northern creeks catchments are shown in **Figure 17-12** and potential impacts of the project in terms of flood levels for representative points of interest (POI) in the catchment are summarised in **Table 17-16**. Note the existing structures and design structures identified in **Figure 17-12** are labelled with the prefix ES and DS respectively. The design structures consist of bridges or culverts. Where a design structure is a bridge, the corresponding bridge number (refer to **Section 5.3.4** of **Chapter 5, Project description**) is included in the table below.

Bridges and culverts have been incorporated into the project to mitigate potential flood impacts.

All areas external to the project achieve required flood afflux criteria (as summarised in **Section 17.1.4**) except for the following locations:

- Pacific Bay Eastern Lands (point of interest BI), where afflux up to 100 mm is predicted on lots proposed as part of the approved development in the 1 per cent AEP event
- Russ Hammond Close/James Small Drive (near point of interest R), where afflux up to 200 mm is predicted in the heavily vegetated creek areas in the 1 per cent AEP event. Afflux would be contained to the existing flood inundation extents downstream of the project near point of interest R
- Campbell Close Korora (point of interest U), where afflux up to 200 mm is predicted in the areas adjacent to the unnamed tributary that drains to Sapphire Beach in the 1 per cent AEP event
- Nautilus Villas (point of interest V), where up to 11 mm of afflux is predicted to the downstream area of the Nautilus Villas, and 28 mm of afflux is predicted on three residential properties adjacent to the waterway in the 1 per cent AEP event.

Table 17-16 Predicted flood levels for the 1 per cent AEP flood event in the northern creeks catchments and potential impacts

POI	Potential flood impacts	Mitigation measures incorporated into the project
P	Existing access to Lot 19 DP771618 via Bruxner Park Road is proposed to be provided via West Korora Road with a new connection provided across Jordans Creek. Predicted afflux in the 1% AEP flood event is 1200 mm within Jordans Creek next to the proposed access crossing.	Afflux is contained to vegetated creek areas and proposed culverts (DS71 and DS72) provide no adverse flood impact. Refer to **Table 17-17** for assessment of impacts on property access.
Q	The Korora Hill interchange results in the removal of the Bruxner Park Road intersection detention, increased road runoff and redistribution of flood flows to the downstream Pacific Bay Resort. Predicted afflux in the 1% AEP flood event is up to 200 mm within the vegetated creek and lakes, golf course and carpark areas.	Afflux is generally contained to non-adverse areas with no adverse flood impact to Resort Drive.

POI	Potential flood impacts	Mitigation measures incorporated into the project
BI	Increased runoff is predicted within the approved development area of Pacific Bay Eastern Lands from the interchange at Korora Hill. Predicted afflux in the 1% AEP flood event is up to 100 mm on Lot 14 of the approved development. New flow paths are predicted through Lots 14 to 16 and Lots 18 to 21 with depths of 30 mm and 50 mm respectively in the 1% AEP flood event. Previous consultation with the proponent of the Pacific Bay Eastern Lands during preparation of the EIS has indicated that the future proposals are also being investigated within the area subject to flooding impact.	
R	The project reconfigures the existing Pacific Highway Pine Brush Creek crossings (ES71) including additional bridges and embankment work. Predicted afflux in the 1% AEP flood event is up to 200 mm and 70 mm over upstream and downstream heavily vegetated creek areas. No adverse flood impact is predicted to the existing Old Coast Road (ES69 and ES72) or James Small Drive (ES74) bridges.	Proposed bridges (DS85 (BR21)) have been sized to ensure adequate flood conveyance.
T	The Opal Boulevard access has been reconfigured, resulting in a modified flood distribution. Localised afflux of up to 300 mm is predicted in the 1% AEP event immediately upstream and downstream of the Opal Boulevard crossing of Pine Brush Creek.	Proposed roadside channels generally provide conveyance of upstream flood flows to the main creek channel. Afflux is contained to the vegetated creek areas with no adverse flood impact to Opal Boulevard flood access.
U	The proposed water quality basins extend into the waterway of the main Sapphire Beach tributary, resulting in localised afflux of up to 200 mm over vegetated areas of a residential property located on Campbell Close, Korora. Existing buildings are not affected.	
V	The project tie-in is predicted to result in up to 11 mm of afflux to the downstream area of Nautilus Villas. Greater peak level impacts of up 28 mm are predicted on three residential properties immediately adjacent to the waterway.	

Mitigation measures for residual impacts

The following design options will be investigated before construction of the project, to reduce the predicted afflux in those areas where afflux is forecast to be greater than the floodplain management objectives (refer to **Section 17.1.4**):

- **Pacific Bay Eastern Lands (point of interest BI):** There are opportunities to reduce potential impacts through further refinement of cross-drainage culverts and by raising the height of the approved residential development area to avoid inundation in the 1 per cent AEP event.

Consultation with the proponent of Pacific Bay Eastern Lands development will be carried out during detailed design to develop a reasonable and feasible design solution to mitigate flood impacts on the approved residential areas and the main resort building. Consultation will also consider future proposals that are being investigated.

- **Russ Hammond Close/James Small Drive (near point of interest R):** Afflux would be contained to the existing flood inundation extents downstream of the project near point of interest R. A finished floor level survey of the properties identified at point of interest R will be carried out during detailed design to confirm whether predicted afflux affects the existing structures. If required, there may be opportunities to carry out localised mitigation work over affected properties, including flood barriers / levees to protect existing structures and confine flows to the main channel. The final mitigation measures would be developed in consultation with the individual property owners
- **Campbell Close, Korora (point of interest U):** Investigate opportunities to reduce the size of the water quality basins (or change to a proprietary spill capture unit) adjacent to the waterway next to the residential properties to reduce potential flooding impacts. Note existing buildings are not adversely impacted
- **Nautilus Villas (point of interest V):** Further investigation will be conducted to improve the accuracy of the model during detailed design stage. Detailed terrain survey will be carried out during detailed design to confirm impacts. Properties adjacent to the waterway will have a finished floor level survey carried out during detailed design to determine if existing buildings are adversely impacted. If required, there may be opportunities to carry out localised mitigation work over affected properties, including flood barriers / levees to protect existing structures and confine flows to the main channel.

Investigation of the potential mitigation measures listed above would need to be carried out in consultation with CHCC and other relevant stakeholders.

Scour

Peak velocity difference maps are provided in **Appendix O, Flooding and hydrology assessment**. All culvert outlets and bridges would be designed with appropriate culvert outlet scour protection and treatments to dissipate high velocity flows. Scour protection and energy dissipation designs would be developed during detailed design to mitigate risks of erosion and bank stability because of high velocity flows.

The critical storm durations in the study area range from one-hour to two-hour storms. The response of the catchments during an extreme flood event would therefore be rapid, with the resulting flood expected to pass relatively quickly meaning bridges would not be subject to prolonged flood discharges over the course of several days.

Potential impacts of the project on scour and flood velocity in the northern creeks catchments include:

- Pacific Bay Resort Golf Course: Minor (up to +0.2 m/s) peak velocity increases are predicted within the current course flow-paths and lakes. Increases are generally limited to existing vegetated creeks and paved areas, except the new flow path downstream of ES57, subject to predicted velocities of around 0.5 and 0.7 m/s in the 18 and 1 per cent AEP events respectively
- Pacific Bay Eastern Lands (POI: BI): There are minor predicted increases in peak velocity on Lot 14 in the 1 per cent AEP of up to 0.2 m/s. Increases were also observed in the PMF event of up to 0.3 m/s on Lots 14-22.
- Localised velocity increases were also predicted downstream of design culverts DS70, DS71 and DS72 of up to 0.5 m/s in events above the 5 per cent AEP.

All culverts, including those mentioned above would be designed with appropriate outlet scour protection and velocity dissipation during detailed design.

Access

Potential flood impacts of the project on existing local and access roads in the northern creeks catchments are summarised in **Table 17-17**. For this assessment, a road or access point is considered non-trafficable where there would be 100 mm or more water over the crest of the road or access point. There are some cases where there would be a minor increase or decrease in the depth of flooding with the project in place, however the predicted flood depth is greater than 100 mm. Despite a minor change in flood depth, access would be non-trafficable and would remain unchanged because there would be more than 100 mm over the road or access point.

The proposed reconfiguration of all local roads and driveways affected by the project results in no adverse impact to access during flood events for most properties. The exceptions to this are for Lot 1 DP527497 (point of interest S) and Lot 19 DP771618 (point of interest P), the predicted flood increase to Opal Boulevard (point of interest T), and the predicted flood increases at the southern end of James Small Drive (point of interest AZ).

These access roads and driveways are proposed to be upgraded by the project. Detailed design will be developed so there is no flood access impact.

Table 17-17 Potential flood impacts on existing and local roads in the northern creeks catchments

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Description
		Existing immunity	Immunity with the project	
AR	West Korora Road, Jordans Creek^	<18% / 1020	<18% / 1380	The project is predicted to increase flooding (360 mm) over West Korora Road, which currently closes during the 18% AEP event with an existing peak depth of 1020 mm. Note the existing West Korora Road and existing Pacific Highway intersection is affected by the 18% AEP event (refer to POI AS) in the existing and developed, however there would be no increase in flood depth.
AX/P	Lot 19 DP771618	>1% / 58	5% / 190^	Local access to Lot 19 DP771618 has been reduced. Existing access via Bruxner Park Road would not be affected by the 1% AEP event. With the project in place and access via West Korora Road, the local access would be overtopped in 5% AEP event flood conditions by 190 mm. New culverts have been incorporated into the design to reduce the extent of afflux at this location.
AS	Pacific Highway, Jordans Creek	<18% / 590	<18% / 590	Access would remain unchanged with the project in place.
AY	Bruxner Park Road	<18% / 130	<18% / 110	Access would remain non-trafficable in the 18% AEP event and there would be a reduction in flood depth of 20 mm with the project in place.

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Description
		Existing immunity	Immunity with the project	
AZ	James Small Drive	>1% / 75	<18% / 130	Local access via James Small Drive has been lowered and would now overtop by greater than 100 mm in 18% AEP event flood conditions by 130 mm. Note James Small Drive is predicted to have water on the road at this location in events up to the 1% AEP event in the existing case, however it is less than 100 mm, and as such the road is considered accessible.
Q	Resort Drive	<18% / 580	<18% / 580	Access would remain unchanged with the project in place.
AU	Langley Close	<18% / 680	<18% / 670	Access would remain non-trafficable in the 18% AEP event and there would be a reduction in flood depth of 10 mm with the project in place.
AT	Driftwood Court	<18% / 760	<18% / 760	Access would remain unchanged with the project in place.
AU	Cutter Drive	<18% / 520	<18% / 510	Access would remain non-trafficable in the 18% AEP event and there would be a reduction in flood depth of 10 mm with the project in place.
AT	Firman Drive	<18% / 830	< 18% / 820	Access would remain non-trafficable in the 18% AEP event and there would be a reduction in flood depth of 10 mm with the project in place.
AZ	Ballantine Drive	>1% / 22	>1% / 49	Access would remain unchanged, with an increase in flood depth of 27 mm with the project in place.
R	Old Coast Road, Pine Brush Creek	10% / 130	10% / 140	Access would remain non-trafficable in the 10% AEP event and there would be an increase in flood depth of 10 mm with the project in place.
T	Opal Boulevard	5% / 110	10% / 100	Existing flood immunity of Opal Boulevard would be reduced to 10% AEP flood event.
S	Lot 1 DP270147	<18% / 130	10% / 120	Local access to Lot 1 DP270147 would be improved and would overtop in the 10% AEP flood event with a flood depth of 120 mm.

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Description
		Existing immunity	Immunity with the project	
S	Lot 100 DP1112799	<18% / 170	>1% / 27	Local access to Lot 100 DP1112799 would be improved and would overtop in 1% AEP flood event flood, however is considered accessible as the depth of water is less than 100 mm.
S	Lot 1 DP527497	>1% / 37	<18% / 220	Flood immunity of local access to Lot 1 DP527497 would be reduced and would overtop in 18% AEP flood conditions by 220 mm.
V	Ocean Dream	<18% / 510	<18% / 520	Access would remain non-trafficable in the 18% AEP event and there would be an increase in flood depth of 10 mm with the project in place.

^ The Pacific Highway / West Korora Road intersection is affected by the existing 18 per cent AEP flood event, which also affects access at this location

Mitigation measures for residual impacts

The following design options will be investigated before construction of the project, to reduce the potential impacts on access in those areas where access is impacted by the project (refer to **Section 17.1.4**):

- **Reconfiguration of property access:** There are opportunities to reconfigure access to properties near point of interest S to reduce potential impacts on access during flood events
- **Alternative property access design:** There are opportunities to provide alternative property access locations for the property affected by flooding at point of interest P, instead of providing access via West Korora Road, to reduce impacts on access during flood events. This would be investigated in consultation with the property owner
- **Flood increases to Opal Boulevard (point of interest T):** The predicted increases are the result of the proposed adjacent drainage channels overtopping and extending longitudinally down the road shoulder. Detailed design of these channels will be developed to contain upstream flows to achieve no adverse flood access impact
- **Refinement of drainage design:** There are opportunities to reduce flood impacts at point of interest AZ through refinement of the drainage design, to reduce impacts on access to the southern end of James Small Drive during flood events.

Investigation of the potential mitigation measures listed above would need to be carried out in consultation with CHCC and other relevant stakeholders.

Direction

There is minimal change to the direction of watercourses or the direction of flood flows because of the project, except for constriction into and expansion out of culverts and bridges needed for flood conveyance and constructed diversions.

Critical infrastructure

Critical infrastructure in the northern creeks catchments comprises the Kororo Public School and the Coffs Harbour Montessori Preschool, both of which are outside the flood model extents. As such, there are no anticipated flooding and hydrology impacts.

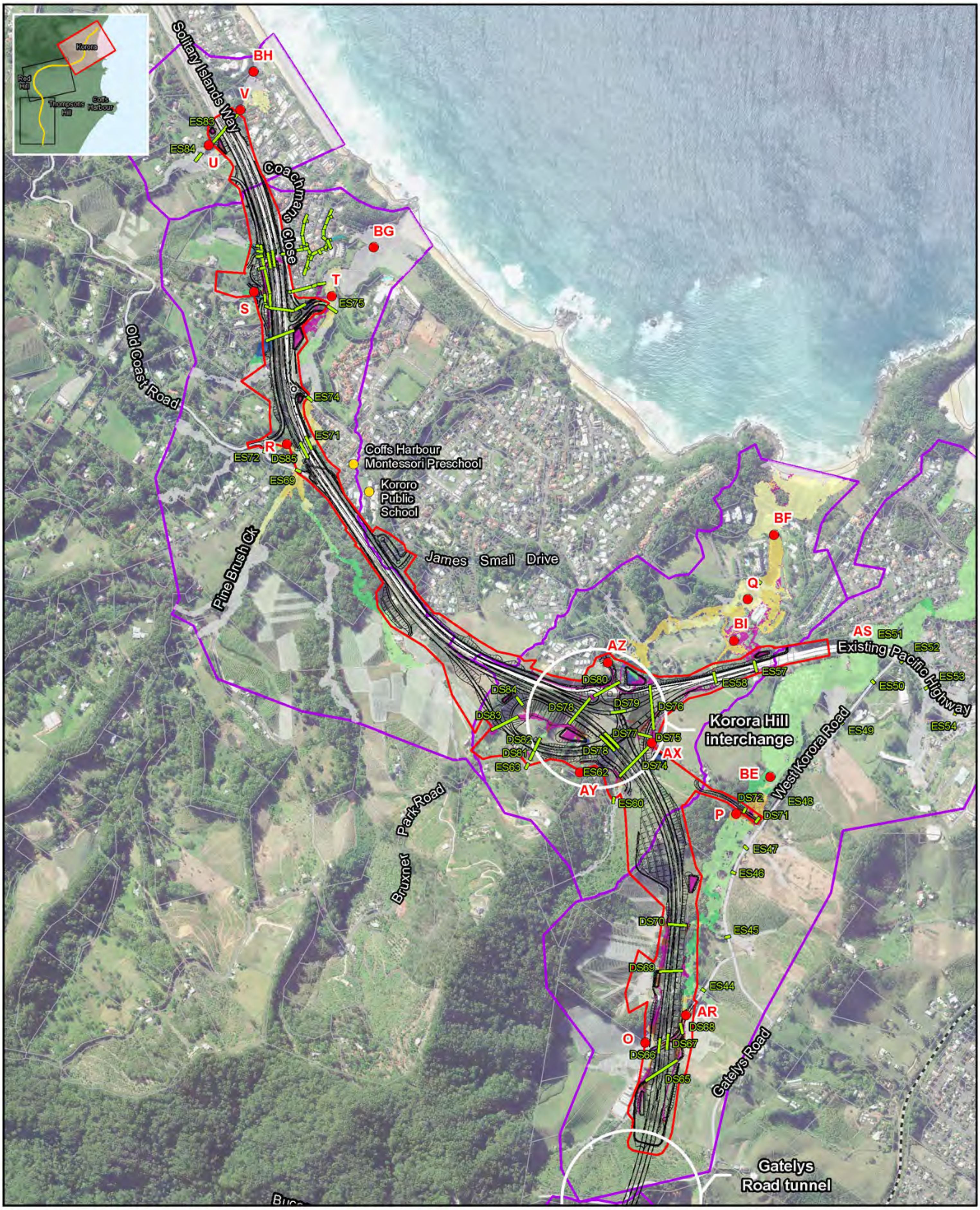
Note the proposed Kororo Public School bus interchange is located adjacent to and to the east of the Pine Brush Creek catchment. It is located at the top of the catchment and as such a flood model has not been developed to assess the potential flooding impacts from construction of the bus interchange. The assessment indicates there would not be an appreciable impact on characteristics because of the project - refer to **Appendix O, Flooding and hydrology assessment** for the assessment of this location.

Emergency management

The existing flood emergency management plan (SES 2017) includes identified evacuation routes and assembly areas as shown in **Figure 17-12**. Peak flood level difference maps within **Appendix O, Flooding and hydrology assessment** indicate no adverse impact to these areas.

The project would provide additional routes and connections above predicted flood levels resulting in potentially more effective flood evacuation procedures.

Consultation with SES and CHCC will be carried out during detailed design if there are any changes to the existing flood evacuation routes or associated roads which may be impacted during operation.



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical infrastructure
- Assembly areas
- Point of interest
- Was wet now dry
- Was dry now wet

Peak level impact (m)

>0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Northern Creeks 1 % AEP peak flood level difference
Figure 17-12

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

17.6.4 Boambee Newports Creek Floodplain Risk Management Plan

Floodplain management measures within the Boambee Newports Creek Floodplain Risk Management Plan (GHD 2016) relevant to the project, are consistent with the outcomes of the project. The plan states that Council is in the process of drafting a development control plan to provide detailed flood planning controls for the Boambee Newports Creek floodplain. This includes a high priority to reduce flooding on the approaches to the Coffs Harbour Health Campus. The project is consistent with the plan as it does not impact flood immunity of the existing Pacific Highway approach to the Coffs Harbour Health Campus and the project would provide an alternative route to the Coffs Harbour Health Campus via the Coramba Road interchange.

17.6.5 Coffs Creek Floodplain Risk Management Plan

The project is consistent with the recommended floodplain management measures within the Coffs Creek Floodplain Risk Management Plan (Bewsher Consulting Pty Ltd. 2005). All four detention basins have been incorporated in the hydraulic models used as part of this assessment. The project would generally provide attenuation upstream, providing the opportunity to balance existing flows and flows from the project to reduce the potential impacts to downstream urban areas.

The project is generally predicted to have a positive impact to the existing flood detention basins, modifying the peak 1 per cent AEP flood level as below:

- 60 mm reduction in level of Spagnolos Road detention basin
- 30 mm reduction in level of Bakers Road detention basin
- No change of Shephards Lane detention basin
- 18 mm increase in level of Bennetts Road detention basin (refer to **Section 17.6.2**).

17.6.6 Flood hazard impacts

Flood hazard maps for the existing case flooding can be found in **Appendix O, Flooding and hydrology assessment**. Under current conditions areas of high hazard are typically confined to existing waterways and detention basins. The project has a very limited impact on hazard behaviour. Changes to hazard categorisation are highly localised and limited to locations where new drainage channels and culvert outlets are proposed. Appropriate culvert outlet scour protection and velocity dissipation design would be considered during detailed design to mitigate any risks of erosion and bank stability at these locations.

Hazard levels have been adversely impacted upstream of the existing Spagnolos Road detention basin (near point of interest J). Under current conditions, the existing Spagnolos Road detention basin provides a level of flood storage. With the project in place this flood storage would be reduced.

The project as proposed would hold back flood waters upstream of the project (point of interest J), on heavily vegetated areas on land currently owned by Roads and Maritime. This would cause the road formation to act as a detention basin and potentially result in a decrease in flood levels within the Spagnolos Road detention basin in the 1 per cent AEP flood event. While this would potentially improve flood conditions downstream of the project, there would be greater operational and management risks for the main carriageway as well as ongoing maintenance and management requirements for this location. Refinement of the cross-drainage design in this location will be carried out during detailed design in consultation with CHCC and DPIE (Environment, Energy and Science). Refinement of the cross-drainage design would aim to maintain the existing flooding / hydrological regime by providing a better balance between holding water upstream of the project and managing downstream flood levels consistent with the floodplain management objectives in **Section 17.1.4**.

17.6.7 Social and economic costs to community

The project includes mitigation and management measures to minimise short and long-term impacts from flooding including consideration for future climate conditions (see **Section 17.6.9**). In many areas, the project would reduce peak water levels downstream.

The project would improve transport efficiency of the existing Pacific Highway through Coffs Harbour, relieve congestion on the wider Coffs Harbour road network and provide an alternative route for some local trips. The project would provide a route which is above 1 per cent AEP flood level from the north of Coffs Harbour to the south of Coffs Harbour, with additional access points for local traffic to access this flood free route (eg via Coramba Road interchange). There would be significant economic benefits from increasing the reliability of a major national freight route such as the Pacific Highway. The project would also improve the local emergency management procedures during storm events, reducing the social and economic impact of flooding to the local community.

There are several affected properties (refer to **Section 17.6.1**, **Section 17.6.2** and **Section 17.6.3**) that are predicted to have design event peak flood level increases around buildings. Actual flood damages may occur if the project results in inundation above the finished floor level where it did not occur previously. Finished floor levels of these properties will be surveyed to determine potential actionable damage and impacts would be mitigated, wherever possible, through further design refinement during detailed design.

17.6.8 Stability of riverbanks and watercourses

The project has been designed to minimise impacts on waterways. However, there is the potential that several waterways may be subject to realignment or adjustment as part of the project.

Proposed permanent waterway realignments and adjustments for the project are discussed in detail in **Chapter 5, Project description** and include:

- Minor realignment of the meandering Newports Creek as it passes beneath the project
- Realignment of a northern tributary of Newports Creek as it passes beneath the project north of North Boambee Road. This realignment is part of proposed flood mitigation design described for point of interest F in **Section 17.6.1**
- Minor realignment of the northern tributary of Newports Creek (about 400 m north of North Boambee Road and about 150 m north of BR05) as it passes beneath the project
- Extension of the existing culvert under Bennetts Road and realignment of Coffs Creek where the project crosses the creek south of Coramba Road
- The upper reaches of Treefern Creek would be replaced with longitudinal catch drains and cross drains where the creek is impacted by the project
- Realignment and temporary work within Pine Brush Creek would be required between the new bridge over Pine Brush Creek (BR20) and the existing bridge over Old Coast Road. In addition to the realignment of the main channel, minor realignment of the northern tributary of Pine Brush Creek immediately upstream the new bridge would also be required.

The differences in flood conditions between the existing and developed case shown in **Table 17-7** indicates there would be limited change in peak flood conditions at these waterway crossings. The exception is at BR23 over Newports Creek where there is a 230 mm flood level increase and a 0.37 m/s increase in peak flood velocity.

Potential impacts from increases in flow velocities include scour, undermining of banks, associated riparian corridor impacts, potential reduction in water quality as sediments become mobilised. Potential water quality impacts are discussed further in **Chapter 19, Surface water quality**.

Adequate revegetation and scour protection would be needed in areas where there is a predicted increase in flow velocities which are likely to cause scour. Scour protection and energy dissipation designs will be developed during detailed design to mitigate risks of erosion and bank instability.

The above waterway realignments and adjustments will be designed to behave in a similar hydrologic and geomorphic manner as existing conditions and will consider the requirements of the Policy and Guidelines for Fish Habitat Conservation and Management (Department of Primary Industries (DPI) 2013). Revegetation and adequate scour protection would be provided so there are no hydraulic impacts on bed and bank stability, erosion, sedimentation or riparian vegetation in accordance with the Guidelines for instream works on waterfront land (DPI 2012a). Regular inspection of the waterways for any potential erosion and scour that may occur, will be carried out during the initial establishment period after realignment or adjustment.

Detailed design of waterway realignments and adjustments would be developed in consultation with DPIE (Regions, Industry, Agriculture and Resources) and will consider:

- Investigation of opportunities to reduce or avoid waterway realignments to maintain existing creek alignments including locating piers outside of the waterway
- Retention of existing riparian vegetation where possible, including retention of tree stumps where trees are removed
- Maintaining existing waterway lengths, velocities and hydraulic grades
- Use of soft engineering approaches to scour protection where landscaping is provided over the rock scour
- Maintaining fish passage in accordance with the waterway classification and DPIE guideline Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (Fairfull & Witheridge 2003).

In addition to potential impacts from waterway realignments and adjustments, the project's transverse drainage could also impact the stability of banks and watercourses downstream. However, culverts would be designed to generally follow the existing waterway alignment to minimise potential for bank erosion, which in some cases results in the culverts being set on a skewed alignment to the project.

17.6.9 Climate change effects on the project

Rainfall and sea level are the two predominant factors which determine the degree and severity of flood events. Climate change has the potential to significantly influence both factors by increasing sea levels and causing an increase in the severity of extreme weather events.

The Practical Consideration of Climate Change – Floodplain Risk Management Guideline (DECC 2007) prescribes indicative changes in extreme rainfall, which are sourced from the CSIRO report for Climate Change in NSW Catchments (CSIRO, 2007). The CSIRO 2007 report has been superseded by the Climate Change in Australia - Projections for Australia's Natural Resource Management Regions: East Coast Cluster Report (CSIRO & BoM 2015), which has been referenced for the climate change effects on the project.

The CSIRO predicts average rainfall would decrease and that wet years would become less frequent. Despite this they also predict, with high confidence, that intense rainfall events would become more frequent and extreme while the magnitude of the increases cannot be confidently projected (CSIRO & BoM 2015). In conjunction with sea level rise, the sensitivity assessment was undertaken to include a 10 per cent and 30 per cent increase in rainfall for 2050 and 2100 scenarios:

- 2050 climate: 0.4 m sea level rise and 10 per cent increase in rainfall intensity
- 2100 climate: 0.9 m sea level rise and 30 per cent increase in rainfall intensity.

The 1 per cent AEP event was used as the basis for the sensitivity assessment with impacts compared to the baseline and proposed project scenarios.

Using these scenarios, the following assessments were conducted:

- Predicted impact of the project during climate change events (ie developed compared to existing scenario under climate change events)
- Predicted climate change impact to the project (ie developed comparison of current to future climate conditions) (refer **Appendix O, Flooding and hydrology assessment**).

Appendix O, Flooding and hydrology assessment includes peak flood level and velocity impact of the project under future climate predictions. The potential increase in storm intensities generally result in peak flood level increases upstream and decreases downstream, because of the projects position within each catchment and that the proposed transverse drainage structures have been sized based on the current climate intensities.

The exception to this is at the Korora Hill interchange and downstream at the Pacific Bay Eastern Lands. Increased peak flood levels are predicted downstream of the project at this location because of reduced stormwater detention currently provided by the existing Pacific Highway and Bruxner Park Road intersection, and an increase in stormwater runoff because of an increase in pavement area. However, the predicted climate change afflux does not extend to any additional buildings.

North Boambee Valley

Impact of the project

The peak flood level and velocity impacts in the North Boambee Valley catchment for the 2050 and 2100 climate change scenarios are shown in **Appendix O, Flooding and hydrology assessment**.

Afflux because of the project under 2050 and 2100 climate change scenarios for the 1 per cent AEP event in North Boambee Valley would be similar to afflux predicted under current climate conditions. An increase in peak water levels is predicted in the 2100 climate change scenario west of point of interest B and south of ES17. The impact occurs at a location where no peak water level impact was predicted under current climate conditions. Note the increase is contained within the existing extent of inundation within the existing waterway and open pasture / grass land.

Hazard classification for the climate scenarios generally remains the same as the 1 per cent AEP event under current climate conditions, except for increases in high hazard areas upstream of the project (see POI: B and POI: E).

Impact to the project

Flood immunity of the project does not change under the climate change scenarios, with the main carriageway remaining trafficable in the 1 per cent AEP event in the 2050 and 2100 climate scenarios within the North Boambee Valley catchment.

Coffs Creek

Impact of the project

The peak flood level and velocity impacts in the Coffs Creek catchment for the 2050 and 2100 climate change scenarios are shown in **Appendix O, Flooding and hydrology assessment**.

Afflux because of the project under 2050 and 2100 climate change scenarios for the 1 per cent AEP event in Coffs Creek catchment are predicted to provide improvements to conditions downstream of the project. In many areas the project would either prevent inundation for the 1 per cent AEP event or decrease the peak water level. A reduction in peak water level of up to 400 mm is predicted at point of interest BB under the 2100 climate change scenario.

Peak flood level increases are generally predicted upstream of the project, with an afflux pattern consistent with the afflux pattern for the current climate scenarios.

An increase in peak water level of up to 15 mm and 23 mm is predicted around the Baringa Private Hospital in the 2050 and 2100 climate change scenarios respectively.

Hazard classifications for both 2050 and 2100 climate scenarios remain generally the same as the current climate scenarios, except for an increase in high hazard upstream of point of interest J. This high hazard area is located within vegetated and open pasture area west and north of the Coramba Road interchange.

Impact to the project

Flood immunity of the project does not change under the climate change scenarios, with the main carriageway remaining trafficable in the 1 per cent AEP event in the 2050 and 2100 climate scenarios within the Coffs Creek catchment.

Northern creeks

Impact of the project

The peak flood level and velocity impacts in the northern creeks catchments for the 2050 and 2100 climate change scenarios are shown in **Appendix O, Flooding and hydrology assessment**. The following impacts of the project are predicted for the climate change scenarios

- The peak water level is predicted to increase by about 70 mm and 170 mm downstream of point of interest AZ for the 2050 and 2100 climate change scenarios respectively. Note the predicted flood depth at this location without the project is 1700 mm and 1800 mm for the 2050 and 2100 climate change scenarios respectively and there are no predicted increases in extent of inundation downstream
- The peak water level is predicted to increase by about 30 mm and 60 mm downstream at point of interest Q around the golf course conference centre for the 2050 and 2100 climate change scenarios respectively
- The peak water level is predicted to increase by about 30 mm and 80 mm on proposed lots 14 -16 and lots 18-21 of the Pacific Bay Eastern Lands development (see point of interest BI) for the 2050 and 2100 future climate scenarios respectively.

Hazard in the future climate scenarios follows the same pattern as the 1 per cent AEP in both with the project and without the project scenarios.

Impact to the project

Flood immunity of the project does not change under the climate change scenarios, with the main carriageway remaining trafficable in the 1 per cent AEP event in the 2050 and 2100 climate scenarios within the northern creeks catchments.

17.7 Environmental management measures

Environmental management measures to mitigate the risk of flood impacts during detailed design, construction and operation of the project, to the surrounding infrastructure, people and the environment are presented in **Table 17-18.** There are interactions between the mitigation measures for flooding and hydrology and **Chapter 10, Biodiversity, Chapter 19, Surface water quality** and **Chapter 20, Groundwater**.

Table 17-18 Environmental management measures for flooding and hydrology impacts

Impact	ID No.	Environmental management measure	Responsibility	Timing
Impacts on flood behaviour during construction	FH01	A Construction Flood Management Plan (CFMP) will be prepared and implemented before construction to manage the impact of a 5% AEP flood event or greater on the operation of ancillary facilities. The CFMP will form part of the Construction Environmental Management Plan (CEMP). The CFMP should detail: • The impacts on hydrology and flooding from the construction phase • Control measures and procedures for construction activities to avoid, minimise or manage potential adverse impacts to construction works in the event of a flood within or adjacent to the project • Management responses for ancillary sites provided in **Section 17.5.1** • Flood monitoring to forecast large rainfall and flood events and notification measures • Emergency response and evacuation procedures in the event of a flood during the construction phase • Suitable evacuation routes and procedures for evacuation of site personnel • A register of all materials stored in work areas prone to flooding • Control measures for stockpiling within the floodplain to minimise loss of material in flood events. • Protocols for equipment and materials that can be removed from the subject area during a flood event where reasonable and feasible • Consultation and coordination with local residents, CHCC and other relevant stakeholders • Induction of all construction site staff and visitors to familiarise with the emergency response procedures.	Contractor	Construction
	FH02	If the detailed construction plan requires staging of additional earthworks within floodplain(s) crossed by the project, revised flood modelling will be carried out as part of the detailed design to determine the potential for changed flooding impacts and any required mitigation and/or management response.	Contractor	Detailed design

Impact	ID No.	Environmental management measure	Responsibility	Timing
Impacts on flood behaviour during construction from temporary waterway crossings	FH03	Temporary waterway crossings will be designed, constructed and maintained in accordance with the following requirements: • Low-flow conditions will be maintained • No additional flooding impacts would occur greater than those assessed for the operational phase • Fish passage will be maintained in accordance with the relevant waterway classification and DPIE guideline, Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (Fairfull & Witheridge 2003) • Material used in temporary waterway crossings will be selected to minimise risk of fine sediment material entering the waterway • Include erosion and sediment controls in accordance with Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004) • Any material used in the temporary creek crossing will be removed following construction and the site rehabilitated to its existing condition where reasonable and feasible.	Contractor	Construction
Hydrology impacts from creek realignments	FH04	Creek realignments and/or adjustments will be designed to behave in a similar hydrologic and geomorphic manner as existing conditions and will consider the requirements of the Policy and Guidelines for Fish Habitat Conservation and Management (DPI 2013). Revegetation and adequate scour protection will be provided so there are no hydraulic impacts on bed and bank stability, erosion, sedimentation or riparian vegetation in accordance with the Guidelines for instream works on waterfront land (DPI 2012a). Detailed design of waterway realignments and adjustments will be developed in consultation with DPIE (Regions, Industry, Agriculture and Resources) and will consider: • Investigation of opportunities to reduce or avoid waterway realignments to maintain existing creek alignments including locating piers outside of the waterway • Retention of existing riparian vegetation where possible, including retention of tree stumps where trees are removed • Maintaining existing waterway lengths, velocities and hydraulic grades	Contractor	Detailed design and construction

Impact	ID No.	Environmental management measure	Responsibility	Timing
		• Use of soft engineering approaches to scour protection where landscaping is provided over the rock scour • Maintaining fish passage in accordance with the waterway classification and DPIE guideline Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (Fairfull & Witheridge 2003).		
Hydrology impacts from creek realignments	FH05	During the initial establishment and operation period of realigned or adjusted waterways, regular inspections will be carried out to ensure effective design of the realignment. An inspection program will be documented in the Soil and Water Management Plan (SWMP). The inspections will assess implementation and success of the controls and identify any maintenance actions required.	Contractor	Construction
Minimise scour potential	FH06	Scour protection for bridges and culverts will be designed in accordance with DPIE guideline, Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (Fairfull & Witheridge 2003) and DPI Office of Water guidelines for controlled activities on waterfront land.	Contractor	Detailed design
Construction impacts on flood evacuation routes	FH07	NSW State Emergency Services will be notified of any partial or total road closures during construction because of the project. The CFMP should detail any impacts on existing flood conditions in relation to flood evacuation routes.	Contractor	Construction
Managing residual flood impacts	FH08	Consultation with CHCC will be carried out during detailed design regarding any residual flood impacts. This will include, but not be limited to: • A whole of government approach will be investigated which considers the relationship between the project and North Boambee Valley (West) URA and what reasonable and feasible options could be implemented to assist in managing potential flood impacts • Modifications to the Bennetts Road detention basin.	Roads and Maritime	Detailed design

Impact	ID No.	Environmental management measure	Responsibility	Timing
	FH09	Consultation with the proponent of Pacific Bay Eastern Lands development will be carried out during detailed design to develop a reasonable and feasible design solution to mitigate flood impacts on the approved residential areas. Consultation will also consider future proposals that are being investigated.	Roads and Maritime	Detailed design
	FH10	Proposed mitigation measures for the North Boambee Valley catchment as described in **Section 17.6.1**. The final design solution may involve combinations of the described mitigation options and the design response developed as part of the concept design and will be subject to further flood modelling and consultation with CHCC, DPIE (Environment, Energy and Science) and adjacent property owners.	Roads and Maritime / Contractor	Detailed design
	FH11	Proposed mitigation measures for the Coffs Creek catchment as described in **Section 17.6.2** will be investigated during detailed design. The final design solution may involve combinations of the described mitigation options and the design response developed as part of the concept design and will be subject to further flood modelling and consultation with CHCC, DPIE (Environment, Energy and Science) and adjacent property owners.	Roads and Maritime / Contractor	Detailed design
	FH12	Proposed mitigation measures for the Northern creeks catchment as described in **Section 17.6.3** will be investigated during detailed design. The final design solution may involve combinations of the described mitigation options and the design response developed as part of the concept design and will be subject to further flood modelling and consultation with CHCC, DPIE (Environment, Energy and Science) and adjacent property owners.	Roads and Maritime / Contractor	Detailed design
Project impacts on flood evacuation routes	FH13	Consultation with SES and CHCC will be carried out during detailed design if there are any changes to the existing flood evacuation routes or associated roads which may be impacted during operation.	Roads and Maritime	Operation

CHAPTER 18

Chapter 18

Soils and contamination

18. Soils and contamination

This chapter presents an assessment of the impacts of the project on soils, including soil contamination, soil salinity, soil and land resources and identifies mitigation and management measures to minimise and reduce these impacts. The assessment presented in this section draws on information from desktop reviews and site investigations completed by RCA (2016 and 2017).

Table 18-1 lists the SEARs relevant to soils and contamination and where they are addressed in this chapter.

Table 18-1 SEARs relevant to soils and contamination

Ref	Key Issue SEARs	Where addressed
9. Soils		
1.	The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	Section 18.1 Section 18.3 **Chapter 22, Waste**
2.	The Proponent must assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the project area.	Section 18.2.3 Section 18.3
3.	The Proponent must assess the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	Section 18.3 **Chapter 20, Groundwater**
4.	The Proponent must assess the impacts on soil and land resources (including bank stability, erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines.	Section 18.3 Section 18.4

18.1 Assessment methodology

Information on soils, including soil contamination, soil salinity and soil and land resources presented in this chapter was sourced from publicly available information and geotechnical and site investigations carried out for the project in 2016 and 2017. Further information on the assessment methodology is provided below.

18.1.1 Soil contamination

A preliminary soil contamination assessment was carried out to identify past and present potentially contaminating activities and land uses along the project, and to identify potential contamination types for further investigation. The assessment of contaminated land involved:

- A site inspection carried out 13 and 14 April 2016 as part of the project geotechnical investigations where observations were made about potential contamination
- Review of historic aerial photography
- A search of the DPIE (Regions, Industry, Agriculture & Resources) website for cattle tick dip site
- Review of the CHCC online mapping viewer for potentially contaminated land and banana contaminated land

- Review of Section 149 zoning certificates for potentially contaminated sites
- Review of Roads and Maritime crash data
- Review of current contaminated sites identified by the EPA and review of the EPA register of EPLs, applications, audits or pollution studies and reduction programs
- Review of the DPIE (Water), groundwater bore database
- Review of existing reports and published maps of the area to inform subsurface conditions and identify other areas of potential contaminations.

The assessment was carried out in relation to key contamination guidelines including:

- Guidelines for Consultants Reporting on Contaminated Sites (EPA 1997b)
- Managing Land Contamination: Planning Guidelines: SEPP55 – Remediation of Land (DUAP & EPA 1998)
- National Environment Protection (Assessment of Site Contamination) Measure (NEPC 1999 as amended 2013)
- Roads and Maritime Guideline for the Management of Contamination (2013c).

The assessment is documented in the following reports prepared for the project:

- Desktop Study of Contaminated Soils, Pacific Highway, Coffs Harbour, No. 11717-801/0, (RCA 2016)
- Geotechnical Interpretive/Design Report, Pacific Highway Upgrade, Coffs Harbour Bypass, Section 1, No. 11717-813/0, (RCA 2017a)
- Geotechnical Interpretive/Design Report, Pacific Highway Upgrade, Coffs Harbour Bypass, Section 2, No. 11717-808/0, (RCA 2017b)
- Geotechnical Interpretive/Design Report, Pacific Highway Upgrade, Coffs Harbour Bypass, Section 3, No. 11717-814/0, (RCA 2017c).

18.1.2 Soil salinity

The assessment of soil salinity involved:

- Review of the Salinity Hazard Report for Catchment Action Plan upgrade – Northern River Catchment Management Authority (CMA) (NSW DPI (Nicholson, Winkler, Muller, Woolridge, Jenkins & Cook 2012))
- Review of the acid sulphate soils (ASS) risk map for the project (Naylor, Chapman, Atkinson, Murphy, Tulau, Flewin, Milford & Morand 1998)
- Conductivity testing for groundwater samples taken from fractured rock aquifer.

The assessment was informed by Site Investigations for Urban Salinity (DLWC 2002).

18.1.3 Soil and land resources

Bank stability and erosion

The assessment of soil erosion, stability and landform involved:

- Review of Soil Landscapes of the Coffs Harbour 1:100,000 scale soil landscape sheet and report (Milford, 1999) to identify the soil landscapes which the project would intersect
- Assessment of the erodibility of soil landscapes based on the soil landscape properties in the project corridor and the potential erosion mechanisms in the construction footprint.

The assessment was informed by the Soil and Landscape Issues in Environmental Impact Assessment (DLWC 2000) and the Landslide Risk Management Guidelines (Australian Geomechanics Society 2007).

An erosion and sediment management report (SEEC 2019) has been prepared for the project, which details erosion and sediment control management and mitigation approaches for the construction phase of the project. The preparation of the report addresses the project's high erosion and sedimentation risk which is due to:

- High rainfall experienced for the region (about 1700 mm per year)
- Project complexity and traffic staging
- Complex topography, including areas that are flood-prone and also very steep hills
- The need for extensive cut and fill
- A sensitive receiving environment
- Site constraints that limit the amount of available land during construction.

18.1.4 Acid sulfate materials

The assessment of ASS involved:

- Review of the ASS risk map for the project (Naylor et al. 1998)
- Review of Sharing and Enabling Environmental Data (SEED Database) and Acid Sulfate Soil Risk layer (OEH)
- Laboratory testing of residual and alluvial soils within the vicinity of the project. Testing was carried out on samples collected near Boambee Creek, Newports Creek and Pine Brush Creek in accordance with the Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze (RTA 2005). This included:
  - Suspension peroxide oxidation – combined acidity and sulfate testing
  - Chromium reducible sulfur testing.

The assessment of acid sulfate rock (ASR) involved:

- Review of the preliminary Acid Sulfate Rock Risk Map (Roads and Maritime 2017) for the project
- Review of Managing the Risks Associated with Acid Sulfate Rock in NSW Road Projects, (Bridgement 2017) in Australian Geomechanics
- Laboratory testing of select rock samples collected along the project. Testing was carried out in accordance with the Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze (RTA 2005).

18.2 Existing environment

The existing soil and land conditions and characteristics relevant to the project are described below.

18.2.1 Sources of contamination

Search of EPA records

A search of NSW EPA records from Coffs Harbour, Boambee and Korora identified two sites with a written notice from the EPA for contamination within or near the project. These sites located next to the Pacific Highway at the southern end of the project in Boambee are:

- BP (former Mobil) Boambee service station. Contamination activity type: service station
- Lindsay Transport depot. Contamination activity type: other petroleum.

Both sites have been assessed by the EPA as not requiring regulation under the *Contaminated Land Management Act 1997* (CLM).

Three EPLs were identified near the project at the Coffs Coast Resource Recovery Park near Englands Road:

- Licence 6267 for waste disposal to land, non-thermal treatment of liquid waste and waste tyre storage. The licence requires monitoring of landfill gas generation, ambient air quality, groundwater, surface water and leachate quality
- Licence 12369 for composting, non-thermal treatment of general waste and waste storage at the biomass facility. The licence requires monitoring of odour levels, air quality and leachate quality, overflow and levels
- Licence 20613 for waste recovery services and waste storage. The licence requires monitoring of noise levels only.

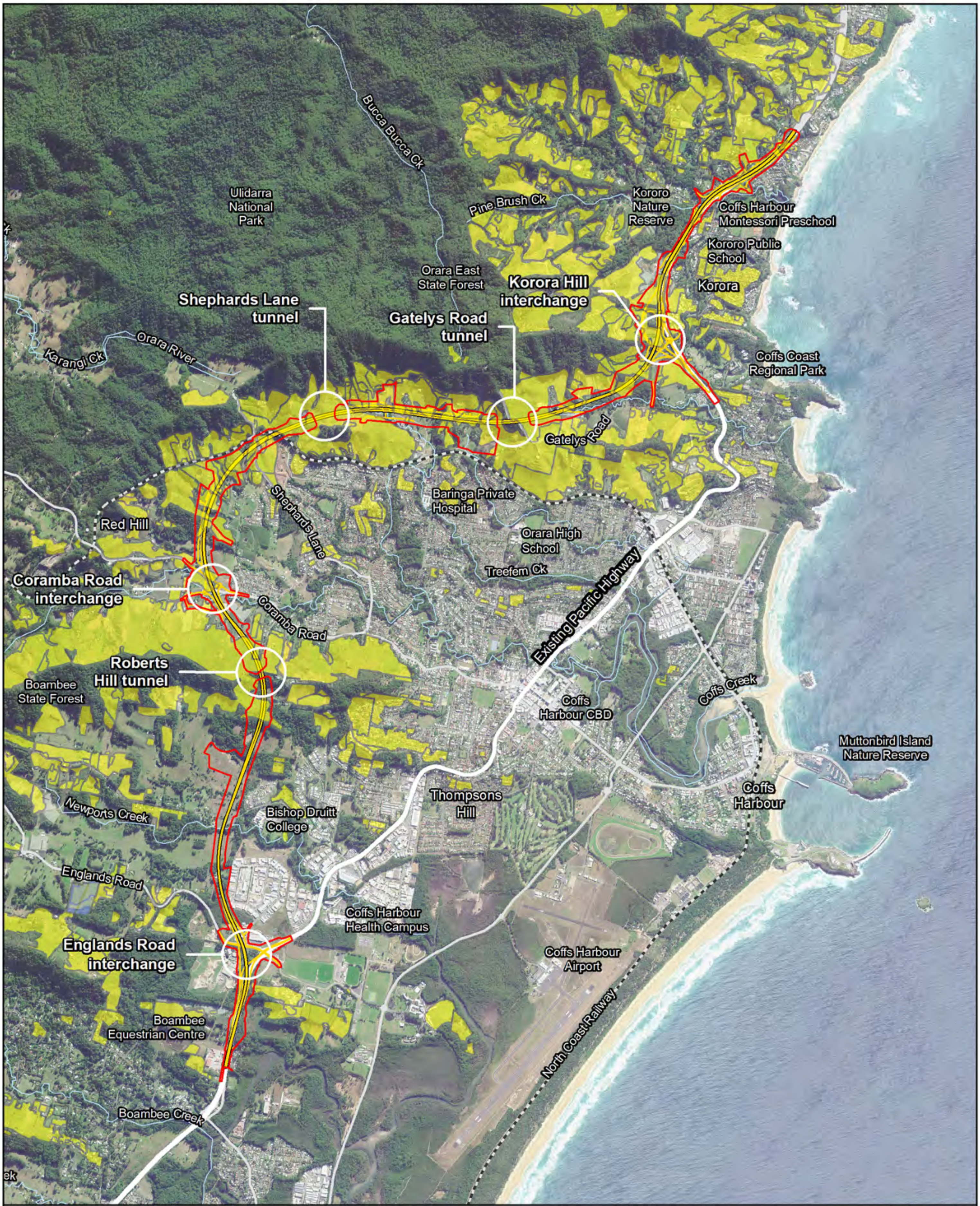
These locations are discussed further in **Section 18.2.2** with further detail regarding the operations at these facilities provided in **Chapter 22, Waste**.

Agricultural and residential sources of contamination

Current or historical agricultural land uses may result in contamination. The CHCC website identifies multiple former and existing banana and blueberry plantations and other agriculture uses within and next to the construction footprint. These properties may contain contaminants of potential concern (COPC) such as pesticides such as Aldrin, Dieldrin and Dichlorodiphenyltrichloroethane (DDT) (**Figure 18-1**). Excavated contaminated soil may require separation from soil that is intended for reuse across the project. This would be managed through the preparation and implementation of a Waste Management Plan (**Chapter 22, Waste**).

Following an initial search of their website, further consultation with DPIE (Regions, Industry, Agriculture & Resources) in September 2018 did not reveal any known cattle dip sites within the construction footprint. Additionally, no specific zones of contamination were identified in residential zones from the preliminary soil contamination assessment. However, residential and farm buildings within the construction footprint have the potential to contain sources of contamination which would not necessarily be picked up in a desktop study. Specific examples include lead paint and asbestos used in the construction of old buildings. This is discussed further in **Chapter 22, Waste**.

Another contamination concern (and biosecurity risk) applicable to the project is Panama disease, which is known to affect banana plantations in the region. Further discussion on the impact of Panama disease to banana plantations adjacent to the project is provided in **Chapter 13, Agriculture**.



Legend

- Construction footprint
- Former and existing banana plantations
- Alignment
- North Coast Railway
- Watercourse

0 0.5 1 1.5 km

Scale @A4: 1:50,000
GDA 1994 MGA Zone 56

N

Coffs Harbour Bypass
Location of potential agricultural sources of contamination
Figure 18-1

Infrastructure and industrial sources of contamination

Previous or current land uses such as automotive, rail or industrial uses may result in contamination. The project would include a bridge over the existing North Coast Railway. Soil within and next to the railway may contain contaminants such as hydrocarbons, polyaromatic hydrocarbons (PAHs), heavy metals, asbestos and herbicides.

There is a flood detention basin between Bennetts Road and Coramba Road which was potentially constructed from locally sourced materials. It is possible that locally sourced material may contain COPCs due to previous agricultural land uses in the vicinity of the basins.

Potentially contaminated soils and groundwater may be present at the two EPA notified sites at the southern part of the alignment. These sites (**Section 18.1.1**) may have contamination of soils and groundwater relating to petroleum diesel hydrocarbons. It is noted however that assessment of the contamination by the EPA decided that the sites do not require regulation under the CLM Act.

A site inspection was carried out between 13 and 14 April 2016 (RCA 2016) to identify potentially contaminated sites. The results of this inspection are presented in **Table 18-2** and **Figure 18-2.** The site inspection targeted potentially contaminated areas identified in the desktop study near the project including:

- Stockpiles of crushed sand and glass within industrial land
- Cleared land that had been used for burning within industrial land
- Indication of a septic system within industrial land
- Buildings potentially to be constructed of asbestos cement material
- Buildings containing lead paint
- Abandoned vehicles
- Waste tyres
- Illegally dumped steel, plastic and used oil containers.

In addition, access to the industrial facility near Englands Road was not provided at the time of the site inspection. However, given the industrial use of the site, it is possible that contamination may be present at the site. Since the site investigations in 2016 the property has been purchased by the Roads and Maritime and further investigation will be undertaken to confirm the potential for contamination.

There may be additional sources of contamination from illegally dumped and buried material within the construction footprint which were identified during site inspection. Further targeted investigation would be completed as part of Phase 2 contamination investigations prior to construction (refer to **Section 18.4**).

18.2.2 Soil and land resources

Soil characteristics vary depending on the underlying geology of the area and the geomorphological processes to which they have been exposed. The Coffs Harbour 1:100,000 scale Soil Landscape Sheet and Report (Milford 1999) indicates six soil landscapes would be traversed by the project. These soil landscapes and descriptors are listed in **Table 18-3** and shown in **Figure 18-3.**

Table 18-2 Areas of potential contamination from infrastructure and industrial sources within or next to the construction footprint

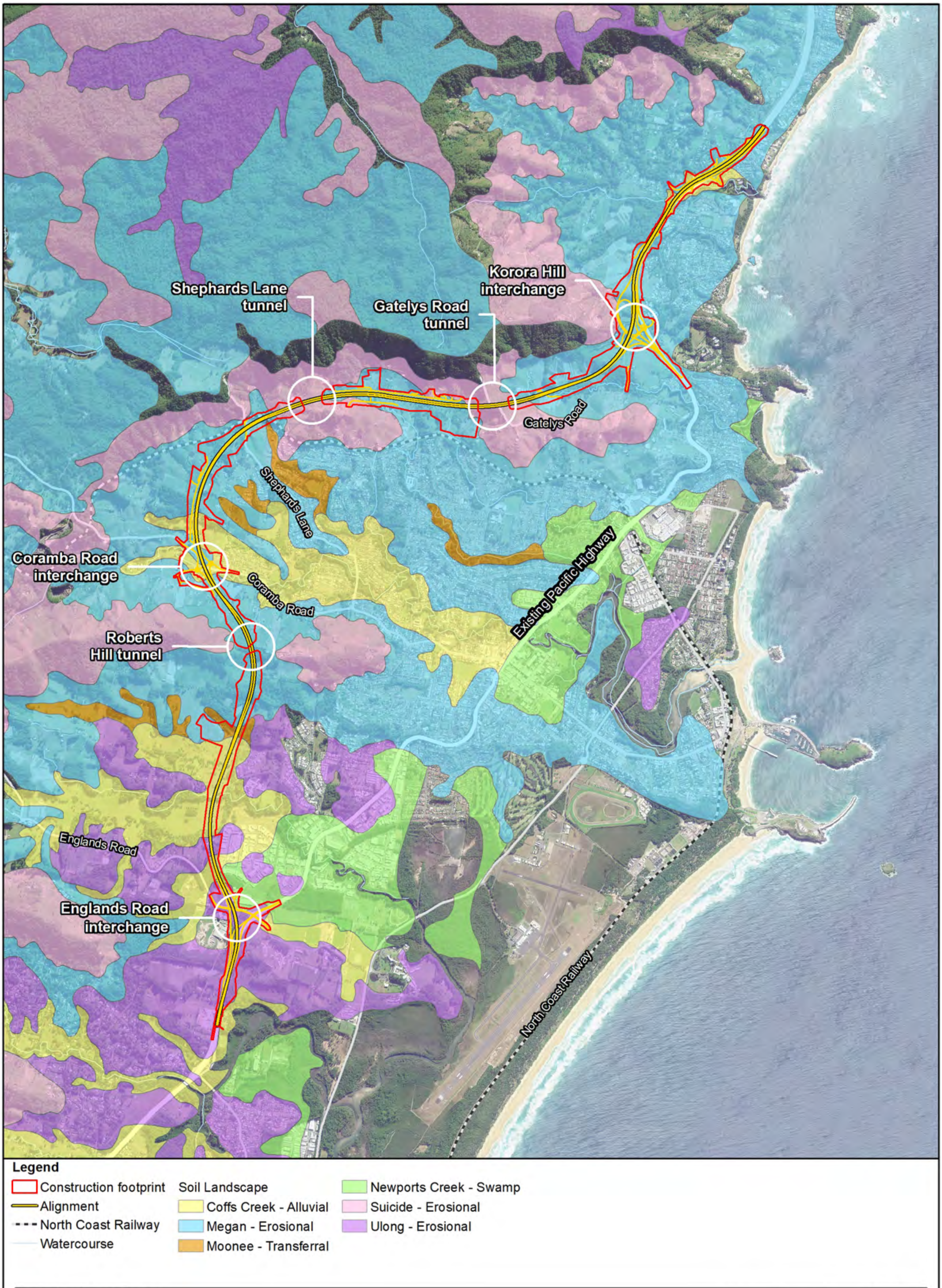
Issue	Location	Ownership	Zoning	Potential contaminants	Potential risk
Former industrial site	Lot 202 800141	Roads and Maritime	IN1 General industrial and SP2 Infrastructure	• Hydrocarbons • PAHs and solvents • Heavy metals • Volatile organic compounds • Asbestos • Sewage (from septic system)	• Contaminated materials from demolition • Contaminated soils • Contaminated groundwater
Abandoned vehicle	Lot 61 1064525	Roads and Maritime	SP2 Infrastructure	• Hydrocarbons	• Contaminated soils
Detention basin	Lot 2 1175477	Roads and Maritime	RU2 Rural Landscape	• Panama disease • Pesticides • Nutrients	• Contaminated soils
Historical fill	Lot 1 874049	Private	SP2 Infrastructure	• Heavy metals • Hydrocarbons • Asbestos	• Contaminated soils
North Coast Railway	N/A	Railcorp	SP2 Infrastructure	• Hydrocarbons • Herbicides • Asbestos • Heavy metals	• Contaminated soils • Leachate and contaminated groundwater
BP Service Station (next to construction footprint)	Lot 13 861055	Private	B6 Enterprise corridor	• Hydrocarbons	• Contaminated soils • Contaminated groundwater • Soil gas
Lindsay Transport (next to construction footprint)	Lot 1 1001301	Private	IN1 General industrial	• Hydrocarbons	• Contaminated soils • Contaminated groundwater • Soil gas

Issue	Location	Ownership	Zoning	Potential contaminants	Potential risk
Underground petroleum storage tank (next to construction footprint)	Lot 31 1090175	Private	IN3 Heavy industrial	• Hydrocarbons • PAHs • Heavy metals	• Contaminated soils • Leachate and contaminated groundwater
Coffs Coast Resource Recovery Park (next to construction footprint)	Lot 31 1090175	CHCC	IN3 Heavy industrial	• Heavy metals • Hydrocarbons • Asbestos • Nutrients	• Contaminated soils • Leachate and contaminated groundwater
Landfill (next to the construction footprint)	Lot 31 1090175	CHCC	IN3 Heavy industrial	• Heavy metals • Hydrocarbons • Asbestos • Nutrients	• Contaminated soils • Leachate and contaminated groundwater
Biomass facility (next to the construction footprint)	Lot 32 1090175	CHCC	IN3 Heavy industrial	• Heavy metals • Nutrients	• Contaminated soils • Leachate and contaminated groundwater

Coffs Harbour Bypass
Potential contaminated sites from infrastructure and industrial sources
Figure 18-2

Table 18-3 Soil landscapes and descriptors

Landscape name	Landscape type	Landscape description	Depth	Drainage	Soil description	Acidity, salinity/ sodicity	Erodibility/Hazards
Coffs Creek	Alluvial	Level to gently undulating floodplains	Deep	Moderate to poorly drained	Alluvial, yellow and red podzolic soils, yellow earths, Gleyed podzolic soils	Strong to very strong acidity	Foundation hazard, seasonal water logging, permanents high water tables, localised flood hazards
Ulong	Erosional	Undulating to rolling low hills on Late Carboniferous metasediments	Moderately deep to deep	Well drained	Red and brown earths, low wet bearing strength	Strongly to very strongly acidic soils	Localised water erosion hazard, steep slopes and high run-on
Newports Creek	Swamp	Low, level to gently undulating coastal back barrier floodplains on Pleistocene estuarine sediments	Deep	Poorly drained	Yellow podzolic soils and humic gleys. High topsoils organic matter and low fertility. Low to very low wet bearing strength	Strongly to very strongly acidic, strongly sodic, strongly saline soils	Localised water erosion hazard, Flood hazard, seasonal water logging, foundation hazard
Moonee	Transferral	Undulating rises, footslopes and drainage plains next to steep low hills on Carboniferous metasediments	Moderately deep to deep	Poorly drained	Humic gleys	Strongly to very strongly acidic soil, high subsoil sodicity	High subsoil erodability, water erosion hazard, permanent high-water tables
Megan	Erosional	Rolling hills to hills on Late Carboniferous Metasediments	Moderately deep to deep	Well drained	Structured red earths and brown earths	Strongly acidic	High erodability, high water erosion hazard, foundation hazard
Suicide	Colluvial	Steep hills and dissected valleys on Late Carboniferous metasediments	Moderately deep to deep	Well drained	Stony structured, yellow earths on crests and upper slopes	Strongly acidic, strong subsoil acidity	High water erosion hazard, foundation hazard, localised rockfall hazard



Coffs Harbour Bypass
Soil landscapes
Figure 18-3

18.2.3 Soil salinity

The DPIE Salinity Hazard Report for Catchment Action Plan upgrade – Northern River CMA, indicates the project is underlain by landscapes with very low to very high mapped salinity hazard potential (Nicholson 2012). These salinity hazards are associated with:

- Acid sulfate potential landscapes – corresponding to areas identified on the ASS risk map (**Figure 18-4**), typically in lower lying topographical areas of the project and along the coastal areas of Coffs Harbour. Landscapes containing ASS potentially have a very high salinity hazard, high salt load, high salt store and low water quality (high salinity – electrical conductivity)
- Coastal ranges metasediments landscapes – corresponding to the foothills and slopes of the Coramba Beds and Brooklana Formation[1], within which most of the project is located.

Further information relating to salinity in groundwater is addressed within **Chapter 20, Groundwater**.

18.2.4 Acid sulfate materials

Acid sulfate materials include ASS and ASR, which are sediments and rock deposits that contain iron bearing sulfides. Typically, ASS is found in swamps and estuaries below 10 m Australian height datum (AHD) and below groundwater level. If potential ASS or ASR are disturbed by activities such as excavation or lowering groundwater levels, the potential acid sulfate materials can react with air (oxidise) rapidly to form sulfuric acid and mobilise aluminium and heavy metals within the subsurface. The risk to the environment from generation of acid leachate is lower when ASS is left undisturbed since the risk of oxidation is less. The generation of acid and toxic heavy metal plumes results in hazards and impacts on the environment and subsurface structures.

Acid sulfate soils

The ASS Risk Map (Naylor 1998) indicates the southern end of the project intersects areas with a low probability of ASS associated with Boambee Creek and Newports Creek and their tributaries. Areas of high ASS risk are located about 120 m east of the southern end of the project next to and within Boambee Creek. The northern end of the project intersects mapped high-risk acid sulfate risk near Pine Brush Creek.

Laboratory indicator testing for ASS confirmed the presence of potential acid sulfate soil (PASS) (pH_{FOX} less than four[2]) within the construction footprint; however, testing did not identify any ASS (ie the field pH was greater than four). Areas of PASS were confirmed near Englands Road, North Boambee Road and Coramba Road*.*

Suspension peroxide oxidation combined acidity and sulfur (SPOCAS) and chromium reducible sulfur testing was conducted based on the results of the ASS indicator testing. These tests determine the amount of acid that could be generated by the PASS and the concentration of sulfides in the PASS[3]. The results

[1] The project is underlain by the Brooklana Formation just north of the North Coast Railway. The Brooklana Formation comprises thinly bedded siliceous mudstone and siltstone with rare lithofeldspathic wacke, locally chert, jasper, magnetite-bearing chert and metabasalt.

[2] Acid sulfate soil indicator testing is completed by initially measuring the field pH value (pH_F) of a soil sample. The soil sample is then allowed to oxidise and the field oxidised pH value (pH_{FOX}) is measured. If the pH_F is greater than 4, but the pH_{FOX} value is less than 4, the soil is considered potential acid sulfate soil. If pH_F is less than four, the soil is considered an actual acid sulfate soil.

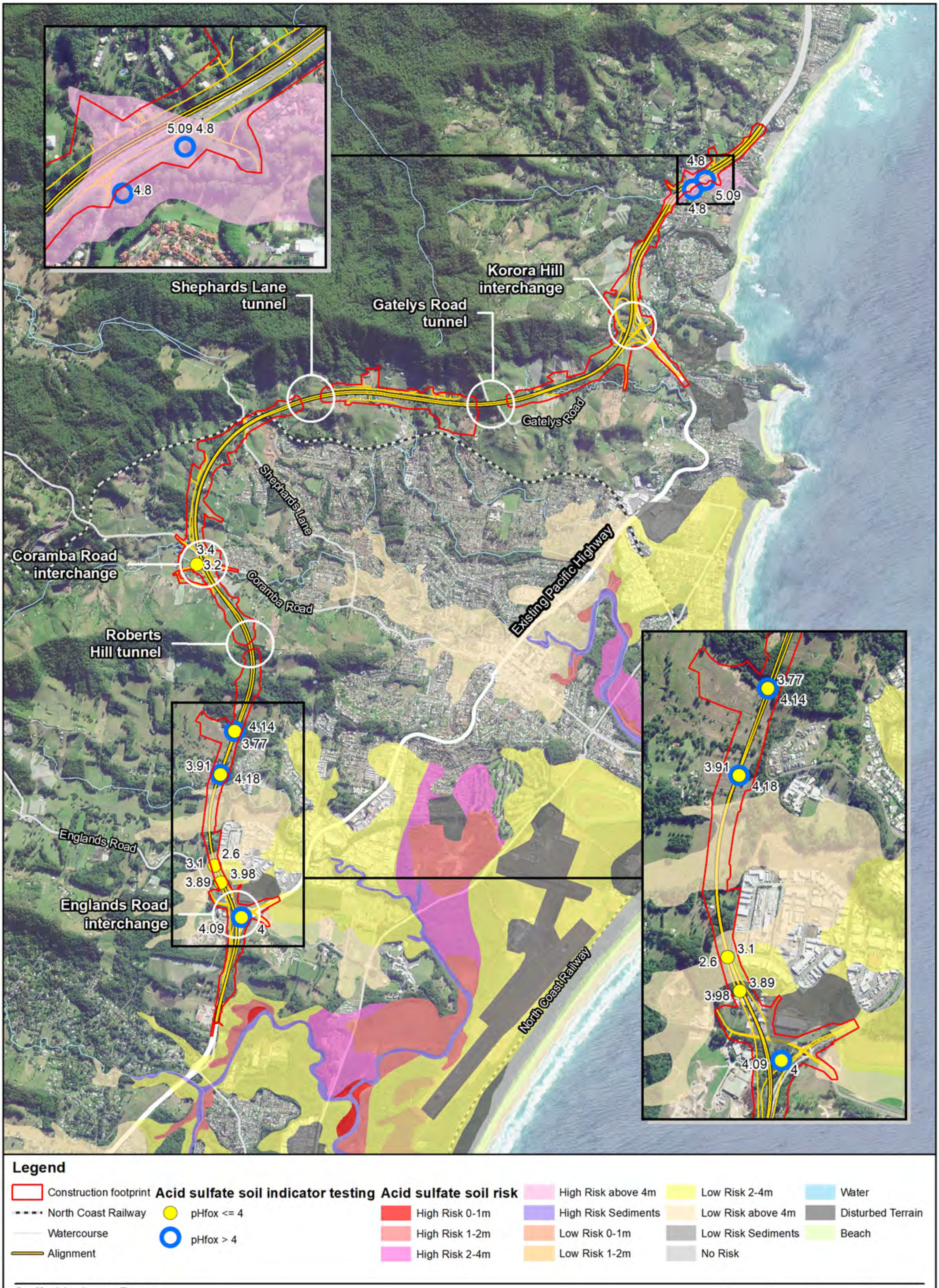
[3] The amount of acid that could be generated by the potential acid sulfate soil and the concentration of sulfides in the potential acid sulfate soil are action criteria used to determine if an acid sulfate soil management plan should be implemented.

from these tests were generally below the ASS Management Plan action criteria, except for one sample at the Coramba Road interchange.

Acid sulfate rock

A review of the preliminary Roads and Maritime ASR risk mapping indicates the construction footprint is located in areas of low and medium ASR risk. Medium risk areas are generally associated with the meta-sediment rock in the Coffs Harbour region; however, it should be noted the low risk designation does not necessarily rule out the presence of ASR requiring treatment in these areas. Unless proven otherwise, ASR should be treated as unknown (Bridgement 2017).

Petrographic and acid base accounting laboratory testing was completed for selected rock samples collected along the project corridor to determine the presence of ASR. Test results indicate the rock samples have sufficient acid neutralising capacity to buffer acid produced by sulfides in the rock mass oxidising (RCA 2017a, 2017b and 2017c). Consequently, ASR is unlikely to be a risk to the project.



Coffs Harbour Bypass
ASS Risk
Figure 18-4

18.2.5 Potential receptors

Certain ecological and environmental receptors are sensitive to potential contamination, sedimentation and erosion. Contamination, sedimentation and erosion can affect surface and groundwater quality, introduce or mobilise adverse compounds and metals, degrade the quality of soil, which can be detrimental to the health of ecological and environmental receptors. Receptors may include:

- Surface water features including rivers, creeks and lakes
- Native flora and fauna within surface water
- Groundwater within fractured bedrock and alluvial aquifers
- Groundwater users including licenced groundwater abstraction bores
- Groundwater dependent ecosystems (GDEs), sensitive aquatic environments and ecological communities including the flora and fauna within them. These receptors typically comprise remnant native vegetation and wetlands protected by NSW Coastal Management SEPP
- Ecological communities and flora and fauna (refer to **Chapter 10, Biodiversity**).

In addition to the environmental and ecological receptors above, there is a risk to the human health of site users that encounter soil and groundwater contamination. Site users are likely to comprise construction workers, site visitors and future operational road users. Potential impacts on these receptors are discussed in the sections below.

It is important to note that any GDEs that have been identified above as potential receptors, are only potential GDEs. The assessment of the study area to support GDEs only identifies high probability GDEs and does not necessarily confirm that a particular ecosystem is groundwater dependent. This is discussed further in **Chapter 20, Groundwater**.

18.3 Assessment of potential impacts

18.3.1 Construction impacts

Contamination

Activities during the construction phase have the potential to interact with existing sources of contamination. Disturbance of potentially contaminated land could have the following potential impacts:

- Mobilisation of surface and subsurface contaminants, which have the potential to impact surface water, groundwater and soils
- Migration of contaminants into the surrounding area, which have the potential to impact surface water, groundwater and soils via leaching, overland flow and/or subsurface flow
- Exposure of contaminants to environmental receivers mobilised and transported via surface water and groundwater, which would impact flora and fauna
- Exposure of contaminated soils and/or groundwater to construction workers and site visitors.

Based on the desktop research and site inspection carried out for the project, sources of potential contamination have been identified along and near the project corridor (RCA 2016). Conceptual source-pathway-receptor models have been developed to better understand how these sources can move through the environment and potentially impact environmentally sensitive receptors.

The models are generally high level and comprise the following information:

- **Source**: The source of contamination is identified. The location could be in the soils, ground or surface waters
- **Pathway:** The pathway is the route the source takes to reach a given receptor. Pathways could include air, water, soil, animals, vegetables and ecosystems
- **Receptor**: For contamination to cause harm, it must reach a receptor. A receptor is a person, animal, plant, ecosystem, property or a controlled water. Each receptor must be identified and their sensitivity to the contaminant must be established.

The conceptual source-pathway-receptor models developed for the project are presented in **Table 18-4**.

Table 18-4 Contaminated land conceptual source-pathway-receptor models

Source	Pathway	Receptor	Potential impact/comments
Plantations and agricultural land			
Former and current use of land for banana and blueberry cultivation, and other agricultural uses which may include surface contamination from heavy metals, pesticides or nutrients.	Ingestion, skin contact or inhalation of contaminated soils and/or contaminated groundwater during construction activity.	Construction workers/site visitors	• Impacts on human health from heavy metals or other COPCs.
	Ingestion, skin contact or inhalation of asbestos, lead paint and other contamination during demolition activity.	Construction workers/site visitors	• Impacts on human health from asbestos, lead paint and other COPCs.
	Transportation of contaminated soil via construction workers, construction machinery (both to and from the project) and/or erosion in areas of bare soils, steeper cuts and/or from material stockpiles during construction.	Surface water – rivers, creeks and lakes	• Contaminated soil entering surface water impacting on water quality and natural flora and fauna.
	Mobilisation of existing soil contamination into rainfall run-off and drainage into groundwater, or mobilisation of existing contaminated groundwater due to construction activity	Groundwater, Groundwater users, GDEs	• Contaminated runoff entering groundwater leading to a reduction in groundwater quality • Impact on downgradient groundwater users and/or GDEs due to reduction in groundwater quality.
Areas of potential industrial contamination			
Former industrial site including COPCs such as heavy metals, hydrocarbons, PAHs and solvents, volatile organic compounds, asbestos and contaminated ground from septic system.	Ingestion, skin contact or inhalation of contaminated soils and/or contaminated groundwater and/or gaseous volatile contaminants during construction activity.	Construction workers/site visitors	• Impacts on human health from COPCs.
	Inhalation of asbestos fibres during demolition activity.	Construction workers/site visitors	• Impacts on human health from asbestos.
	Transportation of contaminated soil via construction workers, construction machinery and/or erosion in areas of bare soils, steeper cuts and/or from material stockpiles during construction.	Surface water – rivers, creeks and lakes	• Contaminated soils or runoff entering surface water impacting on water quality and natural flora and fauna.

Source	Pathway	Receptor	Potential impact/comments
	Mobilisation of existing soil contamination into rainfall runoff and drainage into groundwater, or mobilisation of existing contaminated groundwater due to construction activity.	Groundwater, Groundwater users, GDEs	• Contaminated runoff entering alluvial groundwater aquifer leading to a reduction in groundwater quality • Impact on downgradient groundwater users and/or GDEs due to reduction in groundwater quality.
North Coast Railway	Disturbance of existing soil contamination during construction of bridge over railway line.	Construction workers	• Extent of contamination is expected to be localised and disturbance is likely to be minimal due to the design of the bridge piers being located on the outer edges of the railway corridor and outside areas of that are most likely contaminated.
Existing highway			
Localised surface contamination next to the existing highway from spills, leaks, exhausts, accumulated over time. Likely to comprise petroleum hydrocarbons.	Ingestion, skin contact or inhalation of contaminated soils and/or contaminated groundwater during construction activity.	Construction workers/site visitors	• Impacts on human health from hydrocarbons or other COPCs.
	Transportation of contaminated soil via construction workers, construction machinery and/or erosion in areas of bare soils, steeper cuts and/or from material stockpiles during construction.	Surface water – rivers, creeks and lakes	• Contaminated soil entering surface water impacting on water quality and natural flora and fauna.
	Mobilisation of existing soil contamination into rainfall runoff and drainage into groundwater, or mobilisation of existing contaminated groundwater due to construction activity	Groundwater, Groundwater users, GDEs	• Contaminated runoff entering groundwater leading to a reduction in groundwater quality • Impact on downgradient groundwater users and/or GDEs due to reduction in groundwater quality.
Areas of historic fill areas/detention basin			
Areas of known and unknown historic fill along alignment including	Ingestion, skin contact or inhalation of contaminated soils and/or contaminated groundwater during construction activity.	Construction workers/site visitors	• Impacts on human health from hydrocarbons or other COPCs.

Source	Pathway	Receptor	Potential impact/comments
detention basin with COPCs including hydrocarbons, heavy metals, asbestos, pesticides and Panama disease (detention basin specific).	Inhalation of asbestos fibres disturbed during construction activity.	Construction workers/site visitors	• Impacts on human health from asbestos.
	Mobilisation of contaminated historic fill in areas during excavation of soils. Transportation of contaminated soil via construction workers, construction machinery and/or erosion in areas of bare soils/material stockpiles.	Banana plantations	• Spread of panama disease into surrounding areas and unaffected plantations.
		Surface water – rivers, creeks and lakes	• Contaminated soils or runoff entering surface water impacting on water quality and natural flora and fauna • Offsite impacts are expected to be minimal due to the localised nature of any contamination associated with these areas.
Underground hydrocarbon storage facilities			
Underground hydrocarbon storage facility (off site). Service stations and other hydrocarbon storage facilities.	Mobilisation of existing offsite contaminated groundwater due to construction activity.	Groundwater, groundwater users, surface water	• Impact on downgradient groundwater and/or surface water due to mobilisation of hydrocarbon contamination in groundwater • Impact is likely to be limited due to minor cuttings/at grade/embankment construction in this area of the alignment which is unlikely to significantly affect groundwater.
Illegal sources of dumped waste material			
Illegally disposed waste. Likely to be highly localised. Contamination would be dependent on the waste; however, may typically comprise of hydrocarbons, heavy metals and asbestos.	Mobilisation and disturbance of contamination by excavation and transport of contaminated soils.	• Construction workers/site visitors	• The risks associated with hazardous material are dependent on the material type, condition and location. Risks to construction workers may include inhalation, skin contact and ingestion • Extent of contamination is expected to be highly localised and unlikely to represent a significant risk • Offsite impacts may occur depending on the location of dumping and proximity to waterways and/or sensitive receptors.

Any existing contamination present within the soils or groundwater underlying the construction footprint has the potential to be exposed or disturbed by construction activities. The highest risk activities would be excavation, earthworks and demolition.

It is anticipated that the construction phase would potentially involve the handling and treatment of contaminants, as outlined above. Construction workers may also be at risk of exposure from contaminants through inhalation of dust, ingestion of, and contact with contaminated soil. In some instances, there may also be a risk of construction workers and site visitors coming into contact with contaminated leachate or groundwater, or inhalation of gaseous contamination if volatile organic compounds or hydrocarbons are encountered, for instance from below ground hydrocarbon storage.

Excavation and movement of soils during construction may mobilise contaminants through increased erosion and sedimentation. This may occur in areas of exposed soils, stockpiles and in areas of steep cuts after rainfall events. Left unchecked, contaminated runoff and suspended soils may make their way into surface water bodies such as creeks, rivers and lakes, potentially harming native flora and fauna and leading to a reduction in the water quality downstream. Erosion and sediment controls, including sediment basins, would intercept the contaminated sediments, reducing the risks to water quality in the downstream environment, including groundwater dependent ecosystems, sensitive aquatic environments and ecological communities. Silting up of sediment basins during construction may occur and need active management including excavation and disposal of the material. If the material is potentially contaminated, it would require testing and classification which may result in treatment or disposal at a licensed waste management facility as required.

Leaks and spills may occur when proper handling procedures are not followed, through accidents such as vehicle collisions, wear and tear of protective bunding used to contain contaminated material/site chemicals, poor management of potentially contaminating materials or leakage from construction plant. Spillages of hazardous materials during construction would be managed by using physical controls such as proper storage of potential sources of contamination and site chemicals in appropriately bunded storage facilities and availability of emergency spill kits at all construction sites.

There is the potential for illegal sources of dumped waste material to be present in the construction footprint. As this material is likely to be highly localised, any potential contamination would need to be properly assessed, stockpiled and disposed of appropriately.

There is potential for poor soil and stockpile management practices to cause the contamination of clean stockpiles with contaminated material, if not managed closely during the construction phase. Due to the large quantity of earthworks proposed on site, this risk is likely unless properly managed. This is particularly applicable to the soils that may be contaminated by agricultural pesticides as it may affect significant quantities of shallow soils.

Any contamination that is identified during the pre-construction and construction phase would be managed by the mitigation measures presented in **Table 18-5.**

Soil salinity

There are unlikely to be any salinity impacts during the construction of the project. Larger areas of excavation and tunnelling are associated with soil landscapes further inland which are likely to be less saline than those closer to the estuary. Groundwater drawdown effects are unlikely to mobilise groundwater of a quality which could pose a risk to the environment or proposed infrastructure.

The site is considered to be too far from the ocean to expect salinity as a result of seawater intrusion. Groundwater samples obtained during baseline assessment did not identify any elevated salinity levels; the samples ranged from low to moderate salinity. The assessment of how soil salinity may affect groundwater is discussed in **Chapter 20, Groundwater.**

Acid sulfate materials

Construction of the project may result in the disturbance of PASS. If ASS is exposed and oxidised, it may cause acid leachate to form which can lead to mobilisation of heavy metals and runoff of contamination into nearby soils, surface water and groundwater. Acid leachate may lead to plant and animal mortality due to acidification of soils, potential damage to surface waters and aquatic life mortality and cause a reduction in groundwater quality which may impact on GDEs and groundwater users.

Acid leachate generation may cause corrosion of material such as concrete, iron, steel and some aluminium alloys. It may also have some impacts on the health of construction workers and site visitors who come into contact with the leachate through skin contact and ingestion.

A number of the soils tested as part of the geotechnical investigations indicated presence of residual chromium reducible sulfur, low pH values and high total actual acidity levels. Areas of PASS were confirmed near Englands Road, North Boambee Road and Coramba Road. Laboratory testing of rock samples collected along the project corridor indicates ASR is unlikely to be a risk to the project.

An ASS Management Plan will be implemented during construction to appropriately manage and mitigate potential risk of encountering acid sulfate material during construction. Further testing for acid sulfate soils would be undertaken as part of the Phase 2 contamination investigations prior to construction.

Soil erosion

As discussed in **Section 18.1.3**, the project has been identified as having a high erosion and sedimentation risk due to a number of factors, including but not limited to, high rainfall experienced for the region, project complexity and earthwork requirements, steep topography and available land during construction.

During the construction phase of the project, there is likely to be an increased erosion risk associated with areas of exposed soils, stockpiles, clearing and earthwork requirements. The project would include extensive earthworks, removal of vegetation and stockpiling. It would also involve handling large volumes of soil and fill material for the construction of embankments and bridges. Where these earthworks are carried out there is an increased risk of soil erosion by wind and surface water runoff. The eroded soils can impact environmentally sensitive environments such as watercourses and wetlands which can result in adverse impacts on aquatic flora, fauna and human water uses. The Megan and Suicide landscapes are particularly susceptible to soil erosion.

Typical construction activities that can lead to increased soil erosion include:

- Site establishment activity including site vegetation clearing and construction of temporary access roads
- Bulk earthworks including stripping of topsoil and stockpiling, excavation of cuttings and processing and stockpiling of excavated material and construction of fill embankments
- Construction of drainage infrastructure, open channels and sedimentation basins
- Bridge and civil structures construction work
- Road construction works.

These activities can result in exposure of soils and subsoils, creating an elevated risk of soil erosion and sedimentation. Erosion and sediment control measures would need to be in place during construction to manage erosion and sediment impacts. However, the steep topography associated with the major ridgelines provides a number of constraints to constructing large-scale controls such as sediment basins. For these locations, enhanced controls developed in consultation with a suitably qualified and experienced soil conservationist, would be required to ensure the risk of pollution from erosion and subsequent sediment runoff can be managed. Further discussion on erosion and sediment practices and principles that will adopted for the project is provided in **Chapter 6, Construction**.

18.3.2 Operational impacts

Operation of the project has the potential to result in contamination of soils due to any spills and leaks of fuel, oils and other hazardous materials from routine traffic along the Pacific Highway. The potential for contamination as a result of general maintenance activities is considered to be low, based on the number of vehicles and equipment which would likely be used during maintenance. The risk of accidental contamination release would be managed under standard Roads and Maritime operational procedures and design requirements of pollution traps, spill basins and permanent water quality basins, where necessary.

The potential for contaminated runoff from road surfaces to enter the environment is considered to be low. All surface runoff would be captured by the road drainage network including water quality basins, which would be designed to accommodate chemical spillage and contaminated runoff from the road surface. Further information on operational water quality impacts and controls can be found in **Chapter 5, Project description** and **Chapter 19, Surface water quality.**

There is considered to be no risk to operational site users from existing contamination along the footprint as there is considered to be no credible pathway for users to come into contact with any potentially contaminated soils or groundwater.

The risk from ASS during operational phases of the project is considered to be negligible. Exposure of ASS is not expected to occur, and any existing ASS encountered during construction is expected to have been managed in accordance with the ASS Management Plan. The risk of oxidation of ASS due to the lowering of the groundwater table during operational activity is considered to be low. Areas of ASS are generally located in valleys, away from the major cuts and tunnels where the largest drawdown of water levels would occur. The impact of groundwater drawdown in areas of ASS is considered to be low. As such, the potential for generation of ASS leachate during operation is also considered to be low. See **Chapter 20, Groundwater** for further discussion on the risk from ASS during operational phases of the project.

The risk of mobilisation of saline water from soils of existing groundwater, due to long term drawdown of groundwater at cuttings is considered to be negligible. The major cuttings which are likely to affect groundwater are all located further inland, away from saline soils. Further information on the operational groundwater impacts is found in **Chapter 20, Groundwater**.

The operational phase of the project is not expected to include any significant direct disturbances or exposure of soils. Any earthworks associated with maintenance that would be conducted is expected to be minor and would be managed under standard Roads and Maritime operational procedures.

The risk of bank instability is addressed in **Chapter 17, Flooding and hydrology**. The risk of soil erosion due to concentration of surface water flows from impervious areas would be managed by incorporation of standard scour protection measures at outfalls to sediment basins and waterways.

18.4 Environmental management measures

Soil impacts, including soil contamination, soil salinity, ASS and soil and land resource impacts, have been identified during the construction and operational phases of the project. Expected impacts, environmental management measures, responsibilities and timing has been summarised in **Table 18-5.** There are interactions between the mitigation measures for soils and contamination and **Chapter 10, Biodiversity, Chapter 19, Surface water quality, Chapter 20, Groundwater, Chapter 22, Waste** and **Chapter 24, Hazard and risk**. These measures have been developed so that appropriate management of soil, including contaminated soils and materials would minimise the potential for impacts on the community and environment.

Table 18-5 Environmental management measures for soils and contamination impacts

Impact	ID No.	Environmental management measure	Responsibility	Timing
Contaminated soil	SC01	Phase 2 contamination investigations will be carried out in areas of potential contamination identified during the preliminary site investigation (RCA 2016). The investigation will be carried out in accordance with the Roads and Maritime Guideline for the Management of Contamination (2013c). This will include soil sampling from targeted areas including: • Banana plantations within proposed cuttings (analysed for arsenic, lead and organochlorin pesticides including DDT, Aldrin and Dieldrin) • Incremental soil sampling along construction footprint at existing Pacific Highway where there is a history of truck accidents to assess potential lead and hydrocarbon contamination • Targeted soil sampling at locations with dumped materials, fill materials and other agricultural uses • Areas of PASS within construction footprint to determine oxidised pH level.	Roads and Maritime	Prior to construction
Contaminated land disturbance	SC02	A Contaminated Land Management Plan will be prepared and implemented as part of the CEMP for any areas of existing contaminated land or to address land contamination likely to be caused by the activity. The plan will be prepared in accordance with relevant requirements of the Roads and Maritime Guideline for the Management of Contamination (2013c) and, as a minimum address the following matters: • Control measures to divert surface runoff away from the contaminated land • Capture and manage of any surface runoff contaminated by exposure to the contaminated land • Further investigations required to determine the extent, concentration and type of contamination, as identified in the Phase 2 contamination investigations • Manage the remediation and subsequent validation of the contaminated land, including any certification required • Measures to ensure the safety of site personnel and local communities during construction • Procedures to identify and manage any unexpected contamination finds during construction.	Contractor	Detailed design

Impact	ID No.	Environmental management measure	Responsibility	Timing
Remediation of contamination	SC03	If site contamination investigations indicate that construction works will impact contaminants that are present on site in concentrations above the intended land use criteria, then a Remedial Action Plan will be developed, and remediation works carried out in consultation with the EPA and in accordance with the Roads and Maritime's Contaminated Land Management Guidelines.	Contractor	Detailed design
Soil, surface water and groundwater quality	SC04	A Soil and Water Management Plan (SWMP) will be prepared in accordance with Landcom (Blue Book) Erosion and Sediment Control Principles and Procedures (Landcom 2004) and Erosion and Sediment Management Report: Coffs Harbour Bypass (SEEC 2019) and implemented as part of the CEMP. The plan will identify all reasonably foreseeable risks relating to soil erosion and water pollution associated with carrying out the activity and describe how these risks will be managed and minimised during construction. The plan will include arrangements for managing pollution risks associated with spillage or contamination on the site and adjoining areas.	Contractor	Detailed design
Soil erosion and sedimentation	SC05	A primary Erosion and Sediment Control Plan (ESCP) will be prepared and implemented as part of the SWMP. The plan will identify detailed measures and controls to be applied to minimise erosion and sediment control risks including: • Runoff, diversion and drainage points • Sediment basins and sumps • Scour protection • Stabilising disturbed areas as soon as possible, check dams, fencing and swales • The need for site-specific ESCP to address staged implementation arrangements. The plan will also include arrangements for managing wet weather events, including monitoring of potential high-risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather.	Contractor	Prior to and during construction
Erosion and sedimentation management	SC06	A suitably qualified and experienced soil conservationist will be engaged during construction of project to advise and review the implementation and management of erosion and sediment controls.	Contractor	Detailed design and during construction

Impact	ID No.	Environmental management measure	Responsibility	Timing
Soil erosion and bank stability risk	SC07	Batters will be designed and constructed to minimise risk or exposure, instability and erosion, and to support long term, ongoing best practice management, in accordance with the Guideline for Batter Stabilisation Using Vegetation (Roads and Maritime 2015b).	Contractor	Detailed design and during construction
Spill management during construction	SC08	A site-specific emergency spill response procedure will be developed as part of the SWMP and include spill management measures in accordance with the Roads and Maritime Code of Practice for Water Management and relevant EPA guidelines. The procedure will address measures to be implemented in the event of a spill, including initial response and containment, notification of emergency services and relevant authorities.	Contractor	Detailed design
Disturbance of acid sulfate materials	SC09	An ASS Management Plan will be prepared and implemented as part of the SWMP. The plan will be prepared in accordance with the Guidelines for the Management of Acid Sulfate Materials (RTA 2005).	Contractor	Detailed design

CHAPTER 19

Chapter 19

Surface water quality

19. Surface water quality

This chapter assesses the impacts of the project on surface water quality and identifies measures to manage these impacts.

Table 19-1 lists the SEARs relevant to surface water quality and where they are addressed in this chapter.

Table 19-1 Secretary's environmental assessment requirements for surface water quality

Ref	Key Issue SEARs	Where addressed
10. Water – Quality		
1.	The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine and marine waters (if applicable).	
	a) State the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values;	Section 19.2.1
	b) Identify and estimate the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment;	Section 19.3
	c) Identify the rainfall event that the water quality protection measures will be designed to cope with;	Section 19.3.1 Section 19.3.2 **Chapter 5, Project description** **Chapter 6, Construction**
	d) Assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	Section 19.3
	e) Demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that: - Where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and - Where the NSW WQOs are not currently being met, activities will work toward their achievement over time;	Section 19.3 Section 19.4
	f) Justify, if required, why the WQOs cannot be maintained or achieved over time;	Section 19.3
	g) Demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented;	Section 19.3 Section 19.4
	h) Identify sensitive receiving environments (which may include estuarine and marine waters downstream such as the Solitary Islands Marine Park) and develop a strategy to avoid or minimise impacts on these environments; and	Section 19.2.3 Section 19.3 Section 19.4

Ref	Key Issue SEARs	Where addressed
	i) Identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Section 19.4 Section 19.5 **Chapter 20, Groundwater**
11. Water – Hydrology		
2.	The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including	
	a) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge	Section 19.3 **Chapter 10, Biodiversity** **Chapter 17, Flooding and hydrology** **Chapter 20, Groundwater**
	d) Direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	Section 19.3.1 **Chapter 10, Biodiversity** **Chapter 17, Flooding and hydrology**
	e) Minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems;	Section 19.3.1 **Chapter 17, Flooding and hydrology**
	f) Water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	Section 19.3.1 **Chapter 6, Construction**

19.1 Assessment methodology

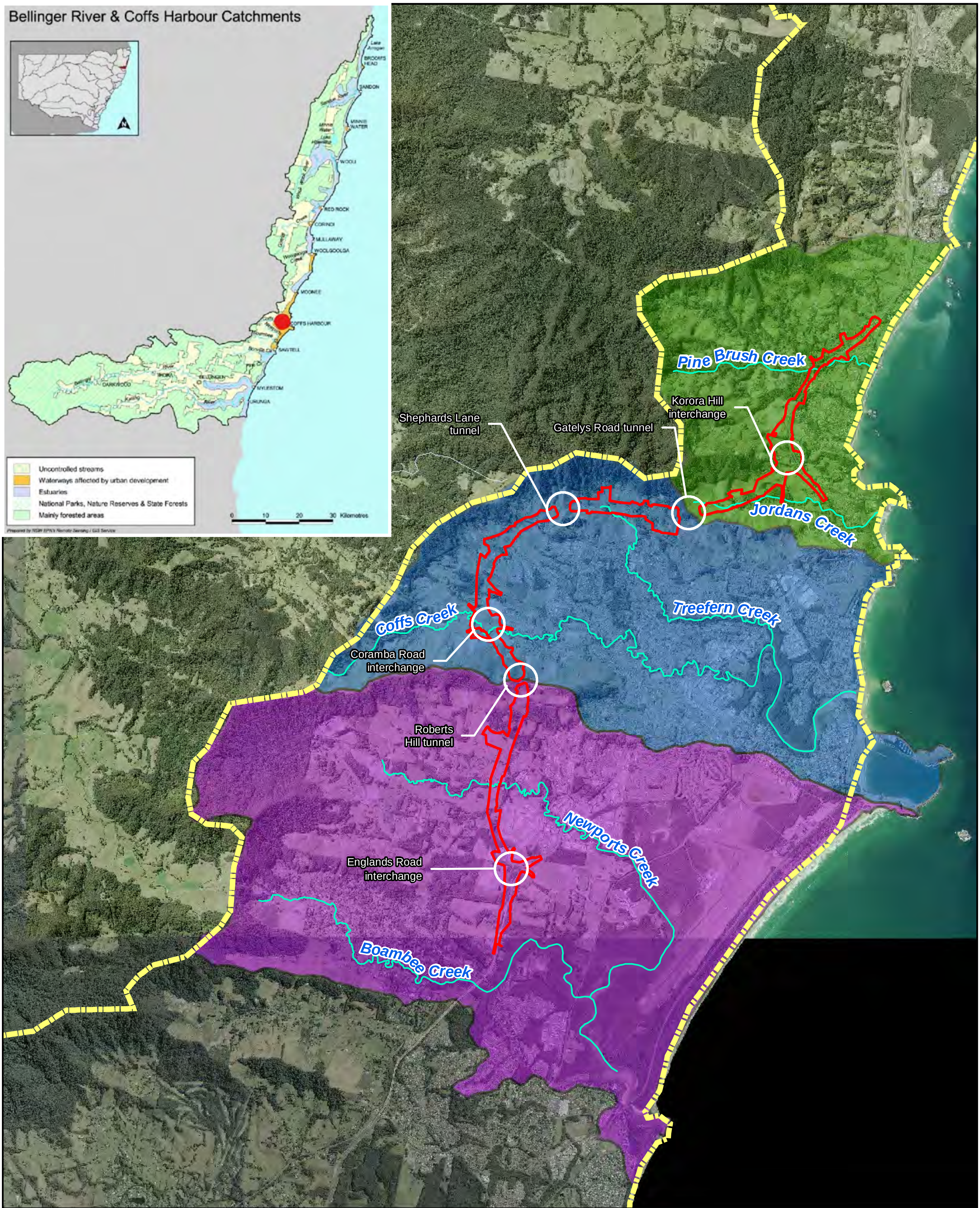
The assessment of the project's impact on surface water quality involved:

- Reviewing background information relevant to the study area to define the existing environment, including previous survey data, studies, mapping and topography
- Identifying and mapping sensitive receiving environments (such as wetlands, marine parks and groundwater dependent ecosystems)
- Identifying water quality objectives for the catchments in which the study area is located, based on the NSW Water Quality and River Flow Objectives for the Bellinger River and Coffs Harbour catchment (OEH 2018b)
- Field investigation involving the collection of water samples in Pine Brush Creek, Jordans Creek, Treefern Creek, Coffs Creek, Newports Creek and tributaries of these creeks
- Reviewing existing water quality conditions in the relevant receiving waterways against relevant water quality guidelines
- Describing the surface water quality treatment measures included in the concept design to reduce pollutants in runoff from the project

- Assessment of proposed stormwater treatment measures and preliminary erosion and sediment control plan using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC)
- Identifying and assessing the potential impacts to local catchment and sensitive receiving environments during construction and operation
- Identification of environmental management measures during construction and operation to mitigate potential impacts.

19.1.1 Study area

The study area for the surface water quality assessment is based on the construction footprint and includes a buffer to consider upstream and receiving environments in and around the project. The study area buffer includes the sub-catchments of Korora Basin, Coffs Creek and Boambee Creek water sharing catchments, as per the Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources, 2009 (DWE 2009). The extent of the study area buffer reflects the varying sizes of catchment areas within the Bellinger River and Coffs Harbour catchment (OEH 2018b) (**Figure 19-1**).



Legend

Bellinger River and Coffs Harbour Catchments

Construction footprint

Sub-catchments in the Study Area

Korora Basin

Coffs Creek

Boambee Creek

Coffs Harbour Bypass
Study area
Figure 19-1

0 0.75 1.5 2.25 km
Scale @A4: 1:75,000
GDA 1994 MGA Zone 56
N

19.1.2 Policy and planning setting

State legislation and guidelines relevant to this surface water quality assessment are provided in **Table 19-2.**

Table 19-2 Legislation and guidelines relevant to this assessment

Legislation / Guideline	Description	Relevance to this surface water assessment
Protection of the Environment Operations Act 1997 (POEO Act)	The POEO Act is the key piece of environment protection legislation administered by the EPA and enables the NSW Government to set out explicit protection of the environment policies and adopt more innovative approaches to reducing pollution. The POEO Act provides a single licensing arrangement relating to air pollution, water pollution, noise pollution and waste management.	Section 120 of the POEO Act prohibits the pollution of waters by any person. Under section 122, holding an environment protection licence is a defence against accidental pollution of watercourses. The Act permits (but does not require) an environment protection licence to be obtained for a non-scheduled activity for the purpose of regulating water pollution resulting from that activity. Refer to **Chapter 2, Assessment process** regarding environment protection licences.
Water Management Act 2000	The *Water Management Act of 2000* (WM Act) governs the issue of water pumping licenses to carry out further pumping work where a sharing license or framework is already in place. The WM Act is primarily a means to manage and safeguard the existence of rivers and aquifers used for commercial purposes as removing water from a system may impact the availability for ecological processes and requirements.	A controlled activity approval under the WM Act is required for certain types of developments and activities carried out in or near land that has the potential to affect water quality. It is noted that, as per section 5.23 of the EP&A Act, an activity approval (including a controlled activity approval) under section 91 of the WM Act is not required for approved SSI.
NSW Water Sharing Plans	The DPIE defines Water Sharing Plans so that the equitable sharing of water and resources can occur sustainably and under a strict licensing and approvals process. Water sharing plans fall under the WM Act.	The construction footprint falls within the Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources 2009 (DWE 2009).
NSW Water Quality and River Flow Objectives	The NSW Water Quality and River Flow Objectives have been set out for fresh and estuarine surface waters to identify: • The community's values and uses of these surface waters • Water quality indicators to assess the current condition of the waterways. These water quality and flow objectives are consistent with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000).	The Bellinger River and Coffs Harbour Water Quality and River Flow Objectives for uncontrolled streams and waterways affected by urban development in lowland rivers are applicable to the assessment.

Legislation / Guideline	Description	Relevance to this surface water assessment
NSW Framework for Biodiversity	The Framework for Biodiversity Assessment (FBA) (OEH 2014a) comprises the assessment methodology to quantify and describe the impact assessment requirements and assess all biodiversity values for major projects. Appendix 2 of the FBA relates to the ordering of waterways and riparian buffer distances.	The project would need to consider impacts to riparian vegetation. This is addressed in **Chapter 10, Biodiversity**.

19.1.3 Strategies and guidelines

The National Water Quality Management Strategy is a joint national approach to improving water quality in Australian and New Zealand waterways. It was originally endorsed by two ministerial councils – the former Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) and the former Australian and New Zealand Environment and Conservation Council (ANZECC). The strategy establishes objectives to achieve sustainable use of the nation's water resources by protecting and enhancing their quality.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (known as the ANZECC guidelines) (ANZECC & ARMCANZ 2000) forms part of the strategy. This document sets water quality guidelines (numerical concentration limits or descriptive statements) for a range of ecosystem types, water uses (environmental values), and water quality indicators for Australian waters.

In 2006, water quality and river flow objectives were developed for 31 river catchments in NSW based on the ANZECC guidelines. These include the Bellinger River and Coffs Harbour catchment, in which the project is located. These objectives (known as the NSW Water Quality and River Flow Objectives) are the agreed environmental values and long-term goals for NSW's surface water receptors. Guidance on the use of the ANZECC guidelines and the NSW water quality objectives is provided by Using the ANZECC Guidelines and Water Quality Objectives in NSW (DEC 2006a). In NSW, these represent the community's environmental values for waterways expressed for each catchment in the state.

19.1.4 Field investigation

Water quality sampling was conducted over two survey events at 17 sites to capture baseline water quality conditions in the study area (**Figure 19-2** and **Table 19-3**). The first survey was completed on 17 and 18 April 2018, to capture the end of the wet season, with the second survey occurring on 24 and 25 July 2018 to capture the early dry season. Sites were not ground-truthed but preselected based on general proximity to the project, likelihood of collecting water and a range of waterway sizes. All sites were assessed for general condition, potential localised impacts and additional features that may contribute to the quality of the water. All sites were selected within the freshwater sections for the purposes of consistency of comparing locations across a number of creek sub-catchments.

Legend

- Construction Footprint
- North Coast Railway
- Water quality sampling sites
- Bellinger River and Coffs Harbour Catchments

Coffs Harbour Bypass
Water quality sampling sites
Figure 19-2

0 0.45 0.9 1.35 km
Scale @A4: 1:45,000
GDA 1994 MGA Zone 56
N

Table 19-3 Water quality sampling sites

Site	Location	Stream order[1]	Description and relevance to the construction footprint	Wet season (April 2018)	Dry season (end July 2018)
1	Newports Creek	4	Defined flowing channel. The site location is about 130 m upstream of the construction footprint and about 180 m north of Englands Road.	Water flowing during sampling	Water flowing during sampling
4	Unnamed tributary to Newports Creek	3	Defined channel. Site surveyed about 200 m upstream of the construction footprint.	Water flowing during sampling	Water flowing during sampling
5	Unnamed tributary of Newports Creek	4	Upstream of the confluence with Newports Creek, about 170 m downstream of Site 4 and downstream of the construction footprint. Moderate riparian coverage throughout this section.	Water flowing during sampling	Water flowing during sampling
6	Coffs Creek	3	Within construction footprint. Limited riparian cover restricted within high banks of channel. Adjacent to Coramba Road.	Water flowing during sampling	Water flowing during sampling
7	Treefern Creek	3	Over 1 km downstream of the construction footprint.	Water flowing during sampling	Water flowing during sampling
8	Unnamed tributary of Coffs Creek	3	Within construction footprint. Some riparian cover present and site is disturbed by cattle.	Water flowing during sampling	Water flowing during sampling
9	Unnamed tributary	Not mapped - 1	Small drainage feature, about 100 m upstream of construction footprint.	Dry	Not surveyed[2]
10	Pine Brush Creek	4	Well defined channel with steep banks, immediately (15-20 m) upstream of construction footprint and downstream from the Kororo Nature reserve.	Water flowing during sampling	Water flowing during sampling
11	Unnamed tributary of Pine Brush Creek	4	Well defined channel with intact riparian vegetation 130 m upstream of the construction footprint.	Water flowing during sampling	Water flowing during sampling
12	Pine Brush Creek	4	Well defined channel 50 m downstream of the construction footprint. Immediately upstream of the Solitary Island Marine Park reserve zone boundary that starts on the downstream side of the James Small Drive bridge crossing. The site surveyed was within the freshwater reach.	Water flowing during sampling	Water flowing during sampling

Site	Location	Stream order[1]	Description and relevance to the construction footprint	Wet season (April 2018)	Dry season (end July 2018)
14	Unnamed tributary of Boambee Creek	1	Minor waterway within the construction footprint. Location associated with existing culvert off the Pacific Highway. Likely a drainage channel however connects to Boambee Creek.	Water present but not flowing during sampling	Water present but not flowing during sampling
15	Upper Pine Brush Creek	3	Well defined channel with intact riparian vegetation, 1.5 km upstream of the construction footprint.	Water flowing during sampling	Water flowing during sampling
16	Unnamed tributary to Newports Creek (upstream of Site 2)	3	Defined channel near existing road crossing 100 m upstream of the construction footprint.	Water present but not flowing during sampling	Water present but not flowing during sampling
17	Jordans Creek	3	Added in dry season survey as a number of sites to account for preselected sites being dry for during the wet season. Located 450 m downstream of existing Pacific Highway.	-	Water flowing during sampling

1 Stream order – consistent with the stream order identified in Chapter 10, Biodiversity
2 Not surveyed due to lack of water and/or was not accessible at the time of the survey

19.1.5 Operational water quality modelling and assessment

MUSIC modelling was carried out to estimate the impact of the project on pollutant loads and concentrations discharged from the project in the three local sub-catchments. The pollutants modelled included total suspended solids (TSS), total nitrogen (TN) and total phosphorous (TP). For all water quality modelling, MUSIC computer software (version 6) was used. MUSIC is a conceptual model and applies typical pollutant generation rates to the project catchments to inform design decisions on the type and size of stormwater treatment devices required.

MUSIC estimates stormwater pollutant generation and simulates the performance of stormwater treatment devices individually and as part of a treatment train (individual devices connected in series to improve overall treatment performance). By simulating the performance of stormwater quality improvement measures, MUSIC provides information on whether a proposed stormwater management system conceptually would achieve water quality targets.

The modelled areas included the full design extent of the project incorporating main carriageways, ramps, interchanges and all local roads. Catchment scale modelling was also completed to measure the change in pollutant concentrations in the sensitive receiving environments (refer to **Section 19.3.3**) of each sub-catchment.

The modelled design scenarios are as follows:

- **Existing condition**: modelled condition of pollutant load entering the receiving environment of the existing hard surfaces before the addition of the concept design
- **Design** – **unmitigated**: modelled pollutant load entering the receiving environment without the addition of any stormwater controls and or mitigation devises

- **Design – mitigated**: modelled pollutant load entering the receiving environment with the addition of stormwater controls and or mitigation devises (inclusive of swales, sediment basins, and propriety devices).

The results from the modelling were then used to assess potential impacts to local catchment and sensitive receiving environments during operation.

Chapter 5, Project description provides further detail on the stormwater controls and or mitigation devices included for the project. The type and design of specific stormwater treatment measures would be further refined as part of the detailed design process.

19.1.6 Construction water quality modelling and assessment

The primary impact to water quality during construction would be through the transport of sediment during vegetation clearing and earthworks. Construction phase impacts to surface water quality in waterways and sensitive receiving environments have been identified through the development of a conceptual Erosion and Sediment Management Report and Plan (SEEC 2019), which included a preliminary erosion and sediment control plan identifying treatment and mitigation strategies.

As part of the preparation of the Erosion and Sediment Management Report, preliminary water quality modelling of the proposed construction-phase sediment basin discharge limits was also carried out using MUSIC modelling to assess against the NSW Water Quality Objectives (NSW WQOs). Similar to operational modelling, the three pollutants of concern for the construction phase were TSS, TN and TP.

This impact assessment also provides a qualitative consideration of construction phase risks and impacts relevant to surface water quality identified in **Chapter 6, Construction**. This included, but is not limited to, bulk earthworks, stockpiling and storage of equipment and materials, operation of batch plants, disturbance of potential or actual acid sulphate soils, temporary and permanent waterway crossings, waterway realignments, release of hydrocarbons through spills and dewatering.

19.2 Existing environment

19.2.1 Bellinger River and Coffs Harbour catchment

The project is located within the Bellinger River and Coffs Harbour catchment which extends north to Yamba and south to the Bongil Bongil National Park (**Figure 19-1**). The catchment is over 1000 km^2 and includes a range of smaller coastal creek sub-catchments bordered by the Great Dividing Range. The section of the Bellinger River and Coffs Harbour catchment where the project is located is quite narrow with the head waters occurring within the surrounding escarpment of the Great Dividing Range before flowing through the sub-catchment and water sharing areas of the Korora Basin (Pine Brush Creek and Jordans Creek), Coffs Creek (Treefern Creek and Coffs Creek) and Boambee Creek. (DPI, 2009).

The catchment area is dominated by historic clearing for the timber industry and agriculture which is predominantly a range of fruit production including bananas and blueberries. Steep areas of the catchment remain vegetated and urban development within Coffs Harbour is expanding from the coastal plain to the foothills. As such, the waterways of the Bellinger River and Coffs Harbour catchment areas have been encroached upon and most have only narrow strips of riparian vegetation remaining.

Agriculture in the area extracts water from waterways for irrigation, which would likely affect the flow levels and rates of the waterways and the runoff of nutrients and sediments into the receiving environments.

The ambient NSW Water Quality and River Flow Objectives (DECCW 2006) are consistent with the agreed national framework of the ANZECC Water Quality Guidelines and are 'primarily aimed at maintaining and improving water quality, for the purposes of supporting aquatic ecosystems, recreation and where applicable, water supply, and the production of aquatic foods suitable for consumption and aquaculture activities' (DECCW 2006).

The NSW Water Quality and River Flow Objectives have been developed by the NSW Government for the Bellinger River and Coffs Harbour catchment. The classifications of receiving waterways in the study area are provided in **Table 19-4**. The water quality and river flow objectives and environmental values relevant to the waterways and catchment in the study area are summarised in **Table 19-5**. These objectives are provided to describe the baseline water quality in the study area.

Table 19-4 Receiving waterway sub-catchments and classification

Sub-catchment	Receiving waterway within study area	Classification of waterway in accordance with NSW WQO and River Flow Objectives
Korora Basin	Pine Brush Creek	*Waterways affected by urban development* within construction footprint and downstream
	Jordans Creek	*Waterways affected by urban development* within construction footprint and downstream
Coffs Creek	Coffs Creek	*Uncontrolled stream* within construction footprint and downstream reaches classified as *waterways affected by urban development*
	Treefern Creek	*Uncontrolled stream* within construction footprint and downstream reaches classified as *waterways affected by urban development*
Boambee Creek	Newports Creek	*Uncontrolled stream* within construction footprint and downstream reaches classified as *waterways affected by urban development*
	Boambee Creek	*Uncontrolled stream* within construction footprint and downstream reaches classified as *waterways affected by urban development*

Table 19-5 NSW environmental values and water quality objectives relevant to the project

Objective	Environmental values	Applicable waterways	Relevant trigger value or criteria
Water quality objectives			
Aquatic ecosystems	Maintaining or improving ecological conditions of waterways and riparian zones.	Pine Brush Creek Jordans Creek Treefern Creek Coffs Creek Newports Creek Boambee Creek	- Total phosphorous: 25 µg/L - Total nitrogen: 350 µg/L - Turbidity: 6-50 NTU - Electrical conductivity: 125-2200 µS/cm - Dissolved oxygen (% sat): 85-110% - pH: 6.5-8.5
Visual amenity	Maintaining the aesthetic qualities of waters.	Pine Brush Creek Jordans Creek Treefern Creek Coffs Creek Newports Creek Boambee Creek	<u>Visual clarity and colour</u> - Natural visual clarity should not be reduced by more than 20% - Natural hue of the water should not be changed by more than 10 points on the Munsell Scale - The natural reflectance of the water should not be changed by more than 50% <u>Surface film and debris</u> - Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour

Objective	Environmental values	Applicable waterways	Relevant trigger value or criteria
			- Waters should be free from floating debris and litter Nuisance organisms - Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts (which can be a by-product of higher levels of nutrients)
Irrigation water supply*	Protecting the quality of waters applied to crops and pasture	Pine Brush Creek Jordans Creek Treefern Creek Coffs Creek Newports Creek Boambee Creek	- No visible blue-green algae - Long term trigger values (LTV) and short-term trigger values (STV) for heavy metals and metalloids in irrigation water are presented in Table 4.2.10 of the ANZECC 2000 Guidelines

** Objective also includes trigger values for faecal coliforms, however these are not considered relevant for the purposes of the assessment*

19.2.2 Major waterways

There are six major waterways within the study area, with multiple tributaries which generally flow in an easterly direction from the foothills of the Great Dividing Range and discharge in the ocean. The lower reaches of the sub-catchments are subject to tidal effects and estuarine processes and are extensively connected to groundwater in the alluvial areas near the coast. The six major waterways within the study area are shown in **Figure 19-1**, with a brief description of the waterways and project components provided in **Table 19-6**.

Table 19-6 Summary description of major waterways within the study area

Waterway	Description	Project components
Pine Brush Creek	Pine Brush Creek is a fourth order stream with headwaters in the steep, northern end of the Coffs escarpment. Where it crosses the construction footprint, Pine Brush Creek is in a reasonable condition with good ecological value, aquatic habitat and a generally intact riparian corridor.	The existing Pacific Highway crosses Pine Brush Creek on a multi-span bridge. The project would include the construction of two new multi-span bridges across Pine Brush Creek, with the retention of the existing bridge. The project would require work within the Pine Brush Creek and realignment of the channel would be required upstream of the new bridge. Realignment of a smaller tributary of Pine Brush Creek, upstream of the highway would also be required.
Jordans Creek	Jordans Creek is a third order stream, with headwaters in the lower escarpment slopes. The majority of the upper catchment of this creek has been modified for agriculture, with native vegetation reduced in the riparian zone.	The project passes through a reach of Jordans Creek that has reasonable riparian vegetation cover and aquatic habitat. The project would require realignment of the headwaters of this waterway and use culverts to cross Jordans Creek and a number of its tributaries.

Waterway	Description	Project components
Treefern Creek	Treefern Creek is a third order stream. The upper catchment of this waterway has largely been cleared for agriculture, including the construction of a farm dam. The lower reaches of Treefern Creek pass through urban areas of Coffs Harbour, eventually flowing into the tidal reaches of Coffs Creek.	The project would traverse the headwaters of Treefern Creek, at the base of the escarpment. The design will require the realignment of the headwaters of Treefern Creek and include a culvert crossing over the new channels.
Coffs Creek	The main channel of Coffs Creek is a fourth order stream where it crosses the project near Coramba Road. There are also a number of lower order reaches in the upper catchment that are within the construction footprint. The upper catchment of this waterway has been cleared, with limited aquatic value and riparian vegetation.	The main channel of Coffs Creek would be traversed by bridges associated with the main carriageway and two entry/exit ramps to the south of the Coramba Road interchange. The project would extend of the existing culvert under Bennetts Road and realign of Coffs Creek where the project crosses the creek south of Coramba Road. The Bennetts Road detention basin would also be modified for flood mitigation purposes and there are also a number of lower order streams of this waterway in the upper catchment that would be diverted through culverts.
Newports Creek	Newports Creek and its tributaries drain the North Boambee Valley. Its upper catchment is in the well vegetated escarpment. The floodplain catchment has been cleared, with some narrow strips of riparian vegetation retained.	The project would cross six tributaries of Newports Creek, including the main channel. The main channel and larger tributaries would be crossed by bridges, with waterway realignments potentially required. Smaller tributaries would be crossed by culverts.
Boambee Creek	Boambee Creek begins in the upper escarpment and traverses through rural residential areas west of the existing highway. The main channel of Boambee Creek crosses the existing Pacific Highway to the south of the project.	The project does not include any components within or immediately adjacent Boambee Creek. At its closest point, the waterway is located about 250 m from the construction footprint.

19.2.3 Sensitive receiving environments

A sensitive receiving environment is defined as one that has a high conservation or community value or supports ecosystems or water for human use and is particularly sensitive to pollution and/or degradation of water quality. The following sections describe sensitive receiving environments relevant to the project.

Solitary Islands Marine Park

Pine Brush Creek, Jordans Creek, Treefern Creek and Coffs Creek waters flow into the Solitary Islands Marine Park area (**Figure 19-3**). The NSW Marine Park boundary extends along Pine Brush Creek to Opal Boulevard and then to James Small Drive, with the construction footprint occurring about 150 m upstream from the NSW Solitary Islands Marine Park boundary.

The Solitary Islands Marine Park is the third largest marine protected area in NSW. The reserve extends north from Coffs Harbour about 75 km to Sandon River and covers a total area of 71,000 ha.

The Commonwealth Solitary Islands Marine Park is directly adjacent to the seaward boundary of the NSW Solitary Islands Marine Park and extends three nautical miles seaward for an area of 152 km^2. This section of the Commonwealth Marine Park is considered a matter of national environmental significance (MNES) under the EPBC Act.

Wetlands

There are three Coastal Management SEPP wetlands within the study area with some (the Boambee wetlands) immediately adjacent to the construction footprint at the southern extent of the project (**Figure 19-3**). Coastal Management SEPP wetlands within the study area include Pine Brush Creek wetlands, Coffs Creek wetlands and Boambee wetlands.

There is a small section of the mapped Boambee wetlands within 100 m of the southern end of the construction footprint. However, no project works will occur within the wetland, or the 50 m wetland buffer.

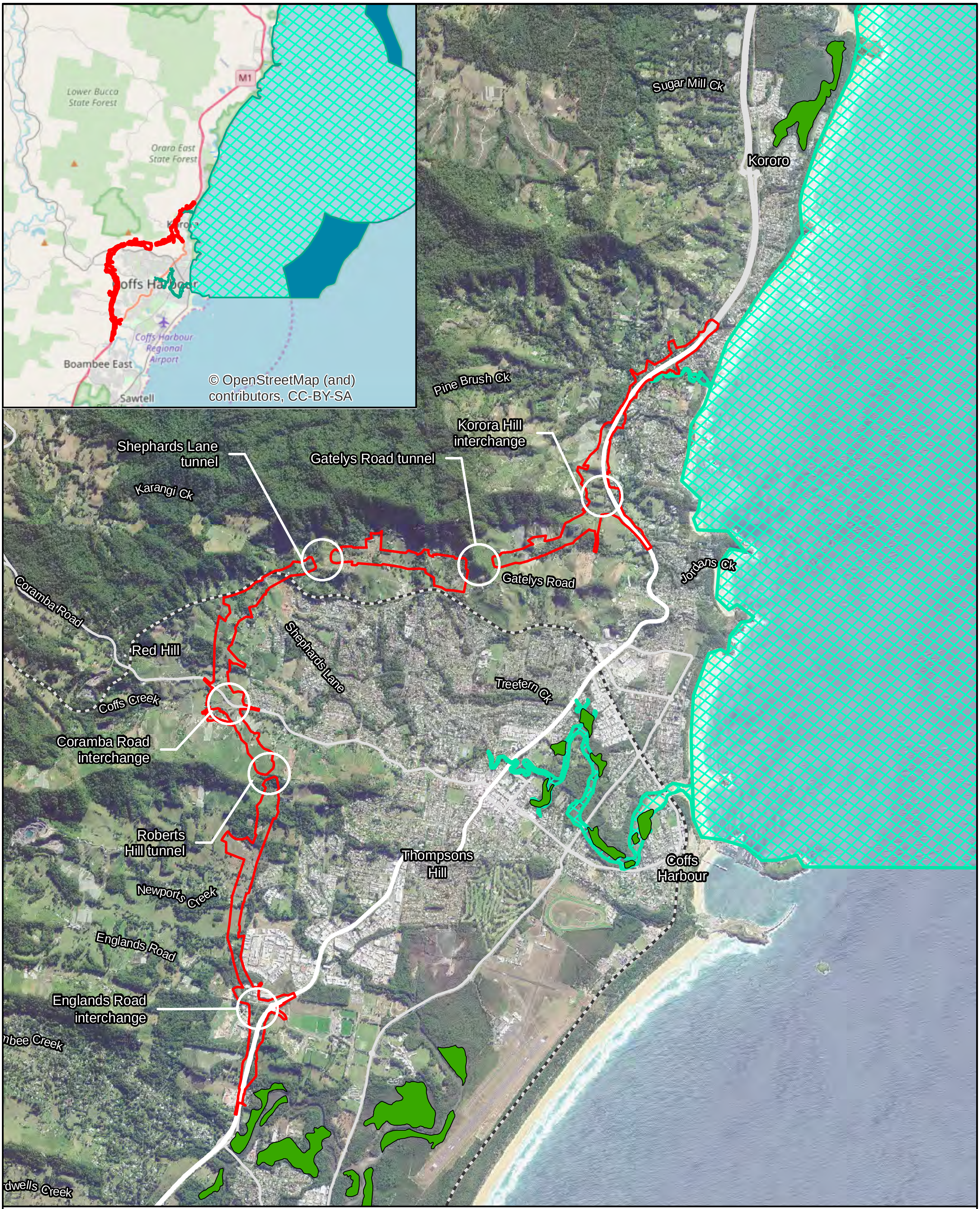
Coffs Creek wetlands are located over five kilometres downstream from the construction footprint following Coffs Creek or about 3.7 km downstream from the construction footprint following Treefern Creek. Coffs Creek wetlands consist of small sections of tidal wetlands and are within and adjacent to sections of the Solitary Islands Marine Park.

The wetlands associated with Pine Brush Creek are mapped about 800 m downstream from the construction footprint and are also within the Solitary Islands Marine Park.

Threatened freshwater fish habitat

Southern purple spotted gudgeon *Mogurnda adspersa* is listed in NSW as an endangered species. Potential habitat includes the main channel of the upper Coffs Creek and upper Newports Creek (DPI 2009). However, no southern purple spotted gudgeons were identified within the aquatic habitat surveys (see **Chapter 10, Biodiversity**) and habitat for this species is considered to be limited within the wider study area.

During the desktop and field ecological surveys carried out for the project, no other threatened freshwater fish species were considered likely to occur or identified within the construction footprint. Habitat suitability and field surveys described in **Chapter 10, Biodiversity** suggest that the construction footprint and study area provide negligible habitat for threatened fish species. This potential sensitive receiver is not considered further in this impact assessment as is it very unlikely that there are threatened freshwater fish habitats within the study area.



Legend

- Construction Footprint
- North Coast Railway
- NSW Coastal Management SEPP wetlands
- Solitary Islands Marine Park (NSW)
- Solitary Islands Marine Park (Commonwealth)

Coffs Harbour Bypass
Solitary Islands Marine Park and NSW Coastal Management SEPP wetlands
Figure 19-3

0 0.6 1.2 1.8 km
Scale @A4: 1:60,000
GDA 1994 MGA Zone 56
N

19.2.4 Surface water quality

An assessment conducted by CHCC and DPIE (Environment, Energy and Science) assessed river and estuarine conditions within the Coffs Creek and Boambee Creek catchment areas between 2014 and 2015 (Ryder 2016). This assessment determined that water quality in the Coffs Creek catchment was a grade D+ (poor), meaning that very few of the NSW WQO objectives and indicators defined in the Ecohealth Project were met. The Boambee Creek sub-catchment was slightly better, being given a grade of C (fair), meaning only some of the NSW WQO objectives were met.

The Coffs Creek Coastal Zone Management Plan (CHCC 2012) identified a number of major issues related to water quality which could affect the water quality in the catchment including:

- Poor water quality resulting from runoff in developed and agricultural areas
- Riverbank erosion and sedimentation and its effects on habitat and water quality
- Management of the estuary entrance and water depth
- Decline in riverbank and aquatic vegetation and habitat
- Climate change, flooding and sea level rise
- Fishing and the impact on fish stocks
- Increasing demands for improved recreational use and public access
- Pressures from urban expansion on natural and cultural values.

Water quality in the area is affected by urbanisation with significant land use changes expected to continue within the catchment with residential, rural and industrial development.

While it is likely that watercourses within the study area would be classified as highly disturbed systems (being urban streams receiving road and stormwater runoff), the ANZECC guidelines recommend that the guideline trigger values for slightly to moderately disturbed systems should also apply to highly disturbed ecosystems wherever possible.

Results of ambient water quality sampling

Water quality results from the field surveys completed in 2018 is provided in **Table 19-7,** with a more detailed summary of sampled key sampled parameter provided in **Table 19-8.** Water quality results were compared to the relevant Bellinger River and Coffs Harbour WQOs (waterways affected by urban development and uncontrolled streams) for aquatic ecosystems. Where sampled water quality parameters are outside the range prescribed in the NSW WQOs, cells are shaded red.

Table 19-7 Existing water quality conditions in the study area

Waterway	Samples collected	Description of key water quality parameters
Pine Brush Creek	Samples collected at Sites 10, 11 and 12 adjacent to existing Pacific Highway	• Water clarity good, with all samples well below the NSW WQO for turbidity • Sites 10 and 12 recorded nitrogen concentrations above the NSW WQOs • Water clear, with low turbidity and no visible films or debris
Jordans Creek	Samples collected at Site 17 located downstream from the project	• Water clarity good, with samples well below the NSW WQO for turbidity • Nitrogen concentration above the NSW WQO

Waterway	Samples collected	Description of key water quality parameters
Treefern Creek	Samples collected at Site 7 located downstream from the project	• Water clarity good, with samples well below the NSW WQO for turbidity and no visible films • Exotic vegetation cover dominant in riparian zone • Dissolved oxygen percentage saturation measured slightly below the NSW WQO • Elevated nitrogen concentration measured at four times higher than the NSW WQO • Substantially elevated phosphorous concentrations measured at 35 times higher than the NSW WQOs
Coffs Creek	Samples collected at Sites 6 and 8 within the project	• Water clarity good, with one sample below the NSW WQO for turbidity and the other within the range. • Exotic vegetation cover dominant, with some visible turbidity • Dissolved oxygen percentage saturation measured below the NSW WQO at both sites • Nitrogen concentration above NSW WQO at both sites
Newports Creek	Samples collected at Sites 1, 4, 5 and 16	• Extremely low dissolved oxygen concentration at Site 16 • Site 16 also high concentrations of nitrogen and phosphorous above the NSW WQOs • Site 1 also had concentrations of nitrogen above the NSW WQOs • Native vegetation cover in riparian zone and no visible films or debris
Boambee Creek	Samples collected at Site14 within the project	• Water clarity good, with samples below the NSW WQO for turbidity • No visible oils, films or floating debris • Extremely low dissolved oxygen percentage saturation • Concentrations of nitrogen and phosphorous above the NSW WQOs • Site 14 also has elevated levels of zinc present in both dissolved and total metals

Table 19-8 Water quality sampling results for key chemical parameters (red cells indicate values outside of NSW WQOs)

Parameter	Unit	NSW WQO	1 Newports Creek	4 Newports Creek	5 Newports Creek	6 Coffs Creek	7 Treefern Creek	8 Coffs Creek	10 Pine Brush	11 Pine Brush	12 Pine Brush	14 Boambee Creek	15 Pine Brush	16 Newports Creek	17 Jordans Creek
pH	**pH Unit**	**6.5-8.5**	7.47	7.06	6.83	6.92	7.14	6.76	6.96	6.89	7.11	7.14	7.05	7.16	7.12
Electrical Conductivity	**µS/cm**	**125-2200**	146.63	134.17	132.83	206.00	176.17	138.00	218.00	209.83	218.00	265.83	173.83	772.33	192.00
Turbidity	**NTU**	**6 to 50**	2.01	2.53	6.87	5.40	0.72	18.13	0.77	0.64	0.67	5.13	2.05	10.77	0.80
Dissolved Oxygen	**% sat**	**85-110**	66.45	33.95	33.40	69.80	82.80	55.70	84.75	92.60	85.15	19.10	77.25	9.95	80.40
Total Nitrogen	**mg/L**	**<0.35**	0.212	0.195	0.206	0.933	2.0	0.725	0.508	0.331	0.463	1.195	0.341	4.133	0.640
Total Phosphorus	**mg/L**	**<0.025**	0.009	0.0083	0.0078	0.0068	0.878	0.0074	0.0063	0.005	0.005	0.071	0.008	0.130	0.008
Calcium (Dissolved)	**µg/L**	**-**	3.25	2.44	2.08	8.21	3.05	3.25	2.75	2.40	2.81	17.50	2.49	44.07	4.90
Hardness	**mg/L**	**90**	23.50	21.00	16.00	43.13	16.39	24.00	18.00	19.13	21.50	68.50	21.00	155.00	29.50
Zinc (total)	**µg/L**	**8**	3.96	2.21	1.94	5.33	6.93	2.23	2.05	2.25	2.28	48.05	2.48	53.12	2.50

* Water quality objectives not defined in the Bellinger River and Coffs Harbour WQOs and ANZECC trigger values for aquatic ecosystem protection applied

All sites sampled were within the normal range of the NSW WQOs for pH and electrical conductivity. Most sites were below the normal range for turbidity and dissolved oxygen. Although turbidity results were often below the NSW WQO normal range of 6-50 NTU, this does not reflect poor water quality, but instead reflects the natural conditions of the catchment area. A low NTU (extremely clear water) can be an indicator of very low levels of microorganisms such as plankton and algae.

The majority of the sites sampled experienced dissolved oxygen levels below the NSW WQOs. Low dissolved oxygen is often a by-product of higher concentrations of nutrients, such as nitrogen and phosphorus. Total nitrogen (inclusive of ammonia, nitrates and nitrites) exceeded WQOs for most sites. This was anticipated given the current and historic land usage in the catchment. Nitrogen can occur naturally in high concentrations within soils but is generally influenced by chemical fertilisers and runoff.

Three sites substantially exceeded the NSW WQO for total phosphorus. These three sites also had generally higher concentrations of most metals and other analytes. These sites included one as part of the lower Boambee Creek catchment, and the other was downstream of the Coffs Coast Resource Recovery Park (Site 14). Water was not flowing at the time of either survey, but they did contain water. This likely has contributed to higher concentrations of these parameters and is representative of limited catchment areas and waterways that typically only flow immediately after rain events.

Concentrations of most metals were below the relevant trigger levels for all sites except for zinc (dissolved) at one site, which was just over the ANZECC guideline (ANZECC & ARMCANZ 2000). All other metals, and total petroleum hydrocarbons were either below available guidelines values and/or below the laboratory limit of reporting (LOR).

There were some fluctuations between the wet season and dry season with the dry season often having higher concentrations of the various parameters measured. This reflects the seasonal influence on the quality of the water in the region.

Overall the water quality was generally within the existing regional WQO and ANZECC guidelines. Given the consistency of conditions within the study area, it can be presumed that the region has high pre-existing concentrations of total nitrogen and total phosphorus with low dissolved oxygen throughout the region. This is further supported by the Ecohealth assessment of Coffs Creek and Boambee/Newports Creek having low dissolved oxygen and high total nitrogen (Ryder 2016). High nutrients were also recorded during the aquatic ecology assessments at most survey locations across the region (refer to **Chapter 10, Biodiversity**).

The above results are common in regions of disturbed water courses surrounded by heavy agricultural uses. One of the major environmental risks during construction of the project would be the release of sediment into the receiving environment. Most waterways assessed had low turbidity and the movement of sediment would also increase the risk of the release of other contaminants bound in the soils (see **Chapter 18, Soils and contamination**).

19.3 Assessment of potential impacts

The sections below describe and assess the potential impacts on water quality during construction and operation of the project as a well potential risks and impacts associated with the sensitive receiving environments describe in **Section 19.2.3**.

19.3.1 Construction

Construction presents a risk to downstream water quality if standard construction management measures are not implemented, monitored and maintained throughout the construction period. If inadequately managed, construction activities could impact water quality if they disturb soil or watercourses, result in uncontrolled discharges of substances to watercourses, or generate contamination.

Potential sources of water quality impacts include:

- Increased sediment loads from exposed soil transported downstream during rainfall events
- Increased levels of nutrients, metals, and other pollutants transported in sediments to downstream waterways or via discharge of water to waterways
- Chemicals, oils, grease, and petroleum hydrocarbon spills from construction activities directly polluting waterways downstream from construction
- Litter from construction activities polluting waterways downstream
- Contamination of watercourses due to runoff from contaminated land
- Tannin leachates from stockpiled vegetation, which could enter watercourses, resulting in increased acidity, reduced water clarity and light penetration, and increased biological oxygen demand
- Exposure of potential or actual acid sulfate soils, which could result in the mobilisation of acidic runoff into watercourses
- Reuse of wastewater in construction activities.

The downstream effects of water quality impacts include:

- Impacts to the ecosystems of downstream sensitive waterways and wetlands
- Smothering aquatic life and/or inhibiting photosynthesis conditions for aquatic and riparian flora
- Impacts to breeding and spawning conditions of aquatic fauna and potential fish kills
- Changes to water temperature due to reduced light penetration
- Increased turbidity levels
- Risk to human health through release of hydrocarbons into receiving waters
- Reduced water clarity in recreation areas.

The sections below discuss activities that have a high risk of impacting water quality during construction and how they will be managed.

Bulk earthworks

Earthworks and soil disturbances during construction present the greatest risk of impact on water quality. The greatest risks during this time include:

- Reduced water quality (including increased total suspended solids and turbidity) as a result of erosion and sedimentation near watercourses
- Untreated stormwater runoff.

The exposure of soils (through topsoil stripping, excavation, stockpiling and transport of soil), could result in soil erosion by the action of wind or stormwater, and transport into waterways, leading to increased turbidity, sedimentation, and potentially the introduction of nutrients and any other pollutants associated with the sediments. Runoff from stockpiles has the potential to impact downstream water quality during rainfall if stockpiles are not managed appropriately. Sediment from the stockpiles could wash into watercourses, increasing levels of turbidity.

Nutrients and other pollutants potentially generated from rainfall runoff over exposed soils (such as TP, heavy metals and organic chemicals) often utilise sediment as the medium for transportation in runoff. The deposition of sediment can result in the release of these nutrients or pollutants later. This mechanism provides the opportunity for pollutant re-mobilisation in later flow events enhancing the risk of further environmental degradation of downstream aquatic ecosystems (Wong et al. 2000).

Earthworks could expose PASS or ASS in some parts of the construction footprint, which could result in the mobilisation of acidic runoff into watercourses. This would result in increased acidity of surface water and/or groundwater. This work could also cause the mobilisation of heavy metals into the environment. Refer to **Chapter 18, Soils and contamination** for further discussion on PASS and ASS.

Although the project has the potential to temporarily reduce water quality from pollutants and run-off, it is not expected that this would cause significant impacts to the overall condition of surrounding waterways. Construction would be unlikely to result in any long-term water quality impacts in the study area. The primary pollutant of concern from bulk earthworks is TSS, which could impact on turbidity within receiving environments.

Surface water at the construction sites will be managed by implementing standard erosion and sediment control measures in accordance with the Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004) (the Blue Book) and Volume 2 (A. Installation of Services; B. Waste Landfills; C. Unsealed Roads; D. Main Roads; E. Mines and Quarries) (DECC 2008). These best practice industry guidelines will be supplemented with Roads and Maritime technical guidelines that address key erosion and sediment risks during construction, such as Technical Guideline: Temporary stormwater drainage for road construction (Roads and Maritime 2011).

Sediment basins would be required for most catchments being disturbed during construction. These have been included in the concept design and are shown in **Chapter 6, Construction**. The final location and size of all sediment basins would be determined during detailed design. Sediment basins would be designed to contain the five-day 90th percentile rainfall event within all sub-catchments that drain into the Solitary Islands Marine Park. All other sub-catchments would include sediment basins designed for five-day 85th percentile rainfall event.

Alternative erosion and sediment control measures will be implemented in locations where designed sediment basins are needed but cannot be provided because of site, soil and drainage constraints to constructing large scale sediment basins. For these catchments, undersized sediment basins, sediment sumps, mulch bunds, sediment fences or similar combinations of thereof would be used. However, to manage potential associated risks, these catchments would also be subject to enhanced erosion control measures and best management practice, such as limiting the size of disturbed land at any one time. The enhanced erosion control measures will be mainly in the form of temporary ground cover and/or soil binders over high-risk areas (ie steep (>30 per cent) batters and concentrated flowpaths) whenever significant rainfall is imminent.

Secondary erosion and sediment control measures will be designed and implemented in accordance the Blue Book to achieve the relevant design average recurrence interval (ARI) criteria.

Permanent and temporary waterway crossing structures

Construction of permanent and temporary waterway crossing structures and associated work could interfere directly and indirectly with surface water quality during the construction. These activities could include construction of:

- Bridges
- Culverts
- Temporary crossings and working platforms.

The above construction work may impact upon the surface water quality through the disturbance of sediments through vegetation removal and earthworks which may increase turbidity and potentially change the water quality for the periods of the initial disturbance and settlement. These activities could also result in bank instability. Ten bridge crossings of major waterways would be constructed as part of the project. The waterways crossed include:

- Unnamed tributary of Newports Creek south of the main channel
- Newports Creek
- Unnamed tributary of Newports Creek near Highlander Drive
- Coffs Creek
- Pine Brush Creek.

In addition to bridges, a number of culverts would be constructed that would convey waterways, smaller tributaries and surface flood water. These permanent structures would require the installation of temporary structures in the forms of earthworks, temporary pads for piling, and possible temporary diversions of water for the installation of the structure.

The construction of waterway crossings is unlikely to result in a significant impact to water quality in receiving environments. Temporary works would increase the potential for the movement of sediments throughout the construction footprint and released into receiving environments. These impacts would be temporary and only occur during the construction phase. The mitigation measures provided in **Section 19.4** would be implemented to minimise the potential for water quality impacts during construction of temporary and permanent crossings.

Waterway realignments

A number of waterway realignments and adjustments would be required as part of the project. During detailed design, any realigned drainage line or watercourse would be designed to behave in a similar hydrologic and geomorphic manner as existing conditions and would consider the requirements of the Policy and Guidelines for Fish Habitat Conservation and Management (DPI 2013) and Guidelines for Instream Works on Waterfront Land (DPI 2012a).

Waterway realignments and adjustments would be needed at the following locations:

- Minor realignment of the meandering Newports Creek as it passes beneath the project. About 50 m of Newports Creek would be realigned around the piers of the bridge BR23
- Realignment of a northern tributary of Newports Creek as it passes beneath the project north of North Boambee Road. About 130 m of Newports Creek would be realigned around the piers of the bridge over the tributary (BR05). The realignment would involve shallow excavation of the floodplain beneath the bridge and would include a low flow channel so that natural flow conditions could be maintained, which would be designed in accordance with the requirements of the DPIE guidelines for fish conservation and management (Fairfull & Witheridge 2003)
- Minor realignment of the northern tributary of Newports Creek (about 400 m north of North Boambee Road and about 150 m north of BR05) as it passes beneath the project. A cross drainage culvert is proposed in this location to convey flood water beneath the project. The alignment of the culvert would generally follow the alignment of the existing creek and would include a low flow channel to provide for fish passage
- Extension of the existing culvert under Bennetts Road and realignment of Coffs Creek where the project crosses the creek south of Coramba Road. As a result of the extensive meander of Coffs Creek main channel at this location and the need for three bridge crossings (BR06, BR07 and BR08), about 90 m of Coffs Creek may require realignment and/or adjustment
- The upper reaches of Treefern Creek would be replaced with longitudinal catch drains and cross drains where the creek is impacted by the project. This includes about 120 m of the main creek channel. Fish passage requirements are not needed at this location because the existing creek is considered a Class 4 waterway, and drainage work would be managed through typical drainage design principles
- Realignment and temporary work within Pine Brush Creek would be required between the new bridge over Pine Brush Creek (BR20) and the existing bridge over Old Coast Road. Works would be limited to the riparian corridor (bank to bank) where feasible. In addition to the realignment of the main channel, minor realignment of the northern tributary of Pine Brush Creek immediately upstream the new bridge would also be required. About 35 m of the northern tributary would be realigned to optimise drainage and flow at this location and to provide a new confluence with the realigned tributary and main channel.

In addition to the above, a number of temporary diversions and minor realignments of drainage lines may also be needed to enable groundwork (such as placement of a drainage rock blanket) or for installation of culverts. The watercourse or drainage line would then be redirected along its natural course where feasible.

During the design process, options were considered to minimise the need for waterway realignments or diversions. The main channels of Pine Brush Creek and Newports Creek would be maintained in the current alignment with bridge structures traversing the channels. Future design for any waterway realignments would also consider solutions to minimise impacts to water quality, including consideration of natural channel design principles such as meanders and riparian vegetation cover.

The required waterway realignments and adjustments are not expected to have a significant impact on the water quality of the receiving environments. These realignments would result in the movement of sediments with the initial phases of construction and potentially until the creek realignments are stable. Impacts associated with waterway realignments are only expected to have an impact on TSS and turbidity in the receiving environments conditions.

The realignments could also impact on the natural deposition of bed sediments within the waterway modifying the water quality and the biotic composition of the waterway, at least for a temporary period until the channel sediments are re-established and bedded in. The ecological impacts of the waterway realignments are discussed in detail in **Chapter 10, Biodiversity** and hydrological impacts are discussed in **Chapter 17, Flooding and hydrology**.

Dewatering

A number of water storages (such as farm dams) have been identified within the construction footprint through aerial imagery and site investigations. Most of these storages are linked to agricultural usage, and the storages could be sources of concentrated levels of nutrients and other pollutants. There would be a risk that the process of dewatering these storages has the potential to affect the surface water quality in adjacent creeks. The release of water from farm dams may introduce nutrients (TP and TN) to receiving environments, through fertiliser runoff from agricultural practices. In addition, sediments within these dams may be contaminated with pesticides such as Aldrin, Dieldrin and DDT due to past land use practices. Water quality and sediment testing of these dams will be carried out as part of the Phase 2 contamination investigations described in **Chapter 18, Soils and contamination**. The results of this investigation will determine if specific management measures are required for treatment of any water discharged into waterways. Measures to minimise impacts associated with dewatering will need to be applied, depending on the identified pollutants in the farm dams.

Similarly, excavation activities may result in dewatering pits and or cuttings that would need to be managed in such a manner to minimise and mitigate potential impacts of the expression of groundwater released to the surface water environment. Considerations for dewatering would be addressed in the mitigation and controls within the Erosion and Sediment Control Plan and the Soil and Water Management Plan.

By applying the mitigation measures in these plans and any specific requirements for dewatering farm dams, the release of water from farm dams and excavations would be unlikely to result in a significant impact to water quality in receiving environments.

Vegetation clearing

Vegetation clearing would expose soils and potentially result in similar impacts as described above for bulk earthworks. Another key risk for water quality from vegetation clearing is from its stockpiling.

Stockpiling cleared vegetation creates a risk of tannins leaching into watercourses, resulting in an increased organic load. Discharge of water high in tannins could increase the biological oxygen demand of the receiving environment, which may in turn result in a decrease in available dissolved oxygen. Once discharged to the environment, tannins may also reduce visibility, light penetration, and change the pH of receiving waters. These impacts may affect aquatic ecosystems in receiving environments.

Procedures will be established for the disposal, stockpiling and reuse of cleared vegetation which would ensure that material is not stored in areas where runoff could cause tannin leachate into receiving waterways. By applying these measures stockpiling of vegetation is unlikely to result in a significant impact to surface water quality.

Vegetation clearing for the project would be limited to that required for the construction and operation of the project. Measures to avoid and minimise impacts associated with vegetation clearing are described in **Chapter 10, Biodiversity**.

Spills and litter

During construction, there is the potential for accidental spills of contaminants such as fuels used in vehicles and machinery, hydraulic fluids, concrete wastes and other construction chemicals to affect surface water quality. High risk areas would include ancillary sites, concreate batching plants, chemical storage sites and refuelling areas. In addition, increased levels of litter from construction activities could pollute downstream watercourses. The potential impact from accidental spills is discussed further in **Chapter 18, Soils and contamination**.

There is a small risk that spills of hydrocarbons (oils, fuels and hydraulic fluids) into receiving environments would pose a threat to human health. There are limited opportunities for recreational activities within the waterways in the receiving environments, and the water in the catchments is not used for human consumption.

With the implementation of the environmental management measures described in **Section 19.4** and **Chapter 18, Soils and contamination**, the potential impact from accidental spills and litter during would not have significant impact on surface water quality, including any risks to ecosystem and human health.

Surface water take and wastewater reuse

Non-potable (low quality) water is needed for a number of construction activities including for compacting and stabilising earthwork, landscape watering and dust suppression. This water may be sourced from local waterways, recycled water, construction sediment basins and farm dams located within the construction footprint. **Chapter 6, Construction** provides indicative non-potable water requirements for the project. However, it should be noted the actual water usage would vary with the weather conditions and the type of activities in progress.

Subject to implementation of the management measures described above, it is not anticipated that the project would have significant impact on surface water quality, including any risks to ecosystem and human health, due to the reuse of wastewater from construction sediment basins and farm dams for the purposes of construction.

Water quality impacts from construction-phase sediment basin discharge limits

Preliminary MUSIC modelling was carried out to estimate the potential impact of the project from the proposed construction-phase sediment basin discharge limits. The purpose of this was to determine whether the Blue Book (Landcom 2004) standards in **Table 19-9** are appropriate for the project or if they needed to be amended to account for the NSW WQOs of the Bellinger River and Coffs Harbour catchment. The indicators modelled included TSS, TN and TP as these are key pollutants that would have an impact to receiving environments.

Table 19-9 Water quality standard for site dewatering as per the Blue Book (Landcom 2004)

Parameter	Recommended standard during construction
TSS	50 mg/L
pH	6.5 to 8.5
Oils and greases	None visible

IECA (2008) notes that 50 mg/L equates to 50 kg, or about three and half domestic buckets of soil, evenly distributed in an Olympic swimming pool (1000m^3). It also notes that setting a design target TSS concentration of 50 mg/L would, in most regions of Australia, limit soil loss rates from construction sites to less than the commonly adopted natural soil loss rate of 0.5 to 1.0 t/ha/yr (the "geological erosion rate").

Following identification of land use, run-off and pollutant generation parameters, the MUSIC model was run to generate water quality pollutant loads for the sub-catchments. The model was developed to include all rainfall events from a representative climatic timeframe (in this case, from January 1999 to December 2003).

To demonstrate the effect of the proposed discharge limits, and assess these against the NSW WQOs, refinement of the MUSIC model focused only on the time periods where controlled discharge from construction-phase sediment basins is likely to occur when the receiving water quality is at (or below) the proposed discharge limit of 50 mg/L (ie basin dewatering after treatment, not overflows from rainfall in excess of the basin design event). **Table 19-10** provides a summary of model results compared against the NSW WQOs within each sub-catchment. The NSW WQOs are provided as turbidity (NTU) and have been converted to TSS using an assumed conversion ratio of 1:2 for TSS:Turbidity (eg TSS of 25 mg/L has been converted to 50 TNU)[1].

Table 19-10 Summary of average water quality data from MUSIC model during basin discharge

Indicator	Korora Basin		Coffs Creek		Boambee Creek		NSW WQO
	All data^	Pump days*	All data^	Pump days*	All data^	Pump days*	
TSS [mg/L]	41.76	4.94	48.48	4.97	36.56	4.65	-
Turbidity [NTU]	83.52	9.88	96.95	9.95	73.12	9.29	6-50
TP [mg/L]	0.057	0.019	0.091	0.023	0.070	0.022	0.025
TN [mg/L]	0.49	0.26	0.66	0.35	0.56	0.31	0.35

^ All data results are the average results that were experienced within the sub-catchment when rainfall was experienced. This includes minor rainfall (eg < 5 mm) to large storm events.

* Pump days are those days when water within the basins would be discharged after it has been treated to meet the discharge limit of 50mg/L TSS concentration. The construction-phase sediment basins are assumed to be discharged within five days following the end of a rainfall event (on the pump day). It is also assumed that there no rainfall during pump days.

Turbidity and TSS are the principle pollutants of concern associated with road construction projects. The MUSIC modelling only calculates TSS and the results generally indicate that the NSW WQO is exceeded in the waterways when using the adopted TSS:Turbidity correlation factor when all days (including large storm events) are reviewed for the representative climatic timeframe.

MUSIC modelling indicated an average existing turbidity concentration of around 9.29-9.95 NTU for the existing catchment on the days of discharge which is within the NSW WQO range of 6-50 NTU. As such, there is predicted to be a negligible impact on this indicator from the proposed discharge limits. Notwithstanding, a number of mitigation and management measures will be implemented during

[1] To allow for a comparison of MUSIC model outputs against NSW WQOs, the relevant turbidity objectives (6-50 NTU for aquatic ecosystems) have been converted to TSS using the above correlation to give a TSS objective of 3-25 mg/L for aquatic ecosystems. The conversion ratio of 1:2 has been used on other Roads and Maritime projects and is considered a conservative correlation for TSS:Turbidity based on results from the Ecohealth Project.

construction to help minimise any potential impacts associated with increased sediment loads and are detailed in **Section 19.4**.

MUSIC modelling indicated an average existing TP concentration of around 0.019-0.023 mg/L for the existing catchment on the days of discharge. The model predicts TP concentrations around 0.057-0.091 mg/L when all rain days (including large storm events) are reviewed. While there are modelled exceedances of the NSW WQO for this indicator within the sub-catchments, these exceedances are characteristic of the prevailing catchment conditions rather than the impacts of the proposed construction-phase sediment basin discharge limits. As such, the proposed discharge limits would have minimal impacts on this indicator.

MUSIC modelling indicated an average existing TN concentration of around 0.26-0.35 mg/L for the existing catchment on the days of discharge. The model predicts TN concentrations around 0.49-0.66 mg/L when all rain days (including large storm events) are reviewed. Similar to TP, while there are modelled exceedances of the NSW WQO for this indicator within the sub-catchments, these exceedances are characteristic of the prevailing catchment conditions rather than the impacts of the proposed construction sediment basin discharge limits. As such, the proposed discharge limits would have minimal impacts on this indicator.

Overall, TSS, TP and TN concentrations are predicted to be close to, or below, the NSW WQO trigger values for these indicators during days of construction phase sediment basin discharge. Notwithstanding, a range of management measures have been included in **Section 19.4** to reduce the potential environmental impacts associated with construction-phase sediment basin discharges.

19.3.2 Operational

During operation, the project has the potential to result in water quality impacts from changes in hydrology leading to an increase in erosion and sedimentation, and the mobilisation of pollutants. Nutrients and toxins, such as phosphorus, heavy metals and organic chemicals, use sediment as the medium for transportation in urban runoff (Wong 2000).

Pollutants on roads are generated from motor vehicles in the forms of air pollutants, heavy metals, motor oils, petrol, trash, and atmospheric exposure to an impermeable surface causing increased concentrations during rain events. During rain events pollutants such as nitrogen and phosphorus enter receiving environments through road runoff. Contaminants of concern for sensitive receiving sites include nutrients, suspended sediments and solids, gross pollutants and litter, metals and hydrocarbons. These pollutants predominantly have the potential to impact on water quality for ecosystem health. Metals and hydrocarbons have the potential to cause an adverse impact to human health.

As the project involves the construction of a new road and upgrade of the existing Pacific Highway, the resulting pollutant sources have been considered and reasonable and feasible controls have been included in the design. To mitigate the potential impacts to receiving water quality, stormwater treatment measures have been designed to manage the release of sediment and would include:

- Grass swales as the primary stormwater treatment measure incorporated into the concept design.
- Spill containment within all swales and basins on the highway, interchange ramps and service roads by inclusion of a reverse grade pipe system. The proposed basins and proprietary spill capture units would be designed to accommodate a spill volume of up to 40,000 L which would contain a major accidental spill, capturing hydrocarbons that may be released into sensitive receiving environments, causing impacts to ecosystem and human health.

In instances where it would not be possible to provide sufficient swale length for treatment, sediment basins are proposed. Sediment basin treatment areas of two per cent (as percentage of contributing catchment area) have been adopted, and a minimum basin depth of 1.3 m (1 m effective depth with 0.3 m allowance for spillway) has been assumed. Water quality treatment devices are required to have five year average recurrence interval (ARI) (18 per cent AEP) flood immunity, where practicable.

As the stormwater quality treatment network also functions as a spill containment network, the system operates on a 'full capture' basis without any high flow bypass. All treatment basins would be designed to retain, as a minimum, the one in three month storm event prior to overflow. However, capture capacity may be much higher following dry periods where the basins are not full at the time of the rainfall event.

Where there was insufficient space for either of the treatment measures described above, proprietary gross pollutant traps such as concrete tanks have been considered. Based on concept design investigations, additional devices have been included for the following locations:

- The southern end of the project near the tie-in with the existing Pacific Highway
- Four are proposed at the Englands Road interchange
- South of Coramba Road interchange
- About mid-way between the Coramba Road interchange and Shephards Lane
- South of the project crossing of Pine Brush Creek
- At the portals of each tunnel, except for the northern portal of Roberts Hill tunnel (alignment crest is just north of the northern portal and all fluid in the Roberts Hill tunnel would drain to the southern portal).

The concept design also has 28 permanent water quality basins incorporated into the design to manage operational water quality impacts. **Chapter 5, Project description** provides further detail on the stormwater controls and or mitigation devices included for the project, including the location of the permanent water quality basins.

While the above represents a practical stormwater treatment design within the engineering and environmental constraints of the project, the type and design of specific stormwater treatment measures would be further refined as part of the detailed design process.

Operational water quality modelling

MUISIC modelling was carried out to estimate the potential impact of the project on pollutant concentrations generated from within the catchment of indicative road corridor (as described in **Chapter 5, Project description**) and the downstream sensitive receiving environments. The indicators modelled included TSS, TN and TP as these are key pollutants that would have an impact to receiving environments.

Results for load-based water quality modelling (shown in **Table 19-11**), indicate that the proposed concept stormwater treatment strategy developed for the project is close to achieving the design reduction targets for TSS and meeting the reduction targets for TP (refer to **Chapter 5, Project description**). Although the load-based reduction target of 80 per cent has not been met for TSS, the results show a likely improvement from the existing condition from a load-based perspective. The design reduction targets for the project are considered to represent a reasonable target for major road projects and have been adopted elsewhere as part of the Pacific Highway upgrade program.

Table 19-11 Load-based water quality modelling results for surface water discharges from indicative road corridor

Indicator	Existing Conditions	Design – Unmitigated	Design – Mitigated	Percent reduction*	Design reduction target
Korora basin					
TSS [kg/yr]	62,000	195,000	42,400	78.3	80%
TP [kg/yr]	121	333	143	57.2	45%
TN [kg/yr]	802	1340	1030	23.0	NA

Indicator	Existing Conditions	Design – Unmitigated	Design – Mitigated	Percent reduction*	Design reduction target
Coffs Creek					
TSS [kg/yr]	55,900	192,000	49,000	74.5	80%
TP [kg/yr]	76.5	321	150	53.2	45%
TN [kg/yr]	530	1310	1020	22.2	NA
Boambee Wetlands					
TSS [kg/yr]	48,200	147,000	32,500	77.8	80%
TP [kg/yr]	69.9	246	104	57.6	45%
TN [kg/yr]	533	1000	777	22.7	NA

Table 19-12 provides results for concentration-based water quality modelling and uses the adopted TSS:Turbidity correlation factor described in **Section 19.3.1** to allow a comparison of the modelled parameters against the NSW WQOs. Note that the values included in **Table 19-11** and **Table 19-12** show the water quality results at point of discharge from the project (ie as soon as the runoff crosses the indicative road corridor boundary) as opposed to water quality results shown in **Table 19-10** and **Table 19-13** which are reporting values within the receiving environment.

Table 19-12 Concentration-based water quality modelling results for surface water discharges from indicative road corridor

Indicator	Existing Conditions	Operational conditions – Unmitigated	Operational conditions – Mitigated	NSW WQO
Korora basin				
TSS [mg/L]	30.70	351.43	70.80	-
Turbidity [NTU]	61.40	702.86	141.60	6-50
TP [mg/L]	0.11	0.59	0.24	0.025
TN [mg/L]	0.93	2.41	1.84	0.35
Coffs Creek				
TSS [mg/L]	27.80	354.54	78.75	-
Turbidity [NTU]	55.60	709.08	157.50	6-50
TP [mg/L]	0.09	0.59	0.25	0.025
TN [mg/L]	0.87	2.40	1.86	0.35
Boambee Wetlands				
TSS [mg/L]	40.50	356.17	79.38	-
Turbidity [NTU]	81.00	712.34	158.76	6-50
TP [mg/L]	0.09	0.59	0.23	0.025
TN [mg/L]	0.84	2.41	1.86	0.35

The MUSIC model predicts substantially higher TSS concentration when comparing the existing catchment with the unmitigated operational conditions. The model relies strongly on volumes of surface water flows to model TSS concentrations. The existing catchment conditions within the indicative road corridor comprise of mainly permeable and vegetated surfaces of predominantly agricultural land uses. These land use types generate substantially less surface water flows and TSS than impermeable surfaces, such as road pavement, due to the ability of vegetated surfaces and permeable surface to capture flows and TSS. The modelled concentrations of TSS discharged from the project area are above the NSW WQOs, however at a catchment wide scale these impacts would not be significant (refer to **Section 19.3.3**).

Modelled results for the mitigated scenario indicate concentrations of TN in surface water runoff directly from the indicative road corridor would be above the NSW WQO, however they fall within range of the surveyed ambient surface water quality conditions assessed during baseline water quality sampling at Treefern Creek, Boambee Creek and Newports Creek (**Table 19-8**).

Similarly, modelled results for the mitigated scenario indicate concentrations of TP in surface water runoff directly from the indicative road corridor would be above the NSW WQO, however they fall within range of the surveyed ambient surface water quality conditions assessed during baseline water quality sampling at Treefern and Newports Creek (**Table 19-8**).

The NSW WQOs are the environmental values and long-term goals for consideration when assessing and managing the likely impact of activities on waterways. The modelling indicates that under existing conditions the average pollutant concentrations generated in the indicative road corridor exceed the NSW WQO in all sub-catchments in the study area. Average pollutant concentrations that directly discharge from the project would increase during operation compared to the existing conditions as outlined in

. However, with the proposed water quality treatment structures, this would reduce pollutant concentrations in all three catchments when compared to the unmitigated scenario. The modelling results show that the project has included measures to minimise impacts to water quality in receiving environments.

Impacts to receiving water environments as a result of operation of the project are not considered to be significant. As water from the indicative road corridor would be discharged into the surrounding waterways, it would experience mixing with the existing water in the creeks as part of perennial flows. Water from the wider catchment contributes to the majority of the flows within the receiving environments. The results of the ambient water quality sampling (refer to **Section 19.2.4**) show that the water quality in the catchment is influenced by elevated nutrients and dissolved oxygen. Any changes to water quality associated with runoff from the indicative road corridor is expected to be localised at the point of discharge. The aquatic flora and fauna that occurs within these receiving environments would be adapted to the agricultural and urban environments in the catchment, and the localised changes to water quality are unlikely to have a significant impact to these features.

Notwithstanding, the type and design of the specific stormwater treatment measures would continue to be refined as part of the detailed design process with the aim of further reducing the potential impacts described above and to work towards meeting the NSW WQOs. This would include review of the proposed stormwater treatment train (individual devices connected in series to improve overall treatment performance) and consideration of the sensitivity of the receiving environment.

Best management practice guidelines including Roads and Maritime's Water sensitive urban design guideline (Roads and Maritime 2017g) will be followed in refining the stormwater treatment train. This may result in the selection of devices and measures that would be more effective in managing the exceedances of the pollutants described above, eg use of bioretention swales or basins to more effectively manage TP and TN. However, the final selection of the specific stormwater treatment measures within the treatment train would be subject to reasonable and feasible considerations that include ongoing maintenance requirements, land use and property impacts, community and maintenance personnel safety and additional environmental impact (should additional space be needed).

19.3.3 Sensitive receiving environments

While no work is anticipated within or directly adjacent to the NSW Solitary Islands Marine Park, construction work has the potential to result in indirect impacts to the Marine Park through sediment and pollutant runoff into the waterways. Operational impacts may be experienced through increased pollutants discharged from the road drainage infrastructure. Impacts to the Commonwealth Marine Park would be negligible as the reserve is three nautical miles off the coast and impacts from construction are not likely to extend this far.

The three Coastal Management SEPP wetlands within the study area are located downstream from the construction footprint, with the Coffs Creek wetlands located between 3.7 and five kilometres downstream from the project. Boambee wetlands are also located within 100 m of the project, however surface water from the construction footprint would not discharge directly into this waterway. The waterways and catchments that feed these wetlands are in highly urbanised and modified environments and would be subject to pollutant and nutrient loads from diffuse and point sources in the catchment. The Pine Brush Creek wetlands is located about 800 m downstream from the construction footprint and is the most at-risk wetland during construction and operation.

The water quality treatment devices included in the operational phase will provide suitable protection to the downstream sensitive receiving environments. Given the proximity of the project to the Solitary Islands Marine Park, Pine Brush Creek wetlands and the Boambee wetlands, additional stormwater pollution controls such as dual-purpose spill containment and water quality treatment devices have been incorporated to further reduce potential impact from road runoff, as well as potentially improving upon the existing condition pollution load.

As described in **Section 19.3.1**, sediment basins would be designed to contain the five-day 90th percentile rainfall event within all sub-catchments that drain into the Solitary Islands Marine Park. However, there would be a number of waterway realignments required within creeks that drain to the identified sensitive receiving environments which may increase the risk of impacting water quality.

Impacts to the downstream sensitive receiving environments of within Coffs Creek and Boambee Creek sub-catchments during construction are considered to be negligible as impacts are anticipated to be highly localised and restricted to the immediate section of directly impacted waterways. However, the proposed waterway realignment and adjustment associated with Pine Brush Creek and its tributary has the potential to impact the water quality associated with the Solitary Islands Marine Park and Pine Brush Creek wetlands. To manage the potential impacts, site-specific controls will be implemented during construction, such as coffer dams and/or silt curtains to prevent or minimise increased turbidity.

Operational water quality modelling

MUSIC modelling was carried out at a catchment-wide scale to compare existing water quality conditions with the operational conditions in the sensitive receiving environments. The modelling predicts average pollutant concentrations in the wider catchment and identifies conditions with treatment (proposed water quality treatment structures (**Section 19.3.2**) and without treatment (**Table 19-13**). By reporting results at a at a catchment-wide scale, it allows for a more meaningful assessment against the NSW WQOs and identification of potential impacts to the sensitive receiving environments.

The modelled results in **Table 19-13** shows the modelled concentrations of TSS, TP, TN and gross pollutants (GP) in the receiving environments of each catchment. This is contrasted with the results in **Table 19-12** that show concentrations of pollutants in water directly discharging from the indicative road corridor.

Table 19-13 Concentration-based water quality modelling results for receiving environments

Design water quality objective	Existing Conditions	Operational – Unmitigated	Operational – Mitigated	NSW WQO
Pine Brush Creek Wetlands of Korora basin				
TSS [mg/L]	25.40	31.28	24.60	-
Turbidity (NTU)	50.80	62.56	49.20	6-50
TP [mg/L]	0.066	0.07	0.064	0.025
TN [mg/L]	0.60	0.59	0.58	0.35
GP [kg/day]	2.13	2.17	2.17	
Coffs Creek Wetlands				
TSS [mg/L]	24.80	28.75	25.00	-
Turbidity (NTU)	49.60	57.50	50.00	6-50
TP [mg/L]	0.075	0.08	0.076	0.025
TN [mg/L]	0.70	0.70	0.70	0.35
GP [kg/day]	5.89	5.89	5.89	
Boambee Wetlands				
TSS [mg/L]	22.50	24.51	22.50	-
Turbidity (NTU)	45.00	49.02	45.00	6-50
TP [mg/L]	0.059	0.062	0.059	0.025
TN [mg/L]	0.55	0.55	0.56	0.35
GP [kg/day]	7.30	7.30	7.30	

** Due to the large scale of the assessment, existing water quality improvement devices in external catchments have not been included in this assessment. These would typically apply to newer urban sites developed in accordance with CHCC guidelines.*

The modelling shows that under the existing conditions the modelled average concentrations of TP and TN are all above the guideline values in the NSW WQOs, whereas under the existing conditions, the modelled average concentrations of NTU (using the adopted TSS:Turbidity correlation factor described in **Section 19.3.1**) are under or marginally over the guideline values in the NSW WQOs.

With the project operational (including the proposed water quality treatment measures), the modelling indicates a negligible to minor increase in TSS, TP and TN. In addition, the modelling does not include any existing water quality treatment devices that may exist in downstream developed areas nor existing natural features such as wetlands and ponds. As such, it provides an upper estimate of the potential increases to pollutant concentrations reporting to the wetlands.

The catchment-scale modelling shows that the NSW WQOs are achieved for NTU but are not currently being met across the study area in the existing scenario for TP and TN. The mitigation strategy included in the design shows that the project is working towards meeting the WQOs in the receiving environment by reducing pollutants when compared with an unmitigated scenario. The design has included all practical and reasonable treatment measures to reduce pollutant concentrations in surface water runoff. With the refinement of the specific stormwater treatment measures as part of detailed (as described above in **Section 19.3.2**), there is the potential for the project to contribute to an improvement in WQOs over time.

19.4 Environmental management measures

Surface water impacts have been identified for the construction and operational phases of the project. Expected impacts, environmental management measures, responsibilities and timing has been summarised in **Table 19-14**. There are interactions between the mitigation measures for surface water and **Chapter 10, Biodiversity, Chapter 17, Flooding and hydrology, Chapter 18, Soils and contamination** and **Chapter 20, Groundwater.** These measures have been developed so that appropriate management of surface water would minimise the potential for impacts to the community and environment.

In particular, **Chapter 18, Soils and contamination** includes a commitment to prepare Soil and Water Management Plan (SWMP) prior to construction. The SWMP is the main project specific environmental management plan to ensure that appropriate practices are implemented to manage risks to surface water quality during construction. Specifically, the SWMP will identify all risks relating to soil erosion, and pollution caused by sediments and other materials, and describes how these risks will be addressed during construction.

Table 19-14 Environmental management measures for water quality impacts

Impact	ID No.	Environmental management measure	Responsibility	Timing
Water quality monitoring program	SW01	A water quality monitoring program will be prepared and implemented prior to and during construction and operation to identify whether the project is resulting in adverse impacts on water quality and assess compliance with statutory requirements and project targets. Monitoring would continue for a period of three years following construction, or before if it can be proved that no impact has occurred. The monitoring program will be prepared in accordance with the Roads and Maritime Guideline for Construction Water Quality Monitoring (RTA n.d.) and details provided in **Section 19.5**. The monitoring program will include requirements for: • Identification of monitoring locations which are representative of the potential impacts • Collection of baseline information prior to construction • Consideration of the identified sensitive environments • Water quality objectives to assess potential impacts against • Contingency and ameliorative measures in the event that adverse impacts are experienced • Reporting of the monitoring results.	Roads and Maritime	Prior to and during construction and operation

Impact	ID No.	Environmental management measure	Responsibility	Timing
Water quality impacts from dewatering existing storages	SW02	Dewatering of existing storages (eg dams) will occur overland in vegetated areas or will be used for dust suppression activities and not discharged directly into waterways to minimise release of high levels of nutrients and or contaminates directly into the waterways.	Contractor	During construction
Water quality impacts from dewatering during construction	SW03	Any dewatering activities will be undertaken in accordance with the Roads and Maritime Technical Guideline: Environmental Management of Construction Site Dewatering (RTA 2011b), in a manner that prevents pollution of waters.	Contractor	During construction
Works within or adjacent to waterways	SW04	A detailed Environmental Work Method Statement (EWMS) will be prepared and implemented for all works undertaken within or immediately adjacent to waterways. The EWMS will detail measures to avoid or minimise risks from erosion and sedimentation to water quality and biodiversity. It will be prepared in accordance with relevant guidelines including, but not limited to consideration of: • Roads and Maritime's Biodiversity Guidelines - Protecting and managing biodiversity on RTA projects • DPIE guidelines Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings.	Contractor	During construction
Managing tannin leachates	SW05	Mulch stockpiles will be managed in accordance with the Roads and Maritime Environmental Direction for the Management of Tannins from Vegetation Mulch (Roads and Maritime 2012b). This would include but not be limited to: • Planning and staging vegetation processing activities • Stockpile location and management to minimise the production and release of tannins • Monitoring the stockpiles for the production of tannins • Response to tannin production.	Contractor	During construction

Impact	ID No.	Environmental management measure	Responsibility	Timing
Inspection and maintenance program	SW06	An inspection and maintenance program as part of the SWMP will be implemented during construction to ensure effective implementation of all temporary and permanent soil, erosion and water pollution safeguards. The timing and frequency of inspections will be set out in the SWMP. The inspections will assess implementation and success of the controls, actions required to ensure on-going effective operation, and compliance with any statutory approvals. A register of inspections will be established.	Contractor	During construction
Operational water quality impacts	SW07	Stormwater and road runoff will be directed towards operational water quality treatment measures that will assist in the removal of pollutants from discharge water to protect ecosystem and human health.	Contractor	Detailed design
	SW08	The type and design of the specific stormwater treatment measures within the overall treatment train will continue to be refined as part of the detailed design process with the aim of achieving the NSW WQOs where reasonable and feasible. This will include review of the proposed stormwater treatment train and consideration of best management practice guidelines including Roads and Maritime's Water sensitive urban design guideline (Roads and Maritime 2017g).	Contractor	Detailed design

19.5 Water quality monitoring

To determine the effectiveness of the controls and management measures developed and implemented for the project, a monitoring program would be established and carried out in accordance with Roads and Maritime's Guideline for Construction Water Quality Monitoring (RTA n.d.). The monitoring program would be implemented prior to construction and would include monitoring of surface water quality and groundwater quality and levels (refer to **Chapter 20, Groundwater**). The key objectives of the monitoring program would be to:

- Identify if water quality problems are occurring as a result of the project during construction and operation
- Demonstrate compliance with legal and other monitoring requirements including the water quality criteria and/or targets for the project.

Indicative surface water quality monitoring sites are shown on **Figure 19-4** and will be confirmed prior to construction. The indicative monitoring sites have been selected to ensure they are representative of the receiving environment with particular attention to sensitive receiving environments described in **Section 19.2.3**.

The water quality monitoring program will commence prior to construction to ensure sufficient baseline information is collected. The monitoring program will continue through construction and for a period of three years following construction, or earlier if it can be proved that no impact to surface water quality and groundwater quality and levels has occurred. Frequency of monitoring within this period will be confirmed in the water quality monitoring program but would generally follow Roads and Maritime's Guideline for Construction Water Quality Monitoring (RTA n.d.) and include sampling following "wet events" when water quality impacts from the project are likely to be most evident (eg, due to erosion and sediment loss).

Monitoring parameters for surface water quality will be selected to assess the likely impacts of the project on water quality and would be consistent with the relevant NSW WQOs trigger values identified in **Table 19-5**. Indicative parameters include:

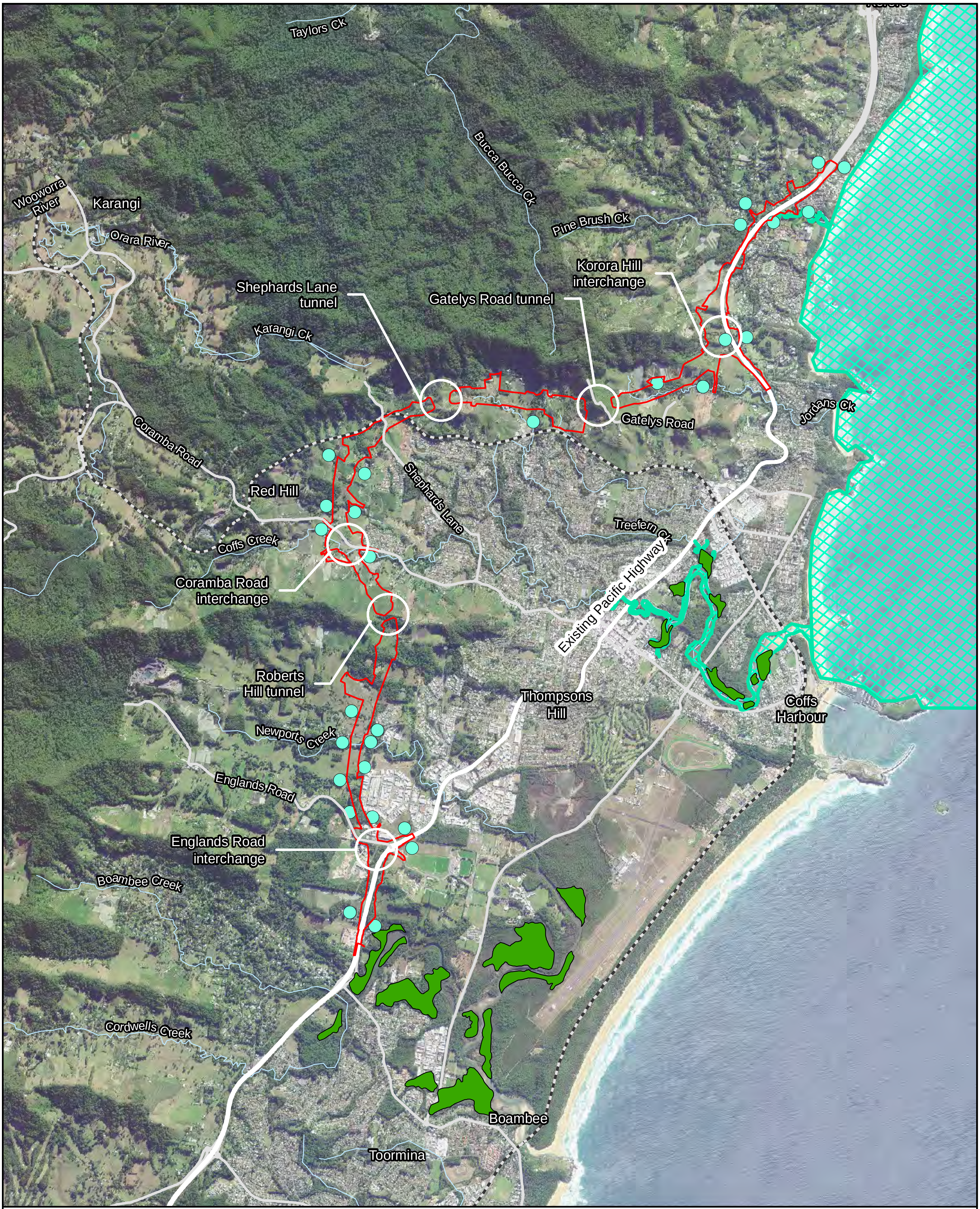
- Chemical properties, eg pH and dissolved oxygen (DO)
- Physical properties, eg electrical conductivity (EC), temperature, turbidity (NTU) and total suspended solids (TSS)
- Nutrients, eg Total Nitrogen (TN) and Total Phosphorous (TP)
- Visual properties, eg water colour, surface film, slick, and/or scum. If oils and grease are visually evident, a sample would be collected to test for Total Petroleum Hydrocarbons.

Trigger values to monitor performance against the objectives of the monitoring program will be established following the collection of baseline conditions. Typical performance indicators and corrective actions for surface water monitoring are described in **Table 19-19-15**. Final performance indicators and corrective actions will be detailed in the water quality monitoring program as required.

Table 19-19-15 Performance indicators and corrective actions for surface water quality monitoring

Triggers for corrective actions	Corrective actions
• Sediment and pollutant levels are outside acceptable parameter limits • Control devices found to be unsuitable	• Review of rainfall data and inspection of erosion and sediment control measures within the vicinity. Correct measures where necessary. • Review and increase monitoring frequency. • Control devices/ measures inspected for suitability and corrected/ reinstated where necessary. • Relevant agencies notified and environmental impacts assessed. • Undertake remedial action on the machinery or process responsible, eg in response to oil or fuel spills full inspection and necessary repairs/corrective action to be undertaken on the machinery or process responsible prior to operation re-commencing.

Further detail on the requirements for groundwater quality monitoring is provided in **Appendix N, Groundwater assessment**.



Legend

- Construction footprint
- North Coast Railway
- Watercourse
- Indicative Surface Water Quality Sampling Locations
- NSW Coastal Management SEPP wetlands
- Solitary Islands Marine Park (NSW)

Coffs Harbour Bypass
Surface water quality sampling locations
Figure 19-4

0 0.5 1 1.5 km
N
Scale @A4: 1:60,000
GDA 1994 MGA Zone 56

CHAPTER 20

Chapter 20

Groundwater

20. Groundwater

This chapter presents an assessment of the impacts of the project on groundwater and identifies mitigation and management measures to minimise and reduce these impacts. The assessment presented in this chapter draws on information in **Appendix N, Groundwater assessment** and **Chapter 18, Soils and contamination.**

Table 20-1 lists the SEARs relevant to groundwater and where they are addressed in this chapter.

Table 20-1 SEARs relevant to groundwater

Ref	Key Issue SEARs	Where addressed
9. Soils		
3.	The Proponent must assess the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	Section 20.3.6
10. Water – Quality		
1.	The Proponent must: i) Identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality	Section 20.5 **Chapter 19, Surface water quality**
11. Water – Hydrology		
1.	The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	Section 20.3 **Chapter 10, Biodiversity** **Chapter 13, Agriculture** **Chapter 17, Flooding and hydrology** **Chapter 19, Surface water quality**
2.	The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	
	a) Natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge	Section 20.4 **Chapter 10, Biodiversity** **Chapter 17, Flooding and hydrology** **Chapter 19, Surface water quality** **Appendix N, Groundwater assessment**
	b) Impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement	Section 20.4

Ref	Key Issue SEARs	Where addressed
	c) Changes to environmental water availability and flows, both regulated / licensed and unregulated / rules-based sources	Section 20.4.1
	d) Direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses	**Chapter 10, Biodiversity** **Chapter 17, Flooding and hydrology** **Chapter 19, Surface water quality**
	e) Minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems	Section 20.4.2 **Chapter 17, Flooding and hydrology** **Chapter 19, Surface water quality** **Chapter 22, Waste**
	f) Water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation	Section 20.4.3 **Chapter 19, Surface water quality**
2.	The Proponent must identify any requirements for baseline monitoring of hydrological attributes	Section 20.5 **Chapter 19, Surface water quality** **Appendix N, Groundwater assessment**
3.	The assessment must include details of proposed surface and groundwater monitoring	Section 20.5 **Chapter 19, Surface water quality**

20.1 Assessment methodology

The groundwater assessment was undertaken using a methodology which comprised of characterisation of the existing groundwater regime, identification of potential receptors, evaluation of the potential impacts caused by the construction and operation of the project and identification of mitigation measures to minimise impacts. The assessment process included:

- Review of existing publicly available resources comprising literature relating to the study area such as geological and environmental maps, published journal articles, government reports and geodatabases, proclaimed areas, available groundwater level, quality and flow data (within a one-kilometre radius of the project, see **Figure 20-1**) and relevant water sharing plans for the area
- Factual and interpretative geological and hydrogeological investigation reports prepared for the project
- Interpretation of groundwater level monitoring provided for the period between July 2017 and February 2019 and laboratory testing data undertaken at 38 groundwater monitoring sites along the project in 2017 (RCA 2017a)
- Identification of locations of potential receptors including groundwater supply wells, agricultural dams, GDEs and sensitive receiving environments such as wetlands

- Development of a regional groundwater conceptual model that considers how groundwater is recharged, flows and discharges, how it is used and how it may interact with the project
- Identification of potential impacts on the groundwater systems with specific focus on areas of cuts and drained tunnels which extend below groundwater level, where interaction with the groundwater system is expected to be the greatest
- Development of local scale conceptual models to highlight potential impacts on the groundwater environment
- Qualitative assessment of potential groundwater impacts for the project during construction and operational phases
- Development of numerical hydrogeological models for cuts and drained tunnels and quantitative assessment to evaluate the scale of groundwater table lowering and potential groundwater take for the project
- Assessment of potential impacts against criteria set out in the NSW Aquifer Interference Policy (DPI 2012) and other relevant guidelines (refer to **Section 20.1.1**)
- Recommendation for additional investigation or monitoring to supplement the existing data (**Section 20.5**) and proposed mitigation measures to be included in the detailed design and construction to mitigate or reduce potential impacts on the groundwater environment.

Coffs Harbour Bypass
Study area and catchments
Figure 20-1

20.1.1 Groundwater modelling

Cuttings and drained tunnels have the potential to impact groundwater levels where they extend below the existing groundwater surface. Where seepage of groundwater into excavations occurs during construction, and into permanent drainage systems during operation, groundwater levels would be lowered (drawdown) in the area surrounding the cuttings and tunnels. Seepage which enters the cuttings and tunnels would also be captured, and without remedial measures would be prevented from flowing along its natural course.

The extent of drawdown and seepage rates into the cuttings/tunnels would depend on the depth below groundwater levels which the elements extend, the length over which seepage occurs and the local hydrogeological conditions at each of the cuttings.

To evaluate the potential impacts associated with each cutting and tunnel along the project, the proposed elevation of the road alignment was compared to groundwater level information obtained from geotechnical investigations and publicly available information.

The range of groundwater levels at each cutting and tunnel was evaluated, with an average level determined over the period of monitoring (July 2017 and February 2019). The average groundwater level was compared to the alignment elevation to assess the maximum potential drawdown which could occur at each cutting or tunnel.

Based on this assessment, each of the cuttings and tunnels were classified into three types based on the following:

- **Type A (moderate to high impact)** – where the design is anticipated to extend below the existing groundwater table, potentially leading to localised lowering of water levels
- **Type B (negligible to low impact)** – where the design level is within five metres of the groundwater table, where there is not expected to be an adverse impact to the groundwater regime and engineering mitigation measures are not expected to be required
- **Type C (no impact)** – where groundwater levels are greater than five metres below the design cut level with no anticipated impact.

Numerical groundwater modelling was undertaken at all Type A cuttings and tunnels. For Type B cuttings, where the average groundwater level is anticipated to be below the base of the cutting, the impacts are anticipated to be minor. Type C cuttings were not assessed further as there are no anticipated impact on groundwater levels.

At each Type A location modelled, a two-dimensional section was created using topographic data and design drawings with the models vertically oriented and broadly aligned with the interpreted groundwater flow lines. Each of the models were calibrated using groundwater level data collected for the project with the aim of reproducing existing groundwater flow patterns. The numerical models were then used to evaluate changes to the groundwater levels and flow by inserting the proposed cutting or tunnel and re-running the model. The models also provided an estimate of the groundwater inflows and the long-term impacts. The results of the modelling provided predictions of the following:

- The extent and magnitude over which the groundwater level declines (drawdown) in the area surrounding the cuttings and tunnels
- The estimated rate of water inflow/seepage into each cutting and tunnel (water take).

The assessment results are provided in **Section 20.4** and further details of the assessment are presented in **Appendix N, Groundwater assessment.**

To further explain the types of issues which may occur due to construction of the cuttings and tunnels, a series of local scale conceptual models are presented in **Figure 20-2** to **Figure 20-5**. The idealised local baseline hydrogeological conceptual model is presented in **Figure 20-2** which provides a simplified model of the local scale hydrogeological setting of the project.

Conceptual models highlighting the potential impacts for Type A cuttings, Type B cuttings and drained tunnels are presented in **Figure 20-3**, **Figure 20-4** and **Figure 20-5** respectively.

These conceptual models highlight the range of potential impacts which could occur as a result of construction of the tunnels and cuttings; it is noted that not all impacts will occur at each location.

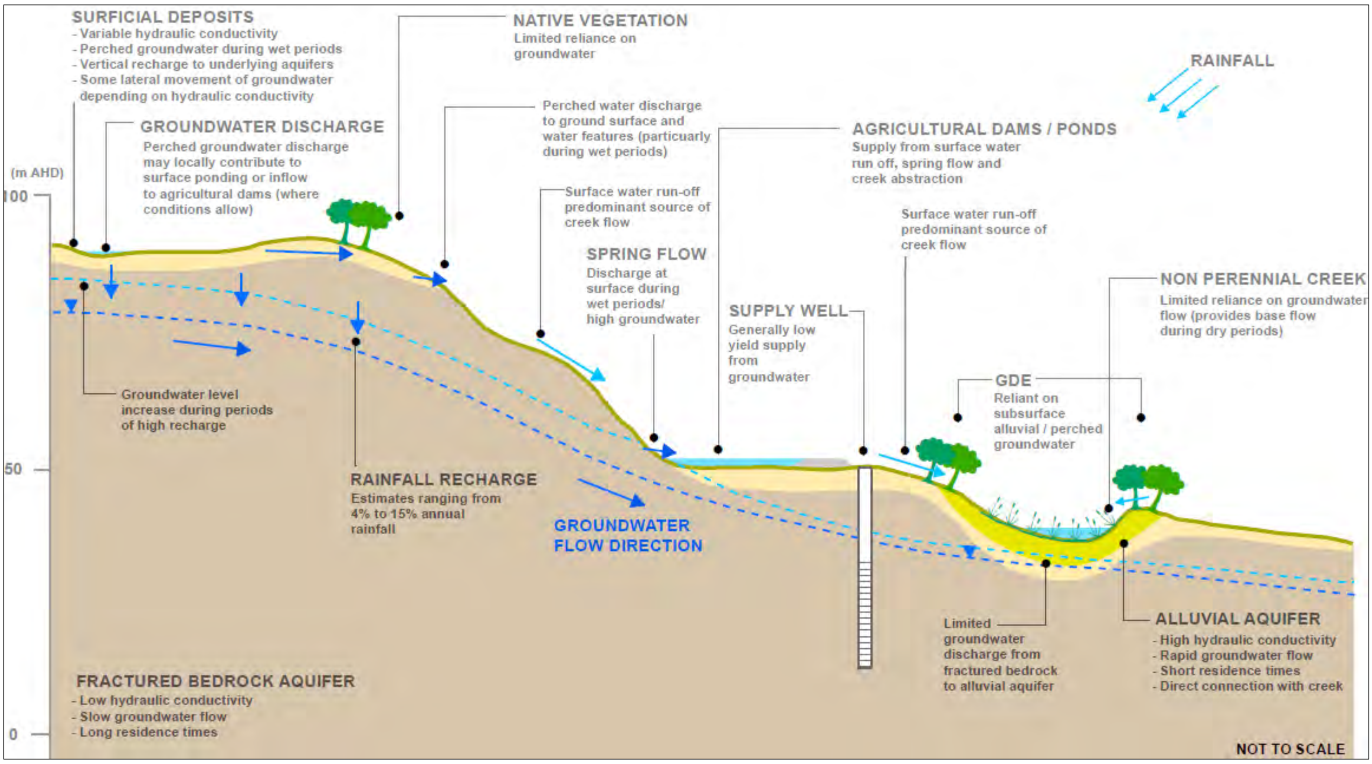


Figure 20-2 Idealised local hydrogeological scale conceptual model

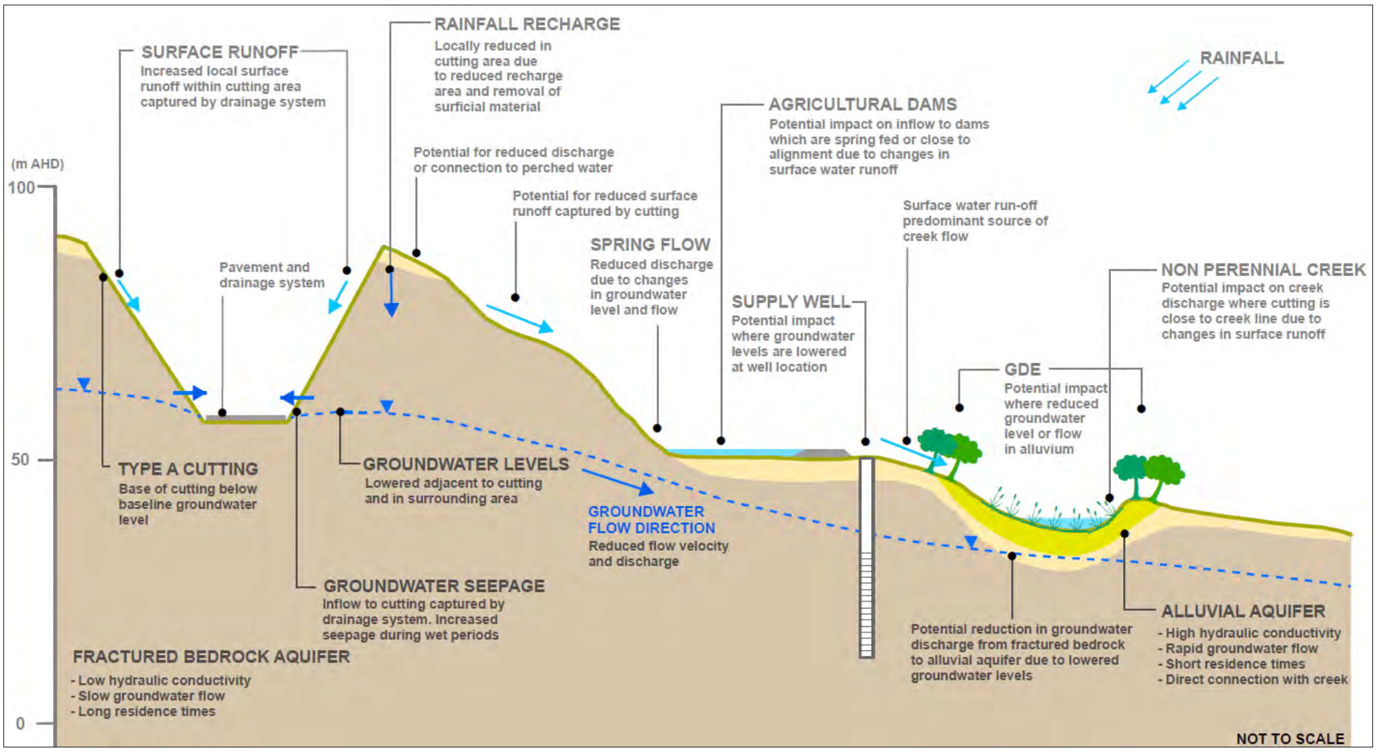


Figure 20-3 Local scale hydrogeological conceptual model (Type A cutting)

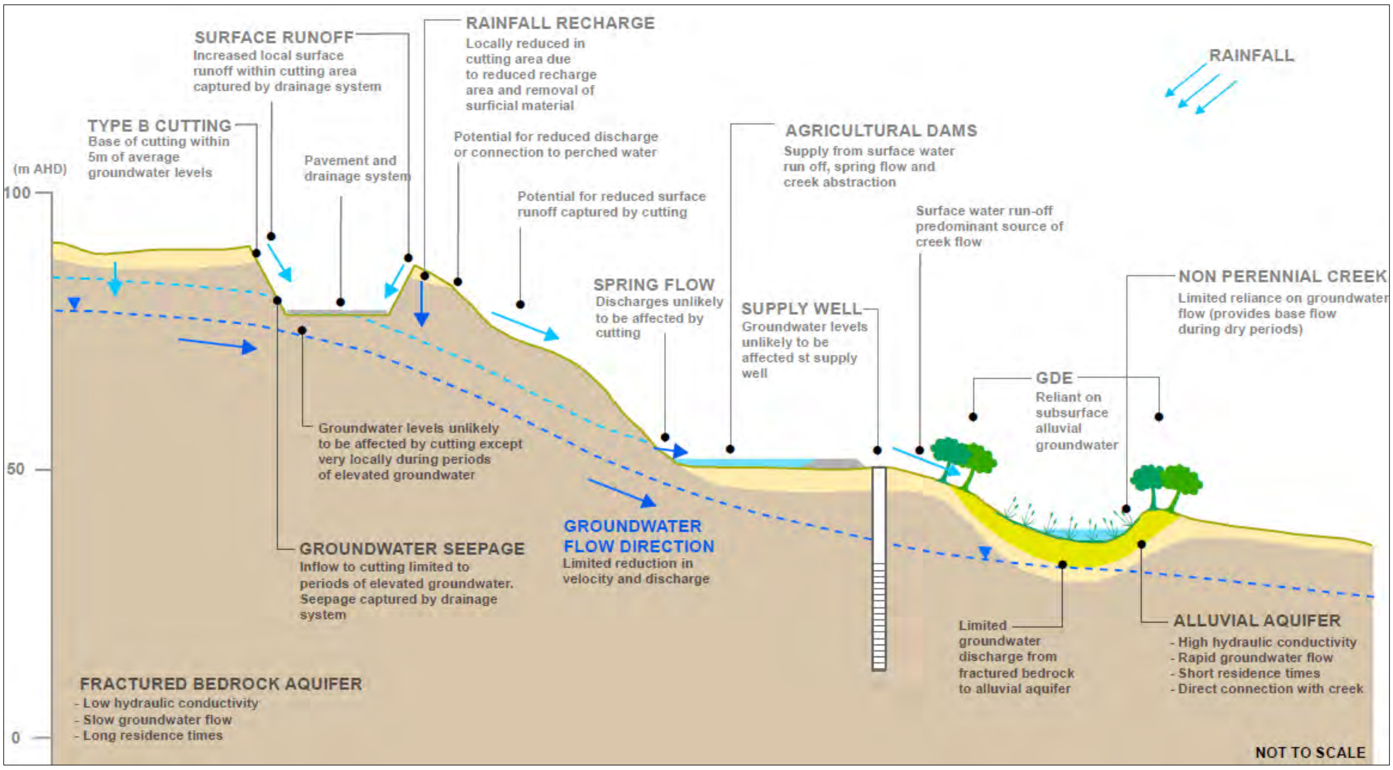


Figure 20-4 Local scale hydrogeological conceptual model (Type B cutting)

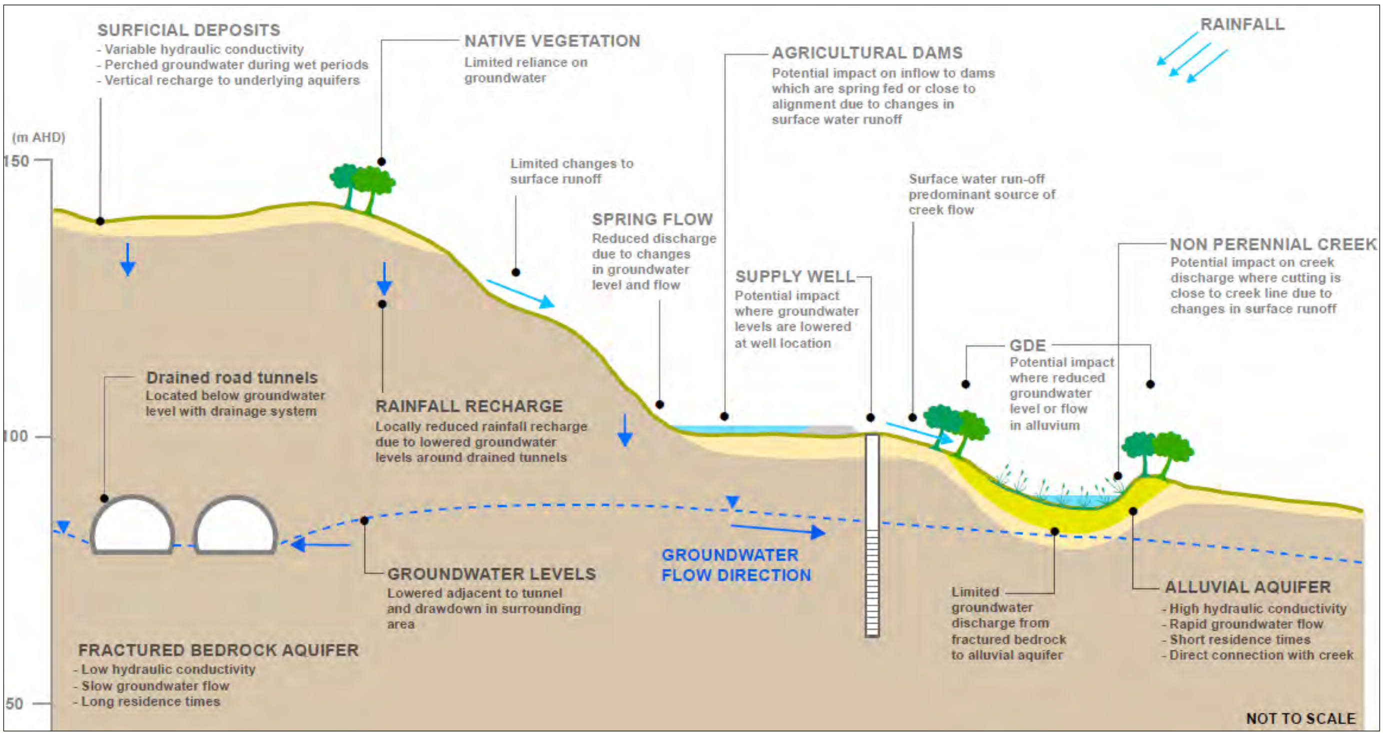


Figure 20-5 Local scale hydrogeological conceptual model (tunnels)

20.2 Policy and planning setting

The assessment has been undertaken with consideration of relevant legislation, policies, guidelines and water sharing plans listed in **Table 20-2.**

Table 20-2 Guidelines relevant to the groundwater assessment

Policy / guideline	Description	Relevance to this assessment and where it is discussed
Water Management Act 2000	The NSW *Water Management Act of 2000* (WM Act) governs the issues of water pumping licenses to carry out further pumping work where a sharing license or framework is already in place. The aim of the WM Act is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It also provides formal protection and enhancement of the environmental quality of waterways and instream uses as well as providing protection of catchment conditions. Water sharing plans are the main tool of the WM Act to allocate and provide water for the environmental health of rivers and groundwater systems, while also providing licence holders access to water. The groundwater sources in the study area are regulated by two water sharing plans which are: • The Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources, 2009 which covers surface water and alluvial groundwater systems • The Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources, 2016 which covers the fractured bedrock aquifer. The unregulated and alluvial water sharing plan area is also divided into 13 Extraction Management Units (EMUs) and correspond to the coastal catchment areas created by creeks and estuaries in the area that discharge into the ocean. The Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources, 2009 indicates that groundwater is primarily used for irrigation and farming purposes. The Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources, 2016 indicates that water requirements from the New England Fold Belt Coast groundwater source (part of a large regional unit on the mid-north coast of NSW) at the commencement of the plan was 35,468 megalitres per year (ML/yr). The long-term average annual extraction limit (LTAAEL) for this is set at 60,000 ML/yr, the upper extraction limit is 365,000 ML/yr indicating water licences may be available.	Primary means of governing rivers. Impacts any licencing of water. Consideration of the WM Act is included in **Section 20.3** and **Section 20.4**

Policy / guideline	Description	Relevance to this assessment and where it is discussed
NSW Aquifer Interference Policy 2012	The Aquifer Interference Policy clarifies the role and requirements of the Minister in charge of administering the WM Act in the water licencing and assessment process for aquifer interference activities. It also establishes consideration and advice structures for the potential impacts of an aquifer interference activity. The policy applies to all aquifer interference activities and if approval is generally required for any works that involve: • The penetration of an aquifer • The interference with water in an aquifer • The obstruction of flow in an aquifer • The taking of water from an aquifer while carrying out mining or any other activity prescribed by the regulation • The disposal of water from an aquifer. Sufficient access licences must be held to account for all water taken form a groundwater source as a result of an aquifer interference activity (both for the life of an activity and after it has ceased) until the aquifer system has reached equilibrium. Section 5.23 of the EP&A Act provides exemption for approved SSI projects for the need of a water use approval under section 89, a water management work approval under section 90 or an activity approval (other than an aquifer interference approval) under section 91 of the WM Act. The policy requires that potential impacts on groundwater sources be assessed against minimal impact considerations outlined in the policy which depend on the groundwater source.	Potential impacts on aquifers and assessment against the Aquifer Interference Policy is discussed in **Section 20.4.5**
Risk Assessment Guidelines for Groundwater Dependent Ecosystems 2012	The risk assessment guidelines are used to manage land and water use activities that pose a potential threat to groundwater dependant ecosystems. The guidelines consist of four volumes that include the conceptual framework, worked examples, identification of high potential groundwater dependant ecosystems and their ecological value for coastal aquifers, and the risk of groundwater extraction on the coastal plains of NSW.	Assessment of GDEs is provided in **Section 20.4.4**
NSW State Groundwater Policy Framework Document 1997	The groundwater policy framework document is used to provide ecologically sustainable management guidance about groundwater resources, so that they can sustain environmental, social and economic uses for the people of NSW. This policy is divided into three components /sub-categories:	

Policy / guideline	Description	Relevance to this assessment and where it is discussed
	NSW Groundwater Quantity Management Policy: The principles of this policy are to: • Maintain use of groundwater within the sustainable yield of the aquifer from which it is withdrawn • Ensure groundwater is managed to prevent unacceptable local impacts • Manage the licencing of all groundwater extraction, which may be allowed to be transferred depending on the physical constraints of the groundwater.	Potential groundwater quantity impacts are discussed in **Section 20.4.2**
	NSW Groundwater Quality Protection Policy 1998: The focus of this policy is the ecologically sustainable management of the State's groundwater resources to: • Slow, halt or reverse any degradation in groundwater resources • Direct potentially polluting activities to the most appropriate local geological setting • Establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource • Establish triggers for the use of more advanced groundwater protection tools (e.g. groundwater vulnerability maps or groundwater protection zones).	Potential groundwater quality impacts are discussed in **Section 20.4.2**
	NSW Groundwater Dependent Ecosystems Policy 2002: This policy is designed to protect valuable ecosystems that rely on groundwater to survive, maintain the biophysical functions and preserve these ecosystems for the resources of future generations. Furthermore, the policy provides practical guidelines that can be used as tools to suit a specific need based on a given groundwater dependant ecosystem or environment.	Assessment of GDEs are provided in **Section 20.4.4**

20.3 Existing environment

20.3.1 Hydrogeology

Hydrogeology is the area of geology that deals with the distribution and movements of groundwater in soils and rocks. The project is situated within the New England Orogen in eastern Australia and is underlain by two geological rock units, the Carboniferous aged Coramba Beds and the Brooklana Formation of the Coffs Harbour sequence.

Quaternary aged alluvial, swamp and estuarine sediments comprising sands, silts and gravels overlay the rock units in topographically low-lying areas and are generally associated with creek lines. The project intersects Quaternary alluvium which includes floodplain deposits, fan deposits, valley deposits and terrace deposits.

Groundwater presents in three distinct strata within the project, these are shallow surficial deposits, alluvial deposits and fractured bedrock. There is a fourth system that was considered in the hydrogeological model, the coastal sands aquifer, but this was sufficiently far enough away not to be considered relevant for this project.

Surficial / perched groundwater

The shallow surficial deposits comprise of relatively thin colluvial and residual soils horizons, comprising clays, silts and gravels that overlie the Brooklana Formation and Coramba beds in the hill slopes and foothill areas. The distribution of surficial materials in the study area is highly variable. The unit is unlikely to act as a single groundwater body, instead presenting as a series of disconnected local perched systems (ie shallow groundwater that sits above the regional water table).

It is anticipated that this aquifer is often unsaturated, with groundwater temporarily perching in this unit following rainfall recharge events. The perched groundwater is expected to infiltrate to the underlying fractured bedrock aquifer and/or move downgradient towards drainage lines and creeks in the surrounding topography. These deposits are not considered an aquifer in its normal sense as they are not a reliable groundwater source. The quantity of groundwater that is stored and flowing through these materials is likely to be small but may be locally important for some vegetation.

Alluvial aquifers

Alluvial aquifers occur along drainage lines which integrate topographically higher areas. The alluvial aquifer units are separated into two types; a shallow up-river alluvial aquifer and a coastal floodplain alluvial aquifer.

The up-river alluvial aquifer system is an unconfined aquifer (where water seeps from the ground surface directly above the aquifer) within Quaternary aged alluvial deposits that increase in thickness east towards the coastal floodplain alluvial and coastal sand deposits. The aquifer comprises interbedded silt, clay, sand and gravel lenses, creating a relatively high permeability aquifer with zones of lower permeability.

The coastal floodplain alluvial aquifer, the boundary of which is defined by the tidal limit of the creek, typically comprises of finer grained deposits such as fine-grained sands, silts and clays. These deposits occur further downstream where the floodplain flattens and widens. Due to the finer grained nature of the deposits, connectivity to surface waters tends is reduced compared to the up-river unit, which is strongly connected.

Recharge to these aquifers is anticipated from two sources. The first source is from rain over alluvial areas which is recharged to the aquifer through shallow surface runoff. The second is surface water within the creek lines.

The NSW Water Sharing Plans which cover the Coffs Harbour Region (DWE 2009 and DPI 2016) indicates the up-river alluvial aquifer is highly connected to creeks in the Coffs Harbour region and has a high impact on instream flow due to contribution from baseflow. The estimated travel time between groundwater and creek (period of time between recharge entering an aquifer and discharging) ranges from days to months (DWE 2009). The coastal floodplain aquifer is less connected to the creeks and therefore has a low impact on instream values.

Based on geological mapping, the project intersects alluvial deposits at several locations and the water sharing plan indicates that these deposits are all part of the up-river alluvial deposits.

Fractured bedrock aquifer

The bedrock has low primary permeability (ie through pore spaces), except where the rock has undergone significant weathering. Groundwater storage, permeability and flow within the rock mass is principally within secondary defects (joints, fractures, faults) and weathered zones. The permeability and storage (volume of recoverable groundwater within the rock) of the fractured bedrock is generally low although there are zones of higher permeability within the rockmass.

The shallow surficial and alluvial aquifers near the project are underlain by the fractured bedrock aquifer comprising the Brooklana Formation and Coramba beds. Groundwater in these units is in geological structures that include faults, shear zones, joint sets and cleavage planes, that in a large part have been created by regional metamorphism.

Although locally the quantity of groundwater and flow in the fractured bedrock may be low, the aquifer has a regional scale and the aquifer comprises a thick sequence of fractured rock units. Rainfall recharge to the west of the study area is likely to contribute to a deep regional groundwater flow system. Groundwater within the bedrock in the study area forms part of a shallower, more local system, where recharge and flow paths are less connected to the regional scale system. Compared to the alluvial aquifers, groundwater movement within the fractured bedrock is slow and may take years to decades or longer from the point of recharge to discharge (DPI 2016).

Groundwater flows in the shallower fractured bedrock are generally expected to follow the topographical features of the area which are broadly towards the east, except locally at ridge lines. Groundwater flow within the deeper regional bedrock is less likely to be affected by local topographic variation with flow anticipated to be eastwards towards the coast, potentially exhibiting strong vertical gradients.

Groundwater

The aquifers identified in the Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources (DWE 2009) have varying degrees of connection with surface waters, typically governed by the type of material which the alluvial aquifer comprises as shown in **Table 20-2**. Sands and coarse-grained alluvial materials will lend to faster groundwater flow rates and strong connectivity with the creek water. Clays and fine-grained materials will have slower groundwater flow rates and less connection with creek waters. For the purposes of water allocation, the Water Sharing Plan assumes that the up-river alluvial aquifer and creek water is the same water source. During periods of high rainfall and recharge, surface water flows are likely to provide direct recharge of the alluvial aquifer. In periods of low rainfall, water within the same aquifer may provide baseflow into these rivers and creeks or to support vegetation in dry creek beds.

The fractured bedrock aquifer, which are generally considered to have low connectivity with surface water are covered by the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources (DPI 2016).

Table 20-3 Excerpt of connectivity between aquifer types and surface water (DWE 2009)

Aquifer type	Water sources	Level of connection between surface and groundwater	Level of impact on in stream values	Estimated time between groundwater and unregulated river
Coastal sands	Coffs Harbour coastal sand and all unregulated rivers[1]	Significant (tidal section only)	Low due to connection with saline water	One day to months
Up-river alluvial	All unregulated rivers[1]	Significant	High due to impact on base flows	Days to months
Coastal floodplain alluvial	Most unregulated river[1] water sources except Dirty Creek, Corindi River, Red Bank River and Arrawarra Creek	Low – moderate (tidal section only)	Low since not a major contributor and low level of connection	One season
Fractured rock	All unregulated rivers[1]	Low - moderate	Low since not a major contributor	Years to decades

Note 1: Unregulated river applies to rivers that do not have major storages along their alignment such as dams

20.3.2 Groundwater levels

Groundwater levels within the fractured bedrock aquifer across the study area range from between 11 m AHD to 117 m AHD. The large range of water levels is due to the variation in topographic levels along the project. Groundwater levels below ground level vary from less than five metres to about 43 m, with the deepest groundwater generally corresponding to topographically higher areas (ie around Shephards Hill and Gatelys Road).

Groundwater monitoring was conducted at 32 standpipes (25 with continuous monitoring data) and 17 vibrating wire piezometers along the project which were installed during field investigations. Near continuous groundwater level monitoring data was gathered between July 2017 and February 2019 (20 months). Additionally, limited groundwater level information was available from 29 licenced bores within the study area (the locations of these bores are shown in **Appendix N, Groundwater assessment**).

Groundwater level monitoring indicated that groundwater is affected by seasonal climatic variations and rainfall events. Between the wetter period from November to April, levels were generally elevated at most of the monitoring locations compared to the period between May and October when they were typically in recession.

Groundwater level variation over the period of monitoring (July 2017 to February 2019) indicated variations in groundwater level of between less than one metre and up to 12 m. Changes in groundwater level indicate that there is variable response in the fractured bedrock aquifer to rainfall events. Some monitoring locations showed rapid and large changes in water levels following rainfall events whereas other locations showed much less response with greater lag time. Further details, including groundwater hydrographs at each of the monitoring locations can be found in **Appendix N, Groundwater assessment.**

Groundwater within the alluvial deposits was encountered in several test pits along the project. Of those which encountered groundwater, standing groundwater levels varied from 0.9 m below ground level (mbgl) to 1.9 mbgl. This indicates that groundwater is close to ground surface within alluvial deposits. Given the expected connection between creek flow and groundwater in the underlying alluvium, these shallow groundwater levels are in line with the anticipated conditions in these areas.

Groundwater level monitoring for the project is ongoing for the purposes of baselining groundwater variation and climatic response.

20.3.3 Groundwater flow and recharge characteristics

The flow of groundwater through the fractured bedrock aquifer is through defects within the rock mass. Groundwater inflows to cuttings would be concentrated at discrete fracture, joint or fault locations and it is anticipated that the extent of complexity of the geological structures within each cut and tunnel setting would not be fully understood until excavation has started.

Groundwater flow directions in the fractured bedrock aquifer for the project are principally in an easterly direction towards the coast, ultimately discharging to the sea or along springs in topographically higher areas. Vertical groundwater flow within the bedrock aquifer also occurs due to infiltration of rainfall in recharge areas and upward flow from deeper parts of the aquifer in discharge areas.

Flow within the alluvial aquifers is constrained by the physical extent of the deposits, however, is generally towards the coast, in the same direction as flow within the overlying creeks. Flow within the alluvial aquifers is through pore spaces of the deposits. In sand/gravel units within the upriver alluvial deposits flow is quick while in clayey alluvial deposits associated with the floodplain alluvium, groundwater flow is much slower. Groundwater flow ultimately discharges at the sea, either as contribution to baseflow to the creek or as flow through the aquifer.

20.3.4 Groundwater quality

Groundwater quality testing has been conducted as part of an ongoing groundwater monitoring program (RCA 2017a). Groundwater samples were collected from standpipes installed at a variety of depths ranging from six mbgl to 68 mbgl. The samples were tested for a range of quality parameters and evaluated using the 95th percentile values of the Bellinger River and Coffs Harbour Catchment Water Quality Objectives (WQO) (as the project is located within this catchment) and the aquatic ecosystem protection guidelines for moderately disturbed systems in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000).

The results of the testing indicated that groundwater pH, conductivity, turbidity, total manganese and total zinc were generally within the water quality objectives and ANZECC guidelines. The pH of the groundwater is generally slightly acidic to slightly alkaline. Dissolved oxygen was between 75 per cent and 110 per cent except for one sample which was lower, indicating that the water was generally oxygenated. Turbidity of groundwater samples was generally low.

Groundwater samples showed concentrations of trace metals above the ANZECC aquatic ecosystem guideline values and the six samples tested for zinc all had concentrations slightly elevated above the guideline (a maximum of 0.05 mg/l with a trigger value of 0.008 mg/l). Of the 26 samples tested, 24 also had concentrations of aluminium above the ANZECC guideline value of 0.055 mg/l. There does not appear to be a trend in the location of exceedances within the study area as concentrations in the fractured bedrock do not generally correspond with any particular source, and elevated concentrations of some metals are likely to be naturally occurring and indicative of regional water quality.

Groundwater in alluvial aquifers has a short residence time and strong connection to surface waters as described in the Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources, 2009 (DWE 2009). Connection between the up-river alluvium and creek flow is such that the water sharing plan considers water in the alluvium and creek to be the same source. The quality of the alluvial groundwater is therefore expected to be similar to that of the surface water within the creeks. Sampling of surface water within creeks of the study area indicated freshwater quality. Further information about this is presented in **Chapter 19, Surface water quality**.

20.3.5 Acid sulfate soils

Acid Sulfate Soils (ASS) are sediment deposits that contain iron bearing sulphides, which are typically found in swamps and estuaries below five metres AHD and where groundwater creates oxygen poor environments. Potential acid sulfate soils (PASS) can be disturbed by construction activity or groundwater drawdown which can lead to oxidation and formation of sulfuric acid, as well as the mobilisation of aluminium and heavy metals within the subsurface. Acid sulfate generating materials can also be present in bedrock units and their disturbance can also lead to generation of acid leachate (in the form of acid sulfate rock (ASR)). The presence of ASS and ASR can have an impact on the groundwater environment as generation of acid leachates can cause acidification and contamination of groundwater resources. The ASS Risk Map (Naylor et al. 1998) and ASR risk map (Roads and Maritime 2017) indicates:

- The southern end of the construction footprint intersects with a low possibility of PASS associated with the Boambee and Newports creeks and their tributaries. At these locations, there is a low probability of PASS at depths between two to four metres and greater than four metres below ground level
- High ASS risk areas are located about 120 m east of the southern end of the project where PASS are expected at one to two metres and less than one metre depth below ground level as well as the Boambee Creek bed sediments
- The northern end of the construction footprint intersects an area mapped high-risk ASS near Pine Brush Creek, where the anticipated depth of PASS is greater than four metres below ground level
- The construction footprint is located in areas of low and medium ASR risk. Medium risk areas are generally associated with the meta-sediment rock in the Coffs Harbour region.

A number of the soils tested as part of the geotechnical investigations indicated the presence of residual chromium reducible sulfur, low pH values and high total actual acidity levels. Areas of PASS were confirmed near Englands Road, North Boambee Road and Coramba Road.

Petrographic and acid base accounting laboratory testing was completed for selected rock samples collected along the project corridor to determine the presence of ASR. Test results indicate the rock samples have sufficient acid neutralising capacity to buffer acid produced by sulfides in the rock mass and that ASR is unlikely to be a risk to the project.

Further information on ASS and ASR for the project can be found in **Chapter 18, Soils and contamination**.

20.3.6 Salinity

The study area is underlain by landscapes with very low to very high mapped salinity hazard potential which are associated with:

- Acid Sulfate Soil Potential landscapes – very high hazard corresponding to areas identified on ASS risk map, typically in lower lying topographical areas and along the coastal areas of Coffs Harbour
- Coastal Ranges Metasediments landscapes – very low hazard corresponding to the foothills and slopes of the Coramba Beds and Brooklana Formation, in which most of the project is located.

Groundwater samples collected as part of geotechnical investigations indicated that the total dissolved solid concentration (salinity) of the groundwater is low (less than 450 mg/l) and is generally of freshwater quality.

Total dissolved solids ranged from 86 mg/l to 437 mg/l and is generally of freshwater quality. Two samples registered slightly brackish electrical conductivity (BHH150 and BHH169) which are located at Gatelys Road and near the waste facility at the southern end of the project (these borehole locations are shown in **Appendix N, Groundwater assessment**). The groundwater sample taken from BHH150 is from one of the deepest standpipes along the project, screened at approximately 58 mbgl to 64 mgbl. This may be indicative of an increase in salinity with depth, possibly due to increased residence times of groundwater in the aquifer, although the overall dataset showed little correlation between sample depth and salinity. Additionally, both samples registered electrical conductivity values of approximately 1.2 decisiemens per centimetre (dS/cm) indicating that the salinity of these samples was only very slightly above the freshwater/brackish threshold. Other nearby standpipes were of freshwater quality indicating that there is likely to be local variability in groundwater quality across the project.

20.3.7 Groundwater users

The Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources 2009 indicates that groundwater in the Coffs Harbour region is primarily used for irrigation and farming purposes. The Korora Basin catchment was identified as having high instream value (ie high water uses from creeks within the basin). Water trading will be limited for this water source with no future increase in water entitlement.

The Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016 indicates that the water requirements from the New England Fold Belt Coast groundwater source at the commencement of the plan was 35,468 ML/yr and the long term annual average extraction limit (LTAAEL) for the groundwater source is set at 60,000 ML/yr; the upper extraction limit is 365,000 ML/yr. This indicates that there is a large water availability from the groundwater source and water licences are likely to be available.

The DPIE (Water) database indicated that there are numerous licenced groundwater bores near the project. **Figure 20-6-01** to **Figure 20-6-06** shows the location of the licenced groundwater bores within close proximity to the project as well as the location of monitoring wells recorded in the National Groundwater Information System (NGIS) database (BoM 2019).

The search results indicate that most groundwater wells in the study area draw from the fractured bedrock aquifer. A total of four water access licences from alluvial water sources were also active at the start of the water sharing plan in 2009 in the Boambee Creek and Coffs Creek EMUs.

Water access licenses

Within the three unregulated river sub-catchment areas, a total of 110 water access licenses have been granted with four water access licenses for alluvial groundwater entitlements under the Coffs Harbour Area Unregulated and Alluvial Water Sources (DWE 2009). The water access license entitlements over the three sub-catchments cumulate to 1524 ML/year in total and 49ML/year in alluvial groundwater.

Within the New England Fold Belt fractured bedrock groundwater source (DPI 2016), the total water entitlements for the source totalled 35,468 ML/year (DPI 2016). These water licences are for an extensive area and not limited to the Coffs Harbour Region.

Agricultural dams

NSW Hydrographic mapping (NSW 2016) indicates that there are about 70 agricultural dams within the study area and within one kilometre of the project. The source of water for these agricultural dams is not known however it is typical that they would be maintained by a combination of surface run off, top up from nearby creeks or groundwater fed (through processes of spring discharge and or direct connection with the underlying water table). Groundwater-fed dams may be from perched water within surficial deposits or from discharge from the underlying fractured bedrock aquifer.

Several agricultural dams and ponds are located close to and within the construction footprint. A number located downgradient of cuttings or drained tunnels could be affected by changes to groundwater flow or level. It is likely that some may be directly or indirectly groundwater fed.

A number of ponds/agricultural dams located around the ridgelines at Shephards Lane, Gatelys Road and Roberts Hill may be groundwater fed. A number of other dam locations near to the project, particularly around cuts 11 and 12 (north of Coramba Road interchange near Spagnolos Road), cut 16 (near Mackays Lane) and the tunnels at Roberts Hill, Shephards Lane and Gatelys Road ridges could also potentially be linked to groundwater. At this stage however, the exact hydrological dynamics of each dam/pond is not known and further ground truthing and field investigations are required to clarify this.

The impacts on agricultural dams is also discussed further in **Chapter 13, Agriculture**.

20.3.8 Groundwater dependent ecosystems

Groundwater dependent ecosystems require access to groundwater on a permanent or intermittent basis to maintain their communities of flora and fauna, ecological and ecosystem processes. There are three types of GDEs based on the type of groundwater reliance. These are:

- Aquatic GDEs dependent on surface expression of groundwater and includes surface water systems which may have a groundwater component (ie groundwater fed wetlands or river baseflow ecosystems),
- Terrestrial GDEs dependent on subsurface expression of groundwater (ie terrestrial and riparian vegetation), and
- Subterranean GDEs dependent on subterranean presence of groundwater (ie karst and cave ecosystems).

An assessment of the potential for the study area to support GDEs was conducted using the BoM GDE Atlas and Statewide GDE mapping (DPI 2016b). Field surveys carried out between August 2016 and May 2018 for **Appendix H, Biodiversity assessment report** included consideration of potential GDEs.

Within the study area there are nine plant community types (PCT), one a groundwater dependent wetland community and eight groundwater dependent vegetation communities, all identified as ‘High probability GDEs’ (from national assessments), and reliant on subsurface expression of groundwater (see **Figure 20-6-01** to **Figure 20-6-06**).

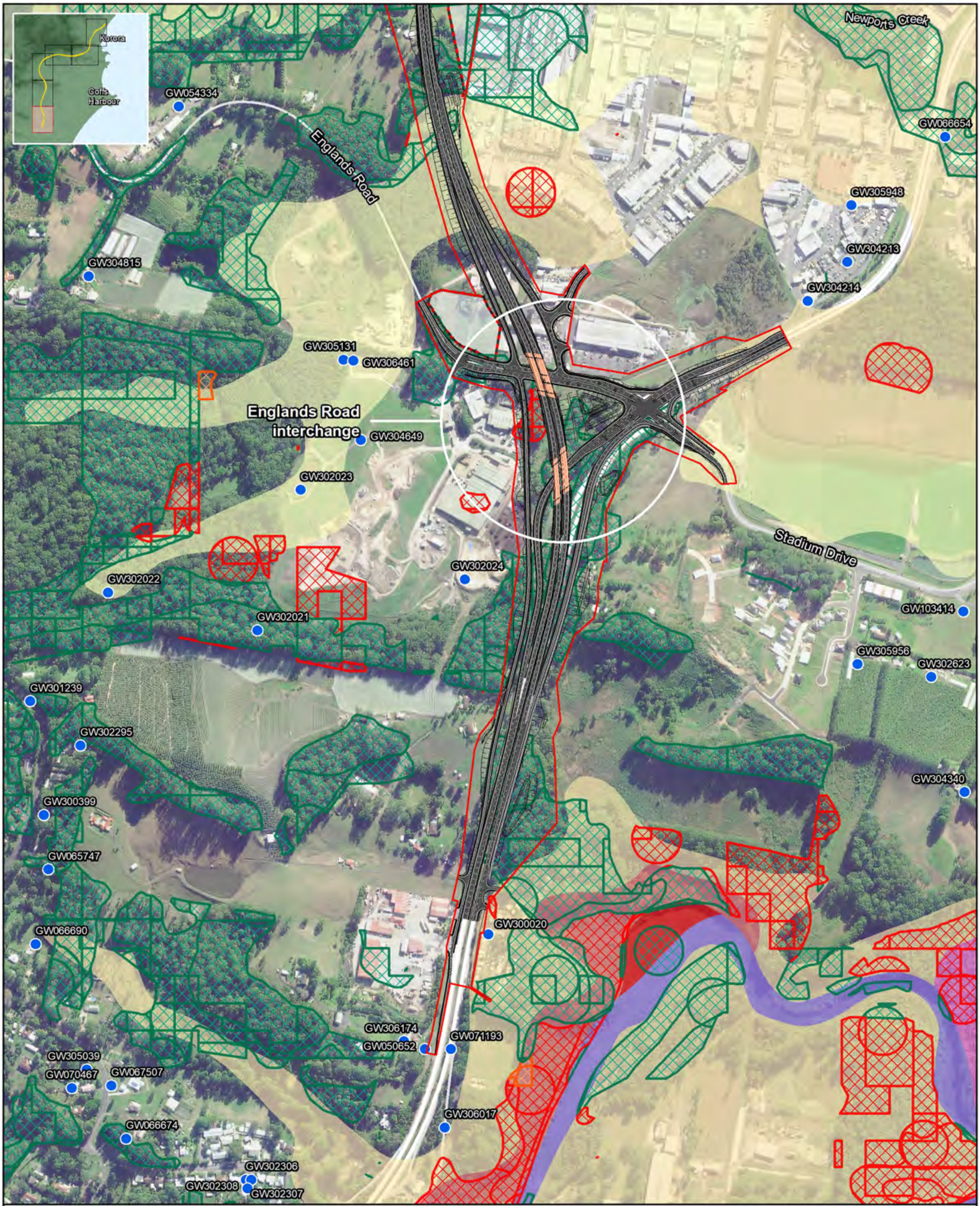
The potential GDEs identified from the GDE Atlas are mostly terrestrial which could rely upon the subsurface expression of groundwater to support the ecological community. These terrestrial GDEs support a variety of vegetation ecosystems and protected areas including for Indigenous use.

The GDE Atlas illustrates that PCT 1064 Paperbark swamp forest vegetation present in the vicinity of the Newports Creek floodplain, south of Englands Road, is the only area of High probability GDE within the study area (from regional studies). Further information relating to these communities is presented in **Chapter 10, Biodiversity**. No GDE fauna species are recorded as occurring within the study area.

Springs

Springs occur where the groundwater table meets the surface and discharges or ponds. Springs form in a variety of settings and may represent point (from discrete fractures) or diffuse discharges. Hydrographic mapping (NSW 2016) indicates there are no mapped springs in the study area however a spring was noted during drilling for BHH138 at Shephards Lane and anecdotal evidence and conceptual understanding of the hydrogeology indicates that springs likely occur from the fractured bedrock aquifer in the region and may be a source of water for creek flows, vegetation and agricultural dams for local landowners.

Springs are most likely to occur during and following the wet season when groundwater levels are highest. They may also occur in areas of steep topographic variation such as the three main ridge lines. The nature of spring emergence will be affected by topographic variation, underlying geological profile and recharge dynamics.



Legend

- Construction footprint
- Ancillary sites
- Pavement
- Bridge
- Tunnel
- North Coast Railway
- Watercourse
- NGIS database groundwater bores

Acid Sulfate Soil Risk

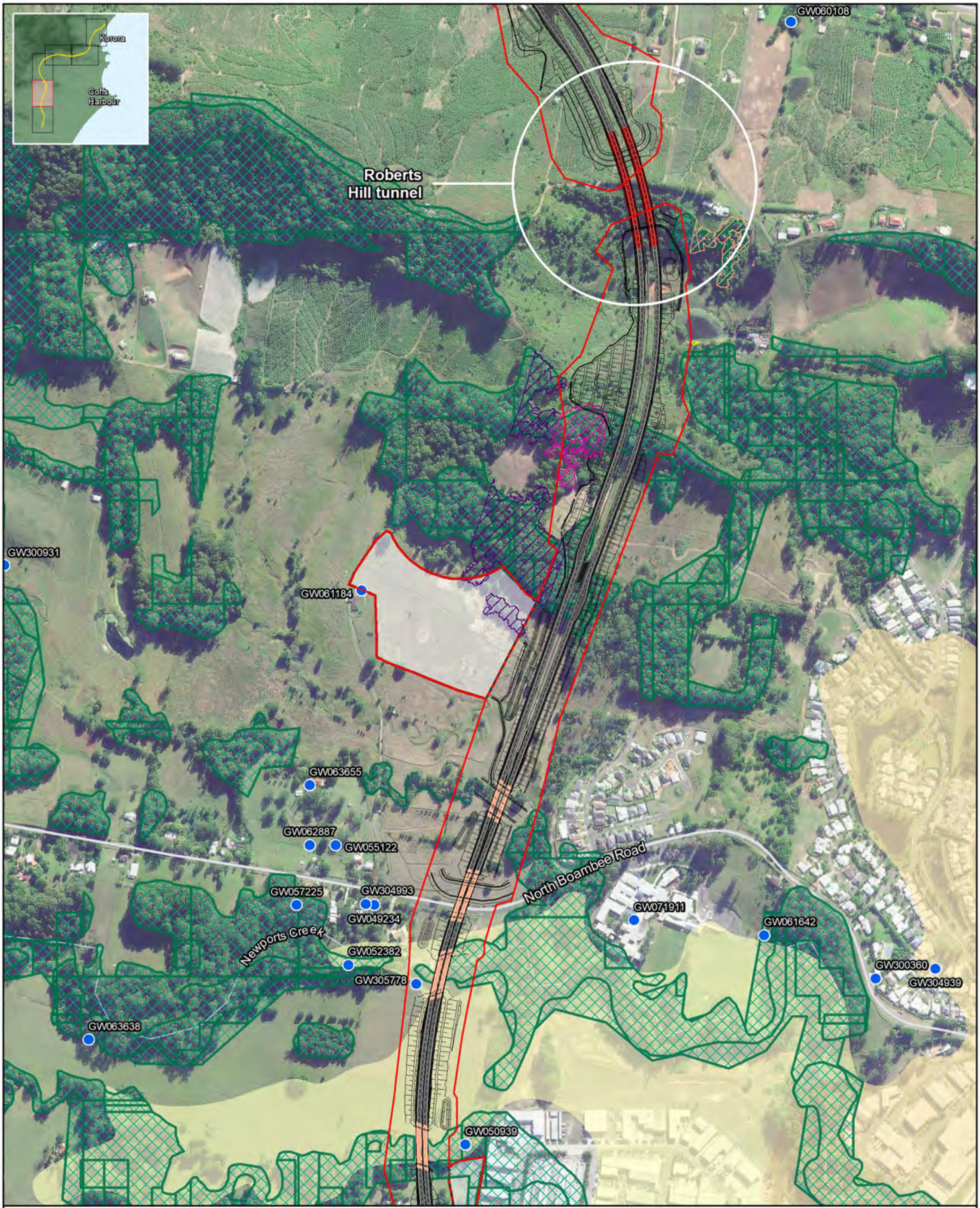
- High Risk 0-1m
- High Risk 1-2m
- High Risk 2-4m
- High Risk Sediments
- Low Risk 2-4m
- Low Risk above 4m

Terrestrial GDEs

- High potential GDE (regional studies)
- Moderate potential GDE (regional studies)
- Low potential GDE (regional studies)

Coffs Harbour Bypass
Existing conditions (bores, ASS risk, GDEs and PCTs)
Figure 20-6-01

0 0.1 0.2 0.3 km
Scale @A4: 1:10,000
GDA 1994 MGA Zone 56
N



Legend

Construction footprint
Ancillary sites
Pavement
Bridge
Tunnel
North Coast Railway
Watercourse
NGIS database groundwater bores

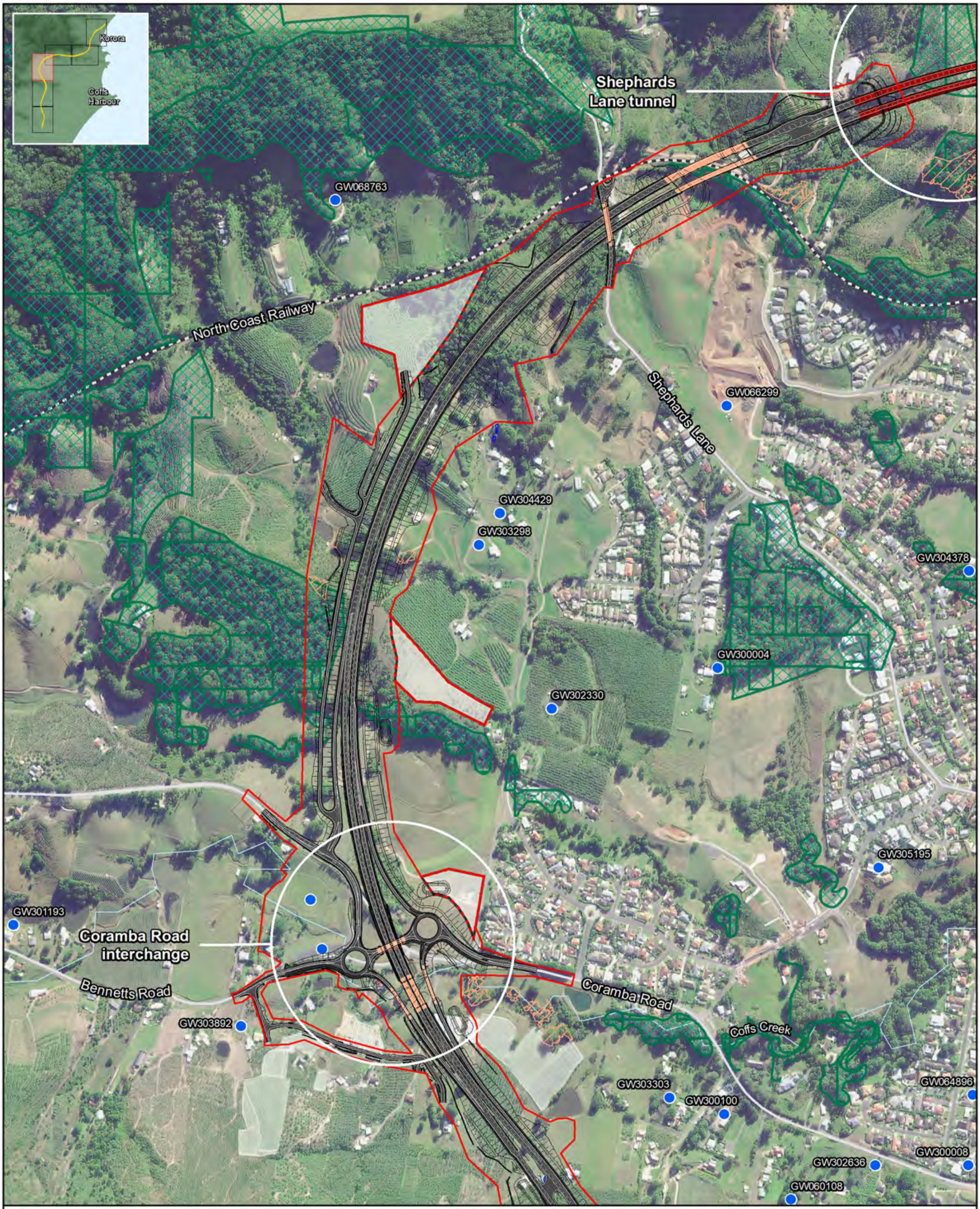
Acid Sulfate Soil Risk
Low Risk 2-4m
Low Risk above 4m

Vegetation Communities
PCT 692
PCT 695
PCT 826
PCT 1244

Terrestrial GDEs
Low potential GDE (regional studies)

Coffs Harbour Bypass
Existing conditions (bores, ASS risk, GDEs and PCTs)
Figure 20-6-02

0 0.1 0.2 0.3 km
Scale @A4: 1:10,000
GDA 1994 MGA Zone 56
N



Legend

- Construction footprint
- Ancillary sites
- Pavement
- Bridge
- Tunnel
- North Coast Railway
- Watercourse
- NGIS database groundwater bores

Vegetation Communities

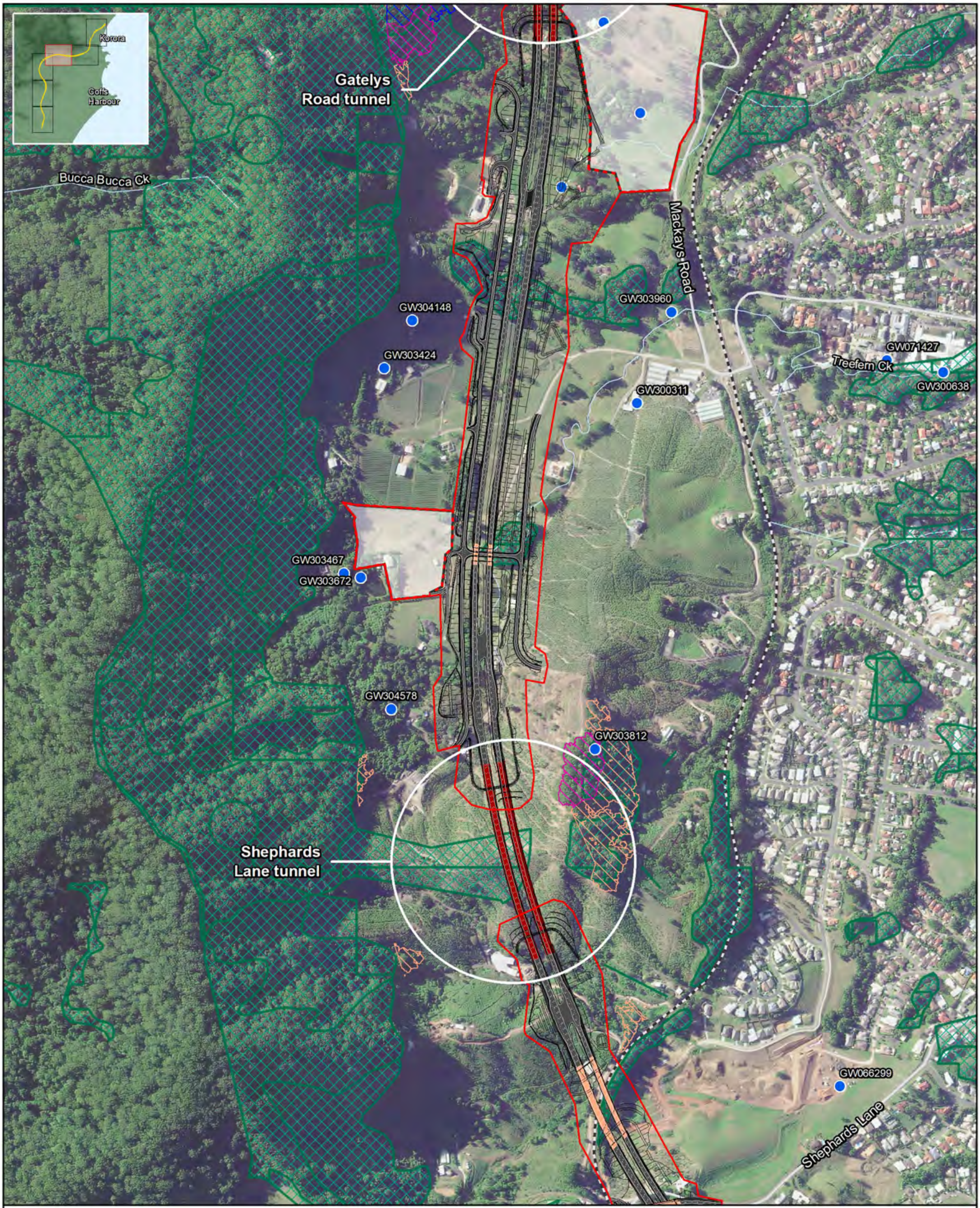
- PCT 686
- PCT 695

Terrestrial GDEs

- Low potential GDE (regional studies)

Coffs Harbour Bypass
Existing conditions (bores, ASS risk, GDEs and PCTs)
Figure 20-6-03

0 0.1 0.2 0.3 km
Scale @A4: 1:10,000
GDA 1994 MGA Zone 56
N



Legend

- Construction footprint
- Ancillary sites
- Pavement
- Bridge
- Tunnel
- North Coast Railway
- Watercourse
- NGIS database groundwater bores

Vegetation Communities

- PCT 686
- PCT 692
- PCT 695

Terrestrial GDEs

- Low potential GDE (regional studies)

0 0.1 0.2 0.3 km

Scale @A4: 1:10,000
GDA 1994 MGA Zone 56

Coffs Harbour Bypass
Existing conditions (bores, ASS risk, GDEs and PCTs)
Figure 20-6-04

Legend

- Construction footprint
- Ancillary sites
- Pavement
- Bridge
- Tunnel
- North Coast Railway
- Watercourse
- NGIS database groundwater bores

Vegetation Communities

- PCT 686
- PCT 692
- PCT 1244

Terrestrial GDEs

- Low potential GDE (regional studies)

Coffs Harbour Bypass
Existing conditions (bores, ASS risk, GDEs and PCTs)
Figure 20-6-05

0 0.1 0.2 0.3 km

Scale @A4: 1:10,000
GDA 1994 MGA Zone 56

Coffs Harbour Bypass
Existing conditions (bores, ASS risk, GDEs and PCTs)
Figure 20-6-06

20.4 Assessment of potential impacts

Construction and operation of the project would involve activities that may result in groundwater impacts. The main risks to groundwater during construction are expected to be:

- Changes to groundwater flows, surface flows and connectivity due to lowering of the groundwater level as a result of cuttings and tunnels being below groundwater level
- Construction of large fill embankments which may concentrate runoff and recharge to groundwater systems
- Impact to GDEs, water supply wells, agricultural dams and creeks from changes to groundwater levels and throughflow along the project
- Groundwater contamination, which may occur during construction if construction activities are not adequately managed
- Changes to groundwater quality due to the oxidation of acid sulfate materials, caused either by exposure of rock due to construction activity or lowering of groundwater levels
- Changes in groundwater quality due to exposure and leaching of saline soils along the project.

Once construction is complete, there would be potential residual impacts associated with the operational phase of the project. During the operational phase, the impacts are mostly associated with the groundwater system reaching an equilibrium with the new topographic surface. In areas of fill there would be limited to no impact on groundwater. In areas of cut and drained tunnels, groundwater levels would be redistributed up and downgradient due to changes in discharge of groundwater into the cuttings.

The main risks to groundwater during operation are expected to be:

- Changes in groundwater levels, flow direction and throughput of groundwater due to potential redistributed flow paths
- Changes to groundwater quality from pollution caused by spills and leakage of road user vehicles or drainage maintenance issues
- Changes to groundwater from longer-term acid sulfate generation caused by exposure or reduction in groundwater levels.

These potential risks during construction and operation are discussed in the following sections.

20.4.1 Groundwater levels and drawdown

The impact on groundwater levels upgradient and downgradient has been predicted using numerical models. As impacts to groundwater levels and drawdown occur over an extended period of time, the construction and operational impacts are addressed as one here.

At the cuttings and tunnels, groundwater levels would be drawn down close to the pavement level (or level of the permanent drainage system). The distance over which groundwater lowering (drawdown) occurs in the surrounding aquifer is dependent on the hydrogeological properties of the aquifer, recharge to the aquifer system and depth below the groundwater level of the cut or tunnel.

The zone of drawdown around each of the cuttings and tunnels is shown in **Figure 20-7-01** to **Figure 20-7-06**. This zone is based on the distance upgradient and downgradient to the one metre drawdown contour.

Drawdown would continue to extend beyond the one metre contour, however this contour is commonly used as a value to delimit or identify a zone of impact. The NSW Aquifer Interference Policy uses a two-metre drawdown as the basis of an impact to groundwater supply wells.

The zone of influence shown in **Figure 20-7-01** to **Figure 20-7-06** is likely to be an overestimate as it assumes that drawdown would occur uniformly across the entire length of the cutting or tunnel. The predicted drawdown however is modelled at the deepest part of the cut/tunnel and as such is likely to be a conservative approach to identifying the potential area of impact.

The distances presented in **Table 20-4** are the long-term steady state averages. During construction, the zone of drawdown would spread away from the cutting and tunnels as excavation proceeded. The rate at which this develops would be dictated by the rate of excavation and the hydrogeological properties of the ground. Changes to groundwater levels, gradients and flow directions would develop over the construction period as groundwater discharges into each of the cuts eventually reaching new equilibrium steady state water levels.

Table 20-4 Estimated zone of influence for modelled cuts and tunnels

Cut / Tunnel	Maximum predicted distance to upgradient 1 m drawdown (m)	Maximum predicted distance to down gradient 1 m drawdown (m)
Cut 4	223	50
Roberts Hill tunnels and portals	143	143
Cut 8-1	99	37
Cut 8-2	100	203
Cut 11	195	154
Cut 12	63	71
Cut 14	185	59
Shephards Lane tunnels and portals	197	197
Cut 16	114	95
Gatelys Road tunnels and portals	355	355
Cut 18	191	125
Cut 18r [1]	50	50

[1] Numerical modelling results from Cut 18 have been used to estimate the steady state drawdown for Cut 18r. This cut extends locally to a few metres into the water table and the resultant drawdown is predicted to be localised within the construction footprint.

Groundwater supply wells

A review of the DPIE Water licenced groundwater bores from the NGIS was undertaken to identify those which might be impacted by groundwater drawdown caused by cuttings and tunnels and those within the construction footprint which would be acquired. At the time of land acquisition, Roads and Maritime would also acquire the water access licence associated with the bores and subsequently become the owner of the licence. The supply wells affected are shown in **Figure 20-6-01** to **Figure 20-6-06** and include:

- 10 supply wells located within the construction footprint (five of which are also within the zone of groundwater drawdown). These wells would be removed during construction, and they have not been assessed further
- 12 supply wells located within the anticipated zone of groundwater drawdown. Of these:
  - Eight are expected to have a drawdown of less than one metre
  - Three are expected to have a drawdown of between one and two metres
  - One is expected to have a drawdown of around 4.3 m which exceeds the Aquifer Interference Policy Minimal requirements.

All of the wells predicted to be impacted by groundwater drawdown are installed within the less productive fractured bedrock aquifer. No groundwater well sources in alluvial aquifers within the study area are expected to be affected by groundwater drawdown.

The NSW Aquifer Interference Policy states that the minimal impact consideration for aquifer interference is a cumulative pressure head decline of not more than two metres at any water supply wells. This assessment indicates that a total of four supply wells could be affected by more than the minimal impact consideration. This is discussed further in **Section 20.4.5**.

Creeks and wetlands

Creeks located near to major cuts or tunnels could be affected by changes in groundwater flow, water levels or surface water runoff. Cuttings located near creek lines may cause lowering of groundwater levels below the creek line (within the bedrock aquifer). The assessment indicates that Coffs Creek and Jordans Creek are those which are most likely to be affected due to their proximity to cut 8 (between the northern portal of Roberts Hill tunnel and Coramba Road interchange) and Gatelys Road tunnel.

The extent of impact, as with the alluvial aquifers, is likely to be small. Changes to water levels in the fractured bedrock in the surrounding aquifer due to construction of the tunnels and cuttings could potentially promote vertical drainage from the alluvial aquifer into the underlying aquifer. However due to the limited connectivity between the alluvial and fractured bedrock aquifer and low permeability of the fractured bedrock, the potential loss of water from the alluvial aquifer is likely to be small. Generally, drawdown impacts do not extend significantly into areas of mapped alluvial deposits and where they do, it is noted that the elevation of the alluvial deposits are generally much lower than the design level of the cutting or tunnel.

Changes to the bedrock groundwater flow system therefore are not anticipated to have a large impact on the creek flows. Changes to the emergence of spring flows due to groundwater drawdown may locally affect creek flow volumes. However, spring flow is likely to occur during wetter periods (ie following sustained rainfall) when creek flow is also likely to be highest due to increased surface runoff. The volume of water discharging from springs is therefore unlikely to be a significant contributor to creek flows, and the impact is likely to be limited.

Additionally, the impact at creeks along the project would likely be limited as cuttings and tunnels are located at the upper reaches of the creek lines. The catchment of each creek increases significantly to the east of the project. As a result, the reduction in groundwater throughput in the fractured bedrock caused by the cuttings is likely to represent a very small fraction of the total flow supplied to the creeks compared to that from surface water runoff and alluvial aquifer baseflow. The Coastal Management SEPP wetlands associated with Boambee Creek are not anticipated to be affected by changes to the groundwater system as a result of the project. The nearest cutting with the potential to lower groundwater levels is located around one kilometre from the wetlands. The impacts on these wetlands are therefore anticipated to be negligible.

Agricultural dams and lakes

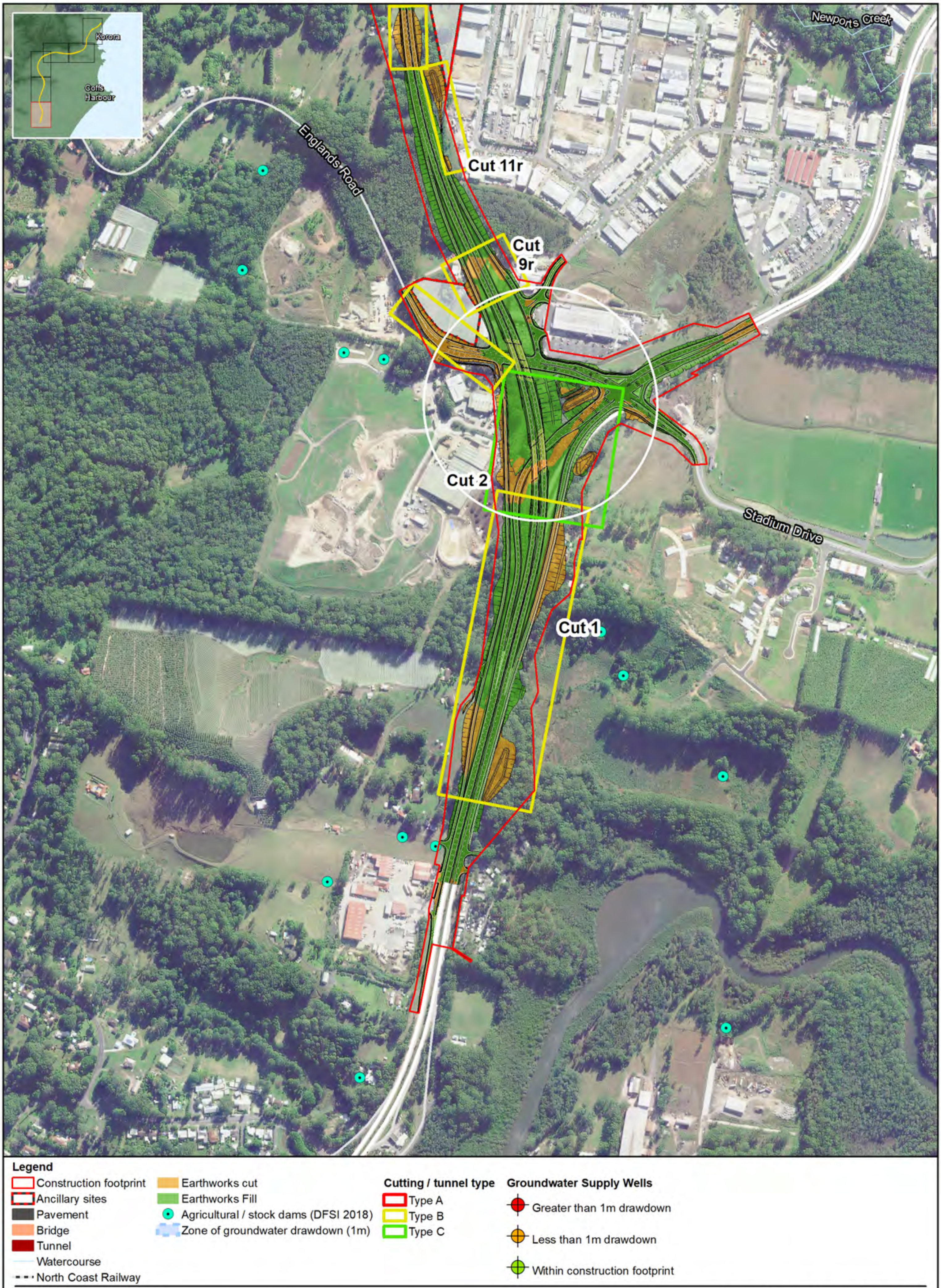
There are several agricultural dams which could potentially be affected by changes in groundwater levels caused by the project (located within the one metre drawdown contour). Three of these locations are within the construction footprint, with a further seven locations across the study area. Several other agricultural dam locations are mapped as occurring downgradient of the proposed tunnels and cuttings and are shown in **Figure 20-6-01** to **Figure 20-6-06** (Department of Finance, Services and Innovation 2018). These are located outside of the one metre drawdown contour but could potentially be affected due to reduction in throughput or changes to spring emergence upgradient. Dams that are spring fed from the fractured bedrock aquifer are likely to be most at risk of impact from changes in the groundwater environment as a result of construction and long-term changes to groundwater levels. Local changes to surface water flows may also affect nearby dams (refer to **Chapter 17, Flooding and hydrology**).

Changes to groundwater levels or through flow down gradient of drained tunnels and cuttings could have a direct impact on those agricultural dams or lakes which are partially reliant on the underlying groundwater. Site investigations for the project have not investigated the exact source of water for those agricultural dams or lakes, which means that it is not possible to accurately predict the impact at these locations. Due to the complexity of the local hydrogeological regime, it is likely that some of the agricultural dams and lake areas are reliant on multiple sources of water for supply, with spring discharge or direct connection with the fractured bedrock likely making up some contribution along with surface run-off (but not necessarily at every location). For the purposes of the assessment, a conservative assumption is made that agricultural dams within the zone of drawdown of the cuttings could be impacted by a reduction in groundwater flow into the dams. The implications of agricultural dams that are located within the construction footprint is discussed further in **Appendix K2, Agricultural assessment**.

Settlement

Lowering of groundwater levels within soils and rocks can lead to ground settlement to changes in the stresses of the material. Drawdown of groundwater levels along the construction footprint is principally within the fractured bedrock aquifer, with the greatest drawdown occurring adjacent to all Type A cuttings and tunnels (see **Section 20.1.1** and **Figure 20-7-01** to **Figure 20-7-06**). The stiffness of bedrock is very high, although it is reduced in the presence of major geological features. The extent and magnitude of settlement occurring within the rock mass surrounding cuttings and tunnels due to groundwater drawdown is anticipated to be small given the high stiffness of the bedrock.

Groundwater levels in alluvial aquifers may be locally affected, although the extent and magnitude of any change is likely to be small. The risk associated with settlement of unconsolidated alluvial material is expected to be negligible.

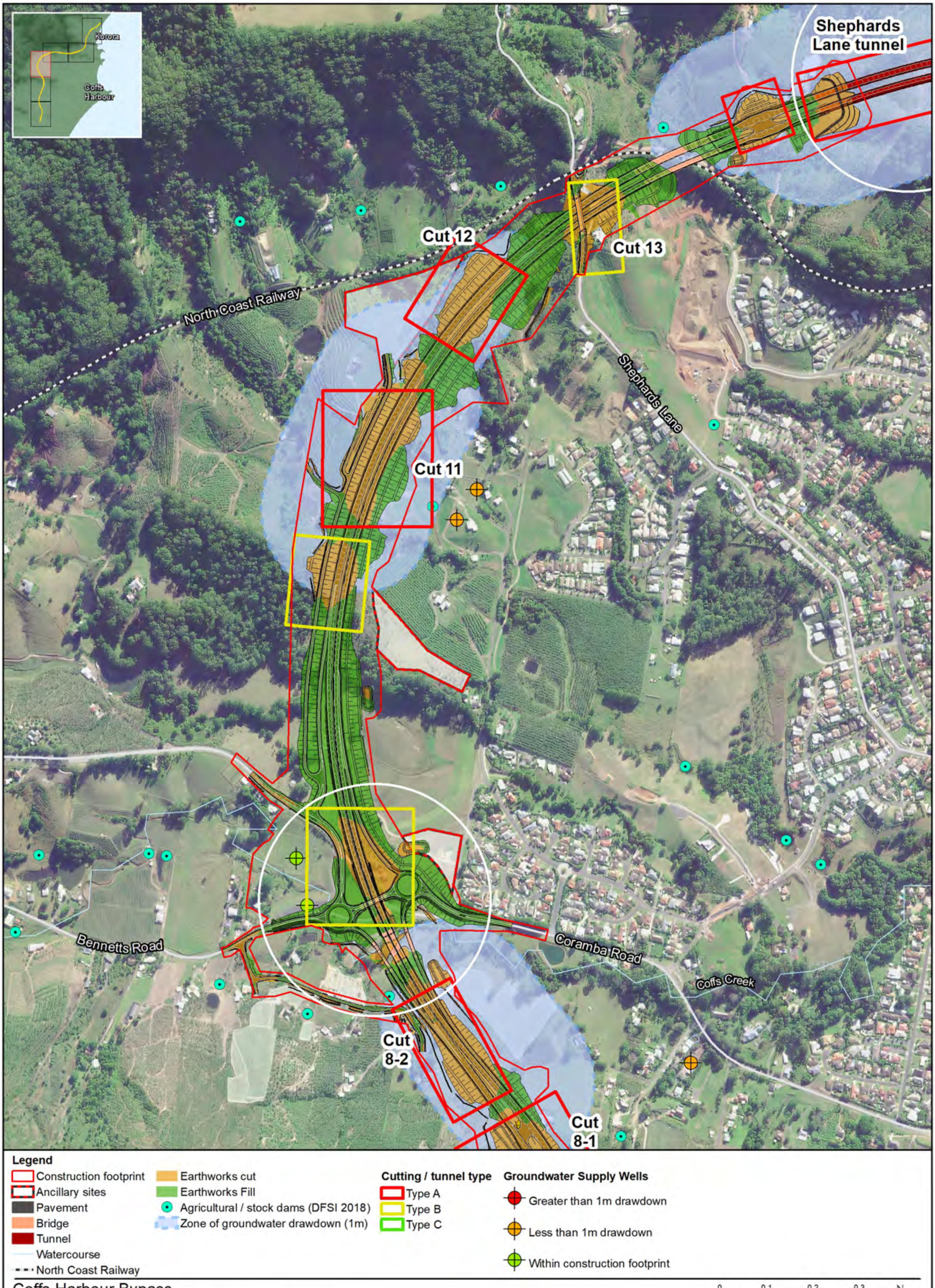


Coffs Harbour Bypass
Cutting type and location and zone of drawdown
Figure 20-7-01

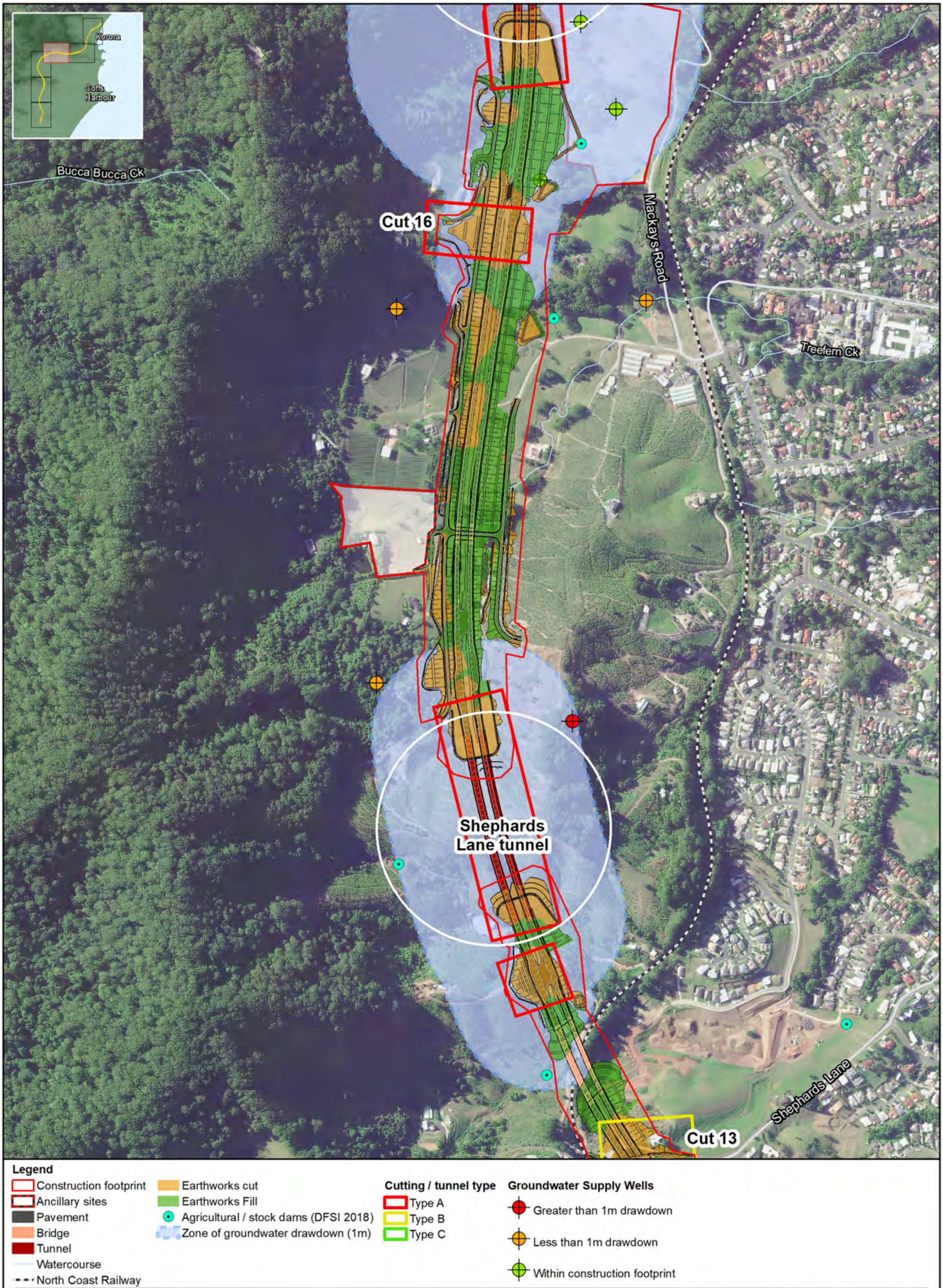
Coffs Harbour Bypass

Cutting type and location and zone of drawdown

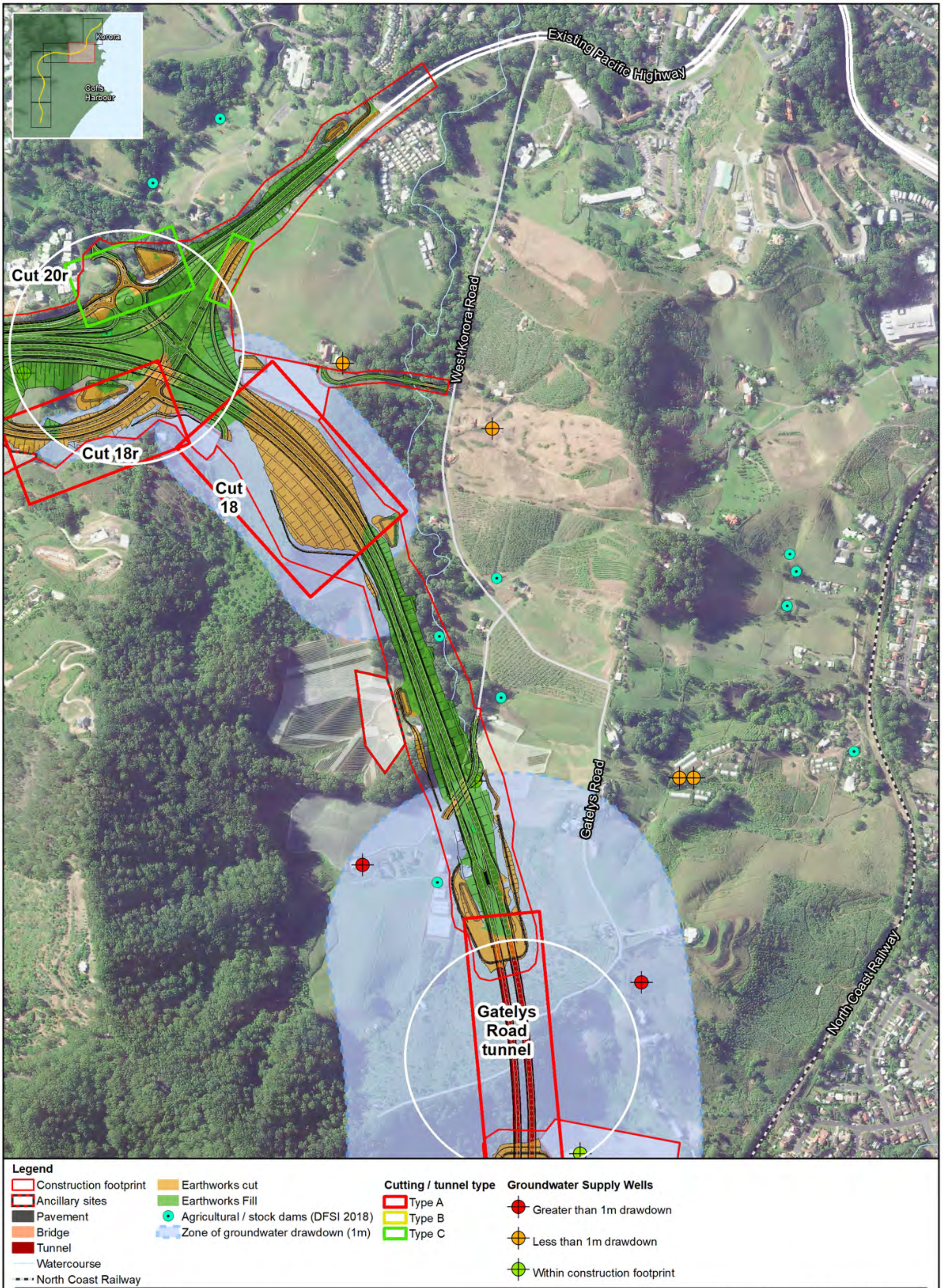
Figure 20-7-02



Coffs Harbour Bypass
Cutting type and location and zone of drawdown
Figure 20-7-03



Coffs Harbour Bypass
Cutting type and location and zone of drawdown
Figure 20-7-04



Coffs Harbour Bypass

Cutting type and location and zone of drawdown

Figure 20-7-05

Coffs Harbour Bypass
Cutting type and location and zone of drawdown
Figure 20-7-06

20.4.2 Groundwater quality

Construction

Potential risks to groundwater quality during construction include:

- Infiltration of contaminated surface water runoff
- Infiltration of captured groundwater from excavations during construction
- Hydrocarbon contamination from potential fuel and chemical spills during construction activities including drill and blast activity, leading to contamination of groundwater
- Exposure of ASS and ASR during excavation or lowering of groundwater levels within the soils, leading to generation of acid leachate into groundwater
- Leaching of saline water into groundwater following disturbance of saline soils during construction and soil salinisation at cuttings due to evaporation of groundwater seepage.

Groundwater discharge quality and contamination

Infiltration into the ground is generally effective at filtering contamination and pollutants bound to particulate matter. Contaminants such as hydrocarbons and solvents which are not bound to particulate matter are therefore at greater risk of polluting groundwater.

Groundwater quality testing undertaken on the fractured bedrock aquifer indicated minor exceedences above the 95th percentile ANZECC aquatic ecosystem guideline values for a small number of heavy metal analytes (as discussed in **Section 20.3**). These exceedences were observed in samples collected from most monitoring locations sampled, indicating that groundwater is likely to be naturally elevated with respect to these heavy metals rather than occurring from a particular source.

Tunnelling will require use of construction water treatment plants to manage groundwater inflow into the tunnelling sites. The captured groundwater will be treated and discharged in accordance with criteria established in consultation with EPA and DPIE (Water). Processes will be established to allow for groundwater recharge back into the underlying aquifers or creeks to mitigate impacts. For cuttings, water will be directed to nearby sediment basins which would be discharged into local creeks/waterways/drainage lines in accordance with environmental protection license (EPL) requirements.

Groundwater captured by cuttings and tunnels will be returned into the aquifer down gradient and within the same catchment from where it was intercepted where reasonable and feasible.

Acid sulfate materials

Exposure of ASS materials during construction may lead to oxidation and cause acid leachate formation. This may occur in situ or in excavated stockpiles during construction. Acid leachate may contain elevated heavy metals and can be transferred through groundwater and surface water and directly impact on aquatic life, water supply quality and construction materials. Acid leachate generation may cause corrosion of material such as concrete, iron, steel, and some aluminium alloys.

Several of the soil samples tested as part of the geotechnical investigations indicated presence of residual chromium reducible sulfur, low pH values and high total actual acidity levels. Potential acid sulfate soil was confirmed near Englands Road, North Boambee Road and Coramba Road.

The only areas of the project which are anticipated to extend into areas of mapped ASS are north of the Korora Hill interchange. PASS testing in these areas indicated that the risk is likely to be limited, and as such the risk to groundwater caused by contamination from acid sulfate soils is considered to be low.

Salinity

Based on groundwater quality testing and observed from publicly available information, there is unlikely to be an impact on groundwater from changes to/in salinity during the construction of the project.

Groundwater quality testing indicated fresh to weakly brackish groundwater present within the fractured bedrock aquifer. Saline water is likely to be associated with estuarine and coastal aquifers. Deeper cuts are associated with soil landscapes further inland which are not saline. Salinisation due to discharging groundwaters is not known to occur within the study area.

Operation

Direct impacts on groundwater quality as a result of operation of the project would be minimal. There would be a risk associated with accidental spillage of hydrocarbons during vehicle crashes impacting on groundwater quality, however, any accidental spillages would be captured by the permanent road drainage systems and managed/treated during emergency response. Potential risks associated with malfunctioning drainage systems are likely to be minimal, having little impact on the groundwater quality. The risk associated with the drainage systems failing would be managed within the standard roads maintenance program.

There may be outstanding residual impacts from the construction phase, including:

- Infiltration of contaminated surface water runoff from unpaved surfaces. Note that during the operational phase of the project all drainage infrastructure would have been installed so opportunity for further contamination of groundwater sources should be significantly reduced
- Hydrocarbon contamination from fuel and chemical spills during construction activities however, the risk to groundwater systems is reduced as all surface drainage would remain in place.

The risk from salinity outlined in the construction phase is expected to be the same for the operational phase of the project.

The risk from ASS during operational phases of the project is also considered to be negligible. Exposure of ASS is not expected to occur during operation and any existing ASS encountered during construction are expected to have been treated or disposed of in accordance with the ASS management plan.

All cuttings and tunnels associated with the project would be fully drained, allowing ongoing seepage during the operational phase. All three tunnels would have separate drainage systems to capture and recharge groundwater, and to manage stormwater ingress and water from the fire suppression (deluge) system. Captured groundwater in the Roberts Hill tunnel would drain through a longitudinal pit and pipe network to the southern portals before being recharged via infiltration pits or basins. Captured groundwater in the Shephards Lane and Gatelys Road tunnels would drain through a longitudinal pit and pipe network to both the southern and northern portals before being recharged via infiltration pits or basins.

20.4.3 Water take

The Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources (DPI 2016) provides rules for granting access licences, managing access licences, water supply well approvals and access licence dealings. The estimated project water take (**Table 20-5**) is compared to the available water in the New England Fold Belt Coast Groundwater Source outlined in the Water Sharing Plan (DPI 2016). The maximum estimated water take is approximately 0.2 per cent of the long-term average annual extraction limit (LTAAEL) and 0.03 per cent of the upper extraction limit (UEL), representing a minor proportion of the total water availability in the groundwater source.

Total recharge to the fractured bedrock across the three sub-catchments which the project crosses (Boambee Creek, Coffs Creek and Korora Basin) is estimated to be about seven GL/yr. This is based on a net recharge of five per cent of annual rainfall of 1651 mm across the three sub-catchments. The total predicted steady state discharge of groundwater into all cuttings and tunnels is 57 ML/yr, or approximately 0.8 per cent of the total annual estimated recharge into the fractured bedrock within the three sub-catchments.

This assessment does not consider the true recharge catchment of the fractured bedrock aquifer which is unlikely to align with that of the surface water creeks and is likely to be much larger. It also does not consider local variation in recharge across the catchments. Even so, it indicates that total water take for the project is likely to represent a small proportion of the total recharge into the fractured bedrock aquifer.

Section 5.23 of the EP&A Act provides exemption for approved SSI projects for the need of a water use approval under section 89 of the WM Act. If required, the project would need to ensure an aquifer interference approval has been granted for the proposed works prior to construction starting.

Table 20-5 Project water take (passive) and available water

Max estimated construction phase water take (ML/yr)	**Estimated water take – operation phase (ML/yr)**	**New England Fold Belt Coast groundwater source**	
		LTAAEL (ML/yr)	UEL (ML/yr)
115	57	60,000	375,000

20.4.4 Groundwater dependent ecosystems and native vegetation communities

GDEs may be affected by lowering of groundwater levels caused by the excavation of cuttings and tunnels which intercept and drain groundwater from the fractured bedrock aquifer. Most GDEs within the study area are likely to draw groundwater from shallow surficial deposits or alluvial groundwater which is within a few metres of the surface. GDEs are unlikely to be dependent directly on groundwater from the fractured bedrock aquifer except where it is close to the ground surface, for instance at spring locations.

Where seepage occurs at excavations during construction, water would be captured and redirected to temporary construction sediment basins. Where a GDE is reliant on this seepage and it is diverted, there is the potential the GDE would be impacted. Vegetation supported by groundwater could also be affected if there is a significant reduction in water levels, where lowered from close to the ground surface. Changes to surface water run-off may also locally affect GDEs due to changing distribution of recharge to surficial deposits and flows to alluvial aquifers and creek lines.

The project intercepts several low potential GDEs and native vegetation communities, which may be intermittently groundwater dependent. The anticipated zone of drawdown from Type A cuttings and tunnels also extends to some low potential GDEs outside of the construction footprint. No moderate or high potential GDEs are anticipated to be within the zone of drawdown. There are no mapped Coastal Management SEPP wetlands within the expected long-term zone of drawdown around any of the cuttings or drained tunnels.

There are several native vegetation communities which are present within the zone of drawdown. These comprise of vegetation communities occurring on creek lines which may be reliant on shallow groundwater within alluvium and more broadly those which may draw water from local perched systems and soils. Changes to groundwater flow and levels would predominantly occur within the fractured bedrock aquifer system. The effect on perched groundwater systems and alluvial aquifers is anticipated to be small as these systems are reliant on surface water runoff and local recharge, rather than connection with the fractured bedrock aquifer (even if there is connection, the contribution of flow from the fractured bedrock is small).

The native vegetation communities anticipated to be within the zone of drawdown from Type A cuttings and tunnels predominantly comprise of sclerophyll forest including:

- Blackbutt – Tallowwood (PCT 692), Turpentine (PCT 695) and Pink Bloodwood (PCT 686)
- Sydney Blue Gum (PCT 1244)
- Flooded Gum (PCT 826).

Since groundwater inflows captured by the project would be from the fractured bedrock aquifer, the potential impact on GDEs and native vegetation communities is expected to be limited. Where native vegetation communities are groundwater dependent, it is likely that they are reliant on water within alluvial aquifers (and perched water within surficial soils), which are predominantly surface water dependent. Groundwater from the fractured bedrock has a low impact on creek instream values and flow into alluvial aquifers, and as such is only likely to have an impact where surface discharge occurs, such as spring locations which is discussed in **Section 20.3**.

20.4.5 NSW Aquifer Interference Policy

The project may directly or indirectly impact upon the alluvial and fractured bedrock aquifers due to the proximity of the project to these aquifers, and the type of design elements proposed. For example, cuttings may intercept one or more of the aquifers, which typically causes groundwater to drain towards the cutting resulting in redistributing the local flow paths.

Potential impacts on the hydrogeological environment are compared to the requirements of the NSW Aquifer Interference Policy in **Table 20-6**. For the purposes of the assessment, the fractured bedrock is considered to be a less productive groundwater source. This is defined as:

- A groundwater source having total dissolved solids greater than 1500 mg/L, or
- A groundwater source that does not contain water supply works that can yield water at a rate greater than 5 L/s.

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and groundwater dependent ecosystems, be assessed against the minimal impact considerations. If the predicted impacts are less than the Level 1 minimal considerations (as outlined in **Table 20-6**) then the impacts of the project are considered to be acceptable.

Table 20-6 Impact assessment against the requirements of the NSW Aquifer Interference Policy

	Requirement	Comment
Water table	Level 1 Less than or equal to 10% cumulative variation in the water table, allowing for typical ‘post water sharing plan’ variations, 40 m from any: a) High priority groundwater dependent ecosystem; or b) High priority culturally significant site listed in the schedule of the relevant water sharing plan. A maximum of a 2 m decline cumulatively at a water supply work. Level 2 If more than 10% cumulative variation in the water table, allowing for typical climatic ‘post-water sharing plan’ variations, 40 m from any: a) High priority groundwater dependent ecosystem; or b) High priority culturally significant site listed in the schedule of the relevant water sharing plan, If appropriate studies demonstrate to the Minister’s satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than a 2 m decline cumulatively at any water supply work, then make good provisions should apply.	No high priority GDEs or culturally significant sites are within Water Sharing Plans for the Coffs Harbour Area Unregulated and Alluvial Water Sources, 2009 or the North Coast Fractured and Porous Rock Groundwater Sources, 2016 are listed in the study area. The project would not result in impacts to a culturally significant site or high priority GDE.

	Requirement	Comment
Water Pressure	Level 1 A cumulative pressure head decline of not more than a 2 m decline, at any water supply work. Level 2 If the predicted pressure head decline is greater than requirement 1 above then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	Predictive modelling indicates that most of the project meets the minimal impact consideration of less than 2 m pressure head decline at any water supply work. The exception to this is at Gatelys Road tunnel where predictions indicate one groundwater supply well may experience a pressure head decline of more than 2 m. GW068986 has a predicted drawdown of around 4 m.
Water Quality	Level 1 Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. Level 2 If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply work.	Groundwater inflows to cuttings will be captured and discharged via water quality basins or absorption trenches, infiltration pits or swales. Captured water during tunnelling will be treated using construction water treatment plants. Water will be discharged in accordance with EPL and DPIE (water) quality requirements. The risk of contamination on site and potential for discharge of pollutants will be managed on site using standard construction management procedures. The project is therefore not anticipated to change the beneficial use category of the groundwater source beyond 40 m from the activity.

As stated above, where the predicted pressure head decline is greater than Level 1 minimal impact requirements then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline would not prevent the long-term viability of the affected water supply. As described in **Table 20-6** the impact at one well is predicted to exceed the minimal impact criteria.

Further investigation of the impact of supply well GW068986 (which has a predicted pressure head decline of about four metres) will be undertaken as part of the detailed design. This investigation will supplement existing information and evaluate the potential impact on the long-term viability of the source.

The investigation would include an examination of the well to determine depth of the well, what the existing usage requirements are, how frequently and to what extent the well is relied upon, as well as identifying operational groundwater level data from the supply well and water quality.

This information would allow a more detailed evaluation of the potential impact on the long-term viability of the well, and if it is determined that the viability would be compromised, mitigation or remediation (make good provisions) would be required, which may include:

- Provision of an alternate water supply/well
- Changing the bore pump so that it is better suited to the decreased water level in the bore
- Deepening the bore to allow it to draw water from a greater length of the aquifer
- Reconditioning of the water bore to improve its hydraulic efficiency
- Increased monitoring of the bore water levels to provide a level of confidence to the property owner that the impacts are managed appropriately.

20.5 Environmental management measures

The proposed management approach to address the groundwater impacts is as follows:

- **Pre-construction investigations and ongoing groundwater monitoring:** Additional geotechnical investigations will be carried out to supplement existing information in particular at cuts and tunnel sections where additional baseline groundwater level information to improve modelling predictions, and longer-term groundwater monitoring information from alluvial deposits close to Type A cuts and tunnels. Additional ASS testing, supplemental investigations and groundwater monitoring at representative locations that considers sensitive receptors described in **Section 20.3** will also be undertaken. More information on the proposed monitoring is provided in **Appendix N, Groundwater assessment**
- **Numerical modelling:** In combination with additional groundwater information obtained from the investigations, further numerical modelling may be undertaken to improve certainty around the predictions and outcomes. Revisions to the modelling would also be based on the detailed design and additional hydrogeological data to supplement the current conceptual understanding of the system
- **Construction and operational monitoring:** Monitoring during construction and operation would be carried out to assess whether the impact assessment predictions are accurate and to aid early intervention should outcomes deviate from those predictions. Monitoring during construction and operation would include both groundwater levels and quality and will be undertaken as part of the water quality monitoring program detailed in **Chapter 19, Surface water quality**. Operational monitoring would be for a period of three years following construction, or before if it can be proved that no impact has occurred
- **Mitigation:** Environmental and engineering management measures listed in **Table 20-7** will be design and implemented to minimise the impacts on the groundwater environment and receptors.

Environmental management measures to mitigate the risk of groundwater impacts during construction and operation of the project on surrounding infrastructure, people and the environment is presented in **Table 20-7**. There are interactions between the mitigation measures for groundwater and **Chapter 13, Agriculture, Chapter 18, Soils and contamination** and **Chapter 19, Surface water quality.**

Table 20-7 Environmental management measures for groundwater impacts

Impact	ID No.	Mitigation measure	Responsibility	Timing
Acid sulfate materials	GW01	Stockpiles containing PASS or ASS treatment areas will be lined and bunded in accordance with the Guidelines for the Management of Acid Sulfate Materials (RTA, 2005) to prevent leachate contaminating groundwater.	Contractor	During construction

Impact	ID No.	Mitigation measure	Responsibility	Timing
Management of groundwater interception	GW02	Additional groundwater monitoring standpipes will be included for Type A cuts for alluvial aquifers along the project and in the areas around the major embankments to supplement existing data.	Roads and Maritime	Prior to construction
	GW03	Groundwater captured by cuttings and tunnels during construction will be returned into the aquifer down gradient and within the same catchment from where it was intercepted where reasonable and feasible.	Contractor	During construction
	GW04	Engineering measures for long-term management of groundwater inflow to cuttings and tunnels will be designed and constructed to ensure groundwater is recharged downgradient of the cutting or tunnel from where it is captured and within the same catchment where reasonable and feasible. This will be facilitated by, but not limited to, absorption trenches, infiltration galleries/pits, sediment basins and grassed swales.	Contractor	Detailed design
	GW05	Where groundwater recharge downgradient of the cutting or tunnel is not reasonable and feasible, measures will be designed and implemented that transfer seepage water downstream via water quality basins before being discharged into a downstream drainage channel or creek, within the same catchment.	Contractor	Detailed design and during construction
Prevention of groundwater impacts from cuttings, tunnels and embankments	GW06	Monitoring of groundwater levels and quality will be included in the water quality monitoring program detailed in **Chapter 19, Surface water quality**.	Roads and Maritime	Prior to and during construction and operation
	GW07	Monitoring of seepage into cuttings will be carried out and evaluated against the predictions of the numerical modelling undertaken during detailed design.	Roads and Maritime / Contractor	During construction
	GW08	Major embankments will be designed to enable distributed flow of surface water to prevent ponding.	Roads and Maritime/ Contractor	Detailed design
	GW09	Additional ground truthing and site inspections will be undertaken for potentially impacted groundwater bores/supply wells (including supply well GW068986), springs and agricultural dams within and immediately surrounding the zone of drawdown. The purpose of the ground truthing and site inspections is to confirm predicted impacts and develop make good provisions where required in consultation with affected property owners.	Roads and Maritime	Detailed design
Prevention of potential impacts on groundwater quality	GW10	Sites used for stockpiles, washdown areas, refuelling and chemical storage will be located away from areas of shallow groundwater or appropriately lined and bunded to protect groundwater.	Contractor	Prior to and during construction

CHAPTER 21

Chapter 21

Air quality

21. Air quality

This chapter presents an assessment of the potential local and regional air quality impacts of the project on sensitive receivers and the local community, including risks to human health and identifies mitigation and management measures to minimise and reduce these impacts.

The assessment presented in this chapter draws on information in the air quality assessment (refer to **Appendix P, Air quality assessment**) and the human health risk assessment (refer to **Appendix Q, Human health risk assessment**) prepared for this EIS.

Table 21-1 lists the SEARs relevant to air quality and where they are addressed in this chapter.

Table 21-1 SEARs relevant to air quality

Ref	Key Issue SEARs	Where addressed
13. Air quality		
1.	The Proponent must undertake an air quality impact assessment (AQIA) for construction and operation of the project in accordance with the current guidelines.	Section 21.1 **Appendix P, Air quality assessment**
2.	The Proponent must ensure the AQIA also includes the following:	
	a) Demonstrated ability to comply with the relevant regulatory framework, specifically the Protection of the *Environment Operations Act 1997* and the *Protection of the Environment Operations (Clean Air) Regulation (2010)*	Section 21.2 Section 21.3
	b) An assessment of the impacts of the construction and operation of the project on sensitive receivers and the local community, including risks to human health.	Section 21.6 **Appendix Q, Human health risk assessment**
	c) Details of the proposed mitigation measures to minimise the generation and emission of dust (particulate matter and TSP) and air pollutants (including odours) during the construction of the project, particularly in relation to the operation of ancillary facilities (such as concrete and asphalt batching), the use of mobile plant and machinery, stockpiles and the processing and movement of spoil, and construction vehicle movement along the alignment	Section 21.7 **Chapter 6, Construction**
	d) A cumulative local and regional air quality impact assessment.	Section 21.6 **Chapter 25, Cumulative impacts**

21.1 Assessment methodology

The study area subject to the air quality assessment is located generally along the construction footprint and the existing Pacific Highway. It encompasses the surrounding area that may be directly or indirectly subject to air quality impacts during construction and operation of the project.

The human health risk assessment uses a number of specific technical assessments carried out for the EIS, including the air quality assessment. As such, the study area evaluated in relation to health impacts from air pollutants is the same as the study area considered for the air quality assessment.

21.1.1 Construction

The main air pollution and amenity issues during construction are:

- Annoyance due to dust deposition (soiling of surfaces) and visible dust plumes (dust on surfaces like cars, washing, swimming pools, rainwater tanks etc)
- Elevated particulate matter less than or equal to 10 micrometre (PM_{10}) concentrations due to dust-generating activities
- Exhaust emissions from diesel-powered construction equipment.

Dust emissions can occur during construction activities such as demolition and earthmoving and can vary substantially from day-to-day dependent on weather conditions, the intensity of work activities and the type of activity being undertaken. For this reason, particulate matter less than or equal to 2.5 micrometre ($PM_{2.5}$) concentrations was also assessed as an air pollution and amenity issue. It is difficult to quantify dust emissions from construction activities using a model. Any effects of construction on particulate matter (PM) concentrations tend to be temporary and relatively short-lived. The assessment and control of construction-related air quality therefore focused on identifying and managing risk.

Activities on construction sites can be divided into four types to reflect their different potential impacts, and the potential for dust emissions is assessed for each activity that is likely to take place. These activities are:

- Demolition – any activity that involves the removal of existing structures
- Earthworks – covers the processes of soil stripping, ground levelling, excavation and landscaping. Earthworks will primarily involve excavating material (mechanical and blasting), haulage, tipping and stockpiling
- Construction – any activity that involves the provision of new structures, modification or refurbishment. A structure will include a residential dwelling, office building, retail outlet, road, etc
- Track-out – involves the transport of dust and dirt by heavy vehicles from the construction/demolition site onto the public road network, where it may be deposited and then resuspended by vehicles using the network.

The construction assessment involved the application of a semi-quantitative risk-based approach following the guidance developed by the UK Institute of Air Quality Management (IAQM 2014) and adapted to conditions representative of Coffs Harbour. The approach was also tailored according to the nature of the project. The assessment involved the following main steps:

- Identifying the construction activities that would be likely to occur in relation to the project
- Dividing activities according to their different potential impacts: demolition, earthworks, construction and vehicle track-out. Risks were assessed in relation to the size of the project, the volume of traffic on unsealed roads and the locations of sensitive receivers
- Identifying project-specific management and mitigation measures to minimise the risk of any potential impacts.

The assessment methodology considers three separate dust risks or issues:

- Annoyance and impacts due to dust deposition
- The risk of health effects due to an increase in exposure to PM_{10} and $PM_{2.5}$
- Harm to ecological receptors (such as agricultural properties which could be impacted by the project and the Kororo Nature Reserve).

A qualitative risk-based assessment of the potential for odour during the construction phase has also been undertaken. Activities assessed include laying of asphalt, operating the asphalt batch plant, bitumen sealing, blasting and earthworks stabilisation.

Construction impact assessment

The construction impact assessment was carried out in two steps.

The first step was a screening assessment. A construction impact assessment would normally be required where:

- There are human receptors within 350 m of the boundary of the project and/or within 50 m of the routes used by construction vehicles on the Pacific Highway and up to 500 m from the site entrances
- There are ecological receptors within 50 m of the boundary of the project and/or within 50 m of the routes used by construction vehicles on the Pacific Highway and up to 500 m from the site entrances

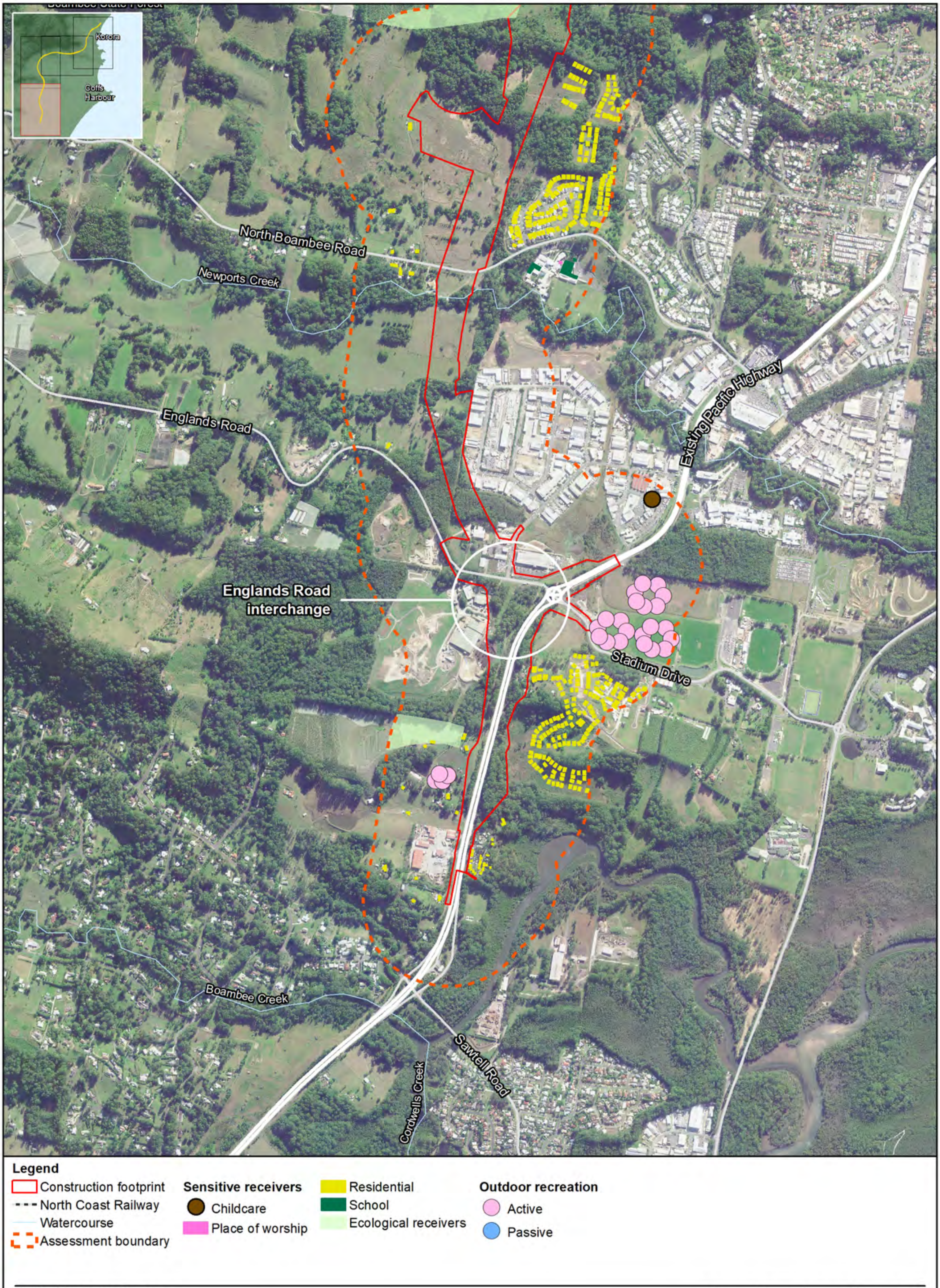
The 350 m buffer, which is representative of the study area for assessing construction impacts, and air quality receivers are shown in **Figure 21-1-01** to **Figure 21-1-04.**

The second step was the risk assessment. This determined where the risk of dust arising was in sufficient quantities to cause annoyance and/or health effects for the four main construction activities (demolition, earthworks, construction and track-out). Risk categories were then assigned based on two factors:

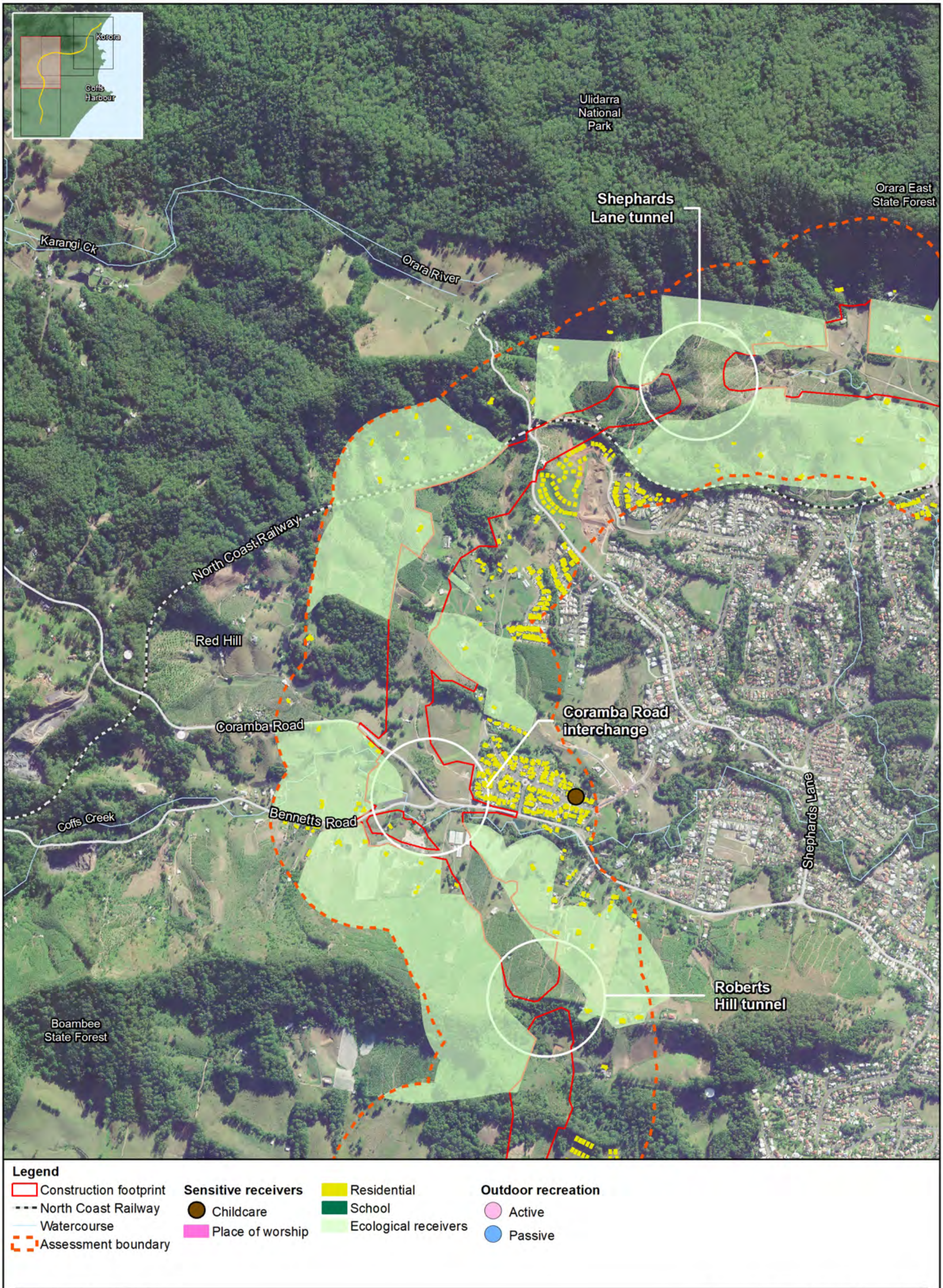
- The scale and nature of the works, which determined the magnitude of potential dust emissions
- The proximity of the sensitive receptors, which determined the sensitivity of the area.

These factors are combined to provide the risk of dust impacts, which are described in terms of being low, medium or high risk of dust impacts for each of the main construction activities.

Further details on the methodology are provided in **Appendix P, Air quality assessment**.

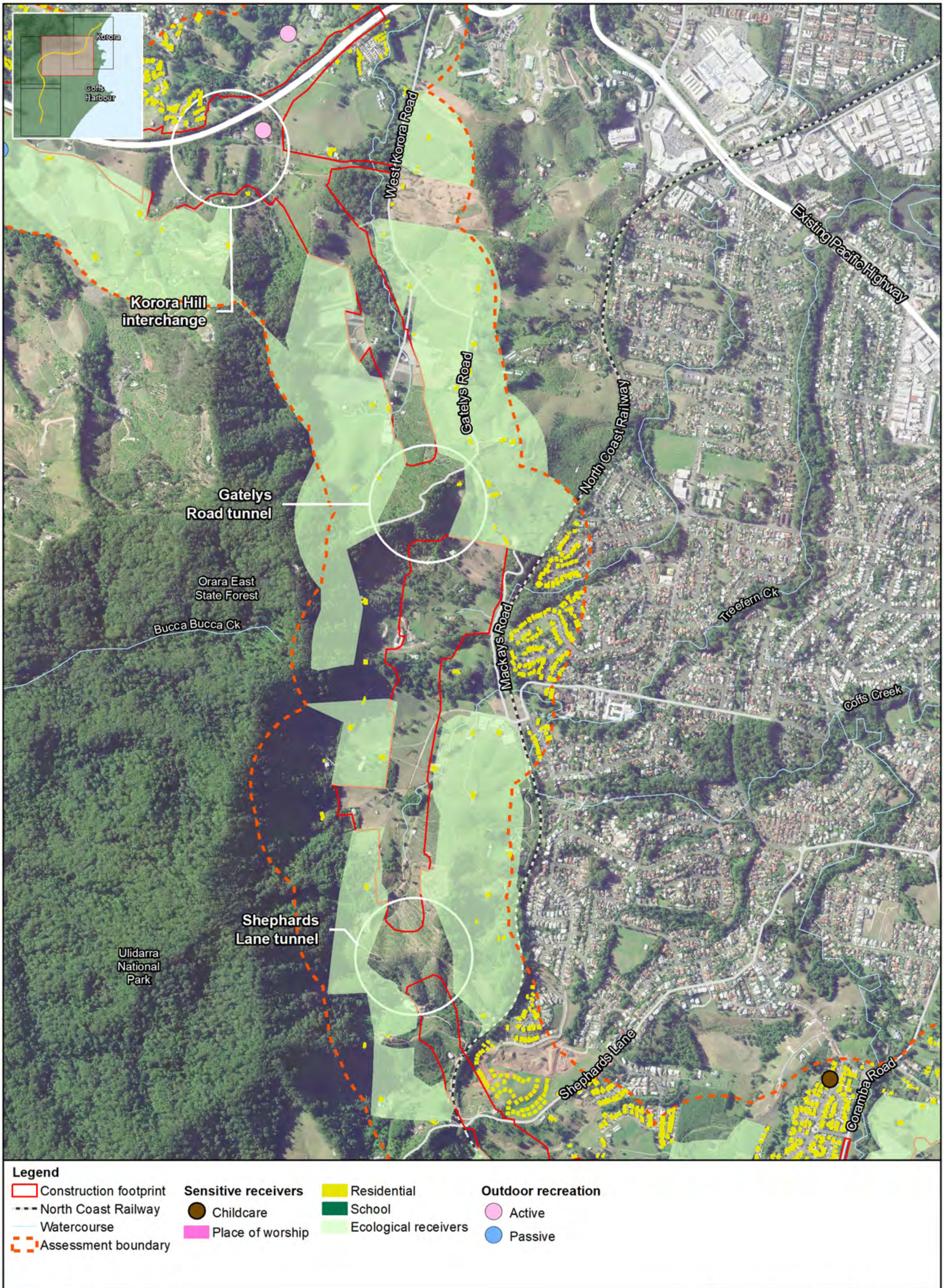


Coffs Harbour Bypass
Buffer area and sensitive receivers
Figure 21-1-01



Coffs Harbour Bypass
Buffer area and sensitive receivers
Figure 21-1-02

0 0.2 0.4 0.6 km
Scale @A4: 1:20,000
GDA 1994 MGA Zone 56
N



Coffs Harbour Bypass
Buffer area and sensitive receivers
Figure 21-1-03

Coffs Harbour Bypass
Buffer area and sensitive receivers
Figure 21-1-04

21.1.2 Operation

The operation of the project has the potential to impact local air quality due to changes in vehicle movement across the road network. The project would provide free-flow conditions along the new Pacific Highway (ie bypass) and the remove 'through' motorists from the existing Pacific Highway. Potential local air quality impacts have been assessed using dispersion modelling (GRAL) for the following assessment scenarios:

- Baseline year (taken as 2016 to be consistent with traffic modelling undertaken for the project)
- Opening year (2024) without the project
- Opening year (2024) with the project
- Opening year + 10 years (2034) without the project
- Opening year + 10 years (2034) with the project.

The GRAL micro-scale dispersion model has been used for the assessment of all major traffic air quality assessments in NSW for the past four years. As such, it is considered an appropriate tool for the current application. **Figure 21-2** presents the study area set for the GRAL dispersion model. It was around 12.8 km along the east-west axis and 16.8 km along the north-south axis. The model system consists of two main modules:

1. A prognostic wind field model (Gratz Mesoscale Model – GRAMM)
2. A dispersion model (GRAL itself).

Prognostic wind field modelling (GRAMM)

GRAMM is the meteorological segment of the GRAL micro-scale dispersion model. Its main features include the use of future wind fields, a terrain-following grid, and the calculation of surface energy balance. The GRAMM study area was defined so that it covered the entire area encompassing the project and the Pacific Highway. Terrain and land-use data was also used as part of the assessment.

Dispersion modelling (GRAL)

GRAL is a dispersion model, that predicts ground-level pollutant concentrations (including nitrogen oxides (NO_x)) by simulating the movement of individual 'particles' of a pollutant emitted from an emission source in a three-dimensional wind field. The trajectory of each of the particles is determined by a mean velocity component and a fluctuating (random) velocity component.

GRAL requires a number of general parameters to be input into the model including surface roughness length, dispersion time, the number of traced particles, counting grids, size of the model domain and vehicle emission rates.

The model system already has in-built algorithms for calculating vehicle emission rates, however, these were replaced by project-specific emission rates to ensure greater accuracy and relevancy. Therefore, project specific vehicle emission models were undertaken for surface roads and tunnel portals and then input into the dispersion model (GRAL).

Surface road emission rates

To calculate emissions from surface roads, the EPA emissions model was used. The EPA emissions module is one of the most sophisticated models that has been developed for calculating surface road emissions from vehicles in NSW.

To calculate vehicle emission rates two roads were taken into consideration – the Pacific Highway and the project. The project was split into four road links and the Pacific Highway was split into six links.

An average mass emission rate (kg/km/h) for each road link was then calculated based on the following inputs:

- Daily and hourly traffic volumes for each link
- Road widths and lengths
- Gradients
- Speed and mix (including fuel split).

In addition to the average mass emissions for each road link, an hourly 'modulation factor' (ratios, relative to the average emission rate for each road link) is calculated for each hour of the day to determine hourly variation. These average mass emission rates and modulation factors were then entered into the dispersion model (GRAL).

Tunnel portal emission rates

Emission rates from the proposed tunnels were also calculated. The project has three proposed tunnels at Roberts Hill ridge (around 190 m long), Shephards Lane (around 360 m) and Gatelys Road (around 450 m long). Based on the relatively short length of these tunnels (ie less than one kilometre), in-tunnel emissions were not assessed and instead, emissions from portals were considered to be appropriate. Given the length of the tunnels, no ventilation facilities are required for the project.

The following six portals were measured for emissions:

- Roberts Hill northbound exit
- Roberts Hill southbound exit
- Shephards Lane northbound exit
- Shephards Lane southbound exit
- Gatelys Road northbound exit
- Gatelys Road southbound exit.

Air velocities at each of the six portals were calculated to determine the number of source groups for modelling. Source groups represent distinct changes in velocity throughout the day and accordingly, allows for hourly variation in modelling.

From this an average mass emission rate (kg/h) was estimated for each pollutant for each source group for each portal. The emissions were estimated using the EPA emissions model along with simplified tunnel geometry and traffic. For each source group, hour 'modulation factors' were calculated to determine the hourly variation. The average mass emission rates and the modulate factors were entered into the dispersion model (GRAL).

Nitrogen oxide to Nitrogen dioxide conversion

The dispersion model outputs NO_x concentrations that are then converted to nitrogen dioxide (NO_2) using an empirical conversion method. This method has been derived by comparing monitored NO_x and NO_2 concentrations at various monitoring locations (both roadside and background) across Sydney. While it is noted that Coffs Harbour is some distance from Sydney, there is a significant amount of data available which can be analysed to show the relationship between NO_x and NO_2, which would apply to the Coffs Harbour region. Full details of the conversion method for annual and one-hour NO_x concentrations are provided in **Appendix P, Air quality assessment**.

Regional assessment

There is minimal guidance in NSW for the assessment of regional air quality impacts. In the absence of guidance or adopted standards, the change in total emissions resulting from a project can be used to assess regional impacts.

Regional air quality can contribute to ozone production by changing the chemistry of the atmosphere. The EPA has recently developed a tiered procedure for estimating ground level ozone impacts from stationary sources. While this does not apply to road projects, it does give an emission threshold for NO_x emissions of 90 t per year resulting from new development. Projects that exceed this threshold may require further assessment of the impacts for ozone.

Vehicle emissions emitted to the atmosphere from the modelled road network were calculated for the 'with' and 'without' project scenarios for the opening year. NO_x emissions have been calculated using the traffic data included in the assessment of local air quality impacts in conjunction with the Roads and Maritime Tool for Roadside Air Quality (TRAQ) software. The change in NO_x emissions as a result of the project has been compared with the emission threshold described above, as well as predicted future levels of anthropogenic NO_x emissions being emitted into the atmosphere.

The change in vehicle emissions for the future year of the project (2034) is likely to be lower than that presented for the opening year due to improvements in vehicle emissions from cleaner vehicles entering the fleet.

Coffs Harbour Bypass
Modelling study areas
Figure 21-2

21.1.3 Approach to the human health risk assessment

The human health risk assessment was a desktop assessment only and was prepared in accordance with the following:

- enHealth Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth 2012)
- enHealth Health Impact Assessment Guidelines (enHealth 2017)
- NEPC National Environment Protection (Ambient Air Quality) Measure (NEPC 2016).

The human health risk assessment involved both quantitative and qualitative evaluations to determine construction and operational impacts as follows:

- The assessment undertaken for construction impacts is qualitative with potential impacts and the identification of relevant management measures to minimise impacts (including nuisance dust) being evaluated
- The assessment of the potential health impacts during operation involves the quantification of health risks. The quantification of health risks requires the use of a few different approaches to address the range of air pollutants relevant to the project, including:
  - Use of health-based air quality guidelines
  - Calculation of an incremental lifetime cancer risk
  - Calculation of impacts, risks and health burden, for changes in nitrogen dioxide and particulate matter concentrations.

Further detail on the methodology and limitations of the above is provided in **Appendix Q, Human health risk assessment.**

21.2 Policy and planning setting

The *Protection of the Environment Operations Act 1997* (POEO Act) sets the statutory framework for managing air quality in NSW. The POEO Act allocates responsibilities between the EPA, local councils and public authorities. The Protection of the Environment Operations (Clean Air) Regulation 2010 contains provisions to regulate emissions from various sources including vehicles.

The standards set for assessing the air pollutant impacts in NSW are documented in the Approved methods for the modelling and Assessment of Air Quality Pollutants in NSW (EPA 2017a). The criteria contained in the approved methods are drawn from a number of sources, including the National Environment Protection (Ambient Air Quality) Measure (NEPM) (Australian Government 2016). The approach for this assessment has followed the approved methods however, the approved methods do not contain any specific information for road transport projects and other guidance has also been considered including Local Government Air Quality Toolkit (EPA 2017c), the Control of dust and emissions during construction and demolition supplementary planning guidance (GLA 2014) and WRAP Fugitive Dust Handbook (Countess Environmental 2006).

21.3 Criteria

21.3.1 Construction

In accordance with the methodology described in **Section 21.1.1**, the criteria for assessment of potential scale of emissions was sourced from the IAQM 2014 criteria in **Table 21-2**. Based on these criteria, the appropriate categories for the project are in bold.

Table 21-2 Site categories (scale of works) (IAQM 2014)

Type of activity	Site category		
	Large	**Medium**	**Small**
Demolition	**Building volume > 50,000 m^3, potentially dusty construction material (e.g. concrete), on-site crushing and screening, demolition activities > 20 m above ground level.**	Building volume 20,000 – 50,000 m^3, potentially dusty construction material, demolition activities 10 – 20 m above ground level.	Building volume < 20,000 m^3, construction material with low potential for dust release (e.g. metal cladding, timber), demolition activities < 10 m above ground and during wetter months.
Earthworks	**Site area > 10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), > 10 heavy earth-moving vehicles active at any one time, formation of bunds > 8 m in height, total material moved > 100,000 t.**	Site area 2500 – 10,000 m^2, moderately dusty soil type (e.g. silt), 5 – 10 heavy earth moving vehicles active at any one time, formation of bunds 4 – 8 m in height, total material moved 20,000 – 100,000 t.	Site area <2500 m^2, soil type with large grain size (e.g. sand), < 5 heavy earth moving vehicles active at any one time, formation of bunds < 4 m in height, total material moved < 20,000 t, earthworks during wetter months.
Construction	**Total building volume > 100,000 m^3, piling, on site concrete batching, sandblasting**	Building volume 25,000 – 100,000 m^3, potentially dusty construction material (e.g. concrete), piling, on site concrete batching.	Total building volume < 25,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber).
Track-out	**>50 HDV (>3.5 t) OUTWARD movements in any one day, potentially dusty surface material (e.g. high clay content), unpaved road length >100 m.**	10 – 50 HDV (> 3.5 t) OUTWARD movements in any one day, moderately dusty surface material (e.g. high clay content), unpaved road length 50 – 100 m.	< 10 HDV (> 3.5 t) OUTWARD movements in any one day, surface material with low potential for dust release, unpaved road length < 50 m.

The sensitivity of the area takes into account the specific sensitivities of local receptors, the proximity and number of the receptors, and the local background PM_{10} concentration.

Dust soiling and health impacts are treated separately. The IAQM guidance[1] was used to determine the sensitivity of the area to dust soiling effects.

[1] Professional judgement is used to identify where on the spectrum between high and low sensitivity a receptor lies. High sensitivity receptors can reasonably expect enjoyment of a high level of amenity. The appearance, aesthetics or value of their properties would be diminished by soiling, and the people or properties would reasonably be expected to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Indicative examples include dwellings, museums and other culturally important collections, medium and long-term car parks and car showrooms.

21.3.2 Operation

In NSW, the statutory methods that are used to assess the air pollution impacts of projects are detailed in the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (EPA 2017a).

The air quality standards for the operational air quality assessment are taken from the approved methods and shown in **Table 21-3.** Assessed pollutant concentrations at sensitive receivers for both 'with' and 'without' project scenarios have been compared against these standards to determine if exceedances occur during operation.

Table 21-3 Air quality standards

Pollutant	Averaging period	Standard (µg/m^3)
Nitrogen dioxide (NO_2)	Annual	62
	1-hour	246
Particulate matter (PM_{10})	Annual	25
	24-hour	50
Fine particulate matter ($PM_{2.5}$)	Annual	8
	24-hour	25
Carbon Monoxide (CO)	8-hour	10 mg/m^3
	1-hour	30 mg/m^3

21.4 Existing environment

Local air quality in Coffs Harbour CBD is dominated by emissions from transport, which is common of most urban areas around Australia. The air quality of the surrounding area is likely to be dominated by a mix of agricultural activity and transport emissions.

21.4.1 Sensitive receivers

In additional to the ecological receptors identified previously, there are a number of sensitive (human) receptors including schools and residences identified within the study area. Sensitive land uses relevant to the project include:

- Educational institutions – Korora Public School, Bishop Druitt College, Boambee Public School and Coffs Harbour Montessori Preschool
- Health care facilities - Coffs Harbour Health Campus and Coffs Harbour GP Super Clinic
- Places of worship – The Foursquare Church Australia
- Childcare facilities – Petit Early Learning Centre Coffs Harbour and Cow & Koala Professional Child Care
- Areas of open space (active use) – Coffs Coast Sport and Leisure Park, Pacific Bay Resort Golf Course, Elite Training Centre Pacific Bay Resort and Boambee Equestrian Centre
- Food handling facilities/restaurants – Oz Group Packhouse (berry packaging and processing business) and Paradise Palms Resort.

Other receivers identified include various large-scale retail shops, businesses and light industrial receivers. Most of these are located at the Isles Drive Mixed Use Centre, just north of Englands Road interchange at the southern end of the project.

21.4.2 Local meteorology

Local meteorology influences dispersion and air quality conditions in an area. Local meteorological data for the area is available from the BoM weather station at Coffs Harbour Airport. Wind data available from this station for recent years (2015–2017) shows that the most common wind directions are from the south-west and the north. North-easterlies are more common in spring and summer, while south-westerlies and north-westerlies are most common in autumn and winter. The average wind speeds from 2011 to 2017 for this location are consistent and relatively high (varying from 4.1 m/s to 4.4 m/s). This suggests that any pollution is likely to be well dispersed in the area.

21.4.3 Ambient air quality conditions

There is no available air quality data for the Coffs Harbour area. Representative background air quality conditions for the area have been calculated by reviewing air quality monitoring data operated by DPIE (Environment, Energy and Science) across NSW. The Albion Park South monitoring location, south of Sydney, is likely to be reasonably representative of conditions in the project area as it is coastal and near a built-up area with a major highway (Princes Highway) close by. Albion Park South measures concentrations for NO_x, NO_2, PM_{10}, $PM_{2.5}$ but does not measure carbon monoxide (CO) so concentrations for CO were gathered from the DPIE (Environment, Energy and Science) Newcastle monitoring location. Similarly, to Albion Park South, the Newcastle monitoring location is likely to be reasonably representative of the conditions in the area of Coffs Harbour as it is also coastal and near a built-up area. Neither Newcastle nor Albion Park South is geographically close to Coffs Harbour, but Albion Park South is more representative in terms of land use. For this reason, it has been used as the primary monitoring location.

A summary of the monitoring data from at Albion Park South and Newcastle is shown in **Table 21-4**.

Table 21-4 Summary of Department of Premier and Cabinet, Heritage monitoring data from Albion Park South and Newcastle; exceedances of the standards are emphasised in **bold red**

Year	Albion Park South								Newcastle	
	NO_x (µg/m³)		NO_2 (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		CO (mg/m³)	
	Maximum 1-hour mean	**Annual mean**	**Maximum 1-hour mean**	**Annual mean**	**Maximum 24-hour mean**	**Annual mean**	**Maximum 24-hour mean**	**Annual mean**	**Maximum 1-hour mean**	**Annual mean**
Standard	-	-	*246*	*62*	*50*	*25*	*25*	*8*	*30*	-
2011	139	10.3	82	4.1	**51**	13.6	-	-	3.90	0.18
2012	117	10.3	82	4.3	44	13.6	-	-	3.49	0.17
2013	148	10.3	76	7.6	**69**	14.7	-	-	3.49	0.20
2014	170	8.2	80	8.6	48	16.2	-	-	5.34	0.38
2015	152	6.2	96	6.2	41	14.0	21.1	6.4	3.49	0.80
2016	133	10.3	88	8.2	43	14.9	**30.7**	7.2	4.31	0.40
2017	133	10.3	78	8.2	45	15.3	19.3	6.6	2.87	0.51
2018	140	7.7	80	8.2	**94**	17.8	**29.4**	6.8	2.46	0.55

Table 21-4 shows that the relevant standards have been met in recent years except for the 24-hour mean criterion for PM_{10} of 50 µg/m^3 in 2011, 2013 and 2018 and the 24-hour mean criterion for $PM_{2.5}$ of 25 µg/m^3 in 2016 and 2018. These exceedances were generally due to regional events such as bushfires and dust storms and not the result of local sources.

The background pollutant concentrations for the project used in this assessment have been determined by taking an average of the monitored annual mean concentrations for the years shown in **Table 21-4**. The maximum one-hour mean concentrations for NO_x and NO_2 have been used. The meanT24-hour PM concentrations fluctuate considerably from day-to-day and it would be unrealistic to use the maximum monitored 24-hour mean PM_{10} or $PM_{2.5}$ concentrations in the assessment. For this assessment, the 99th percentile of monitored 24-hour mean PM_{10} and $PM_{2.5}$ concentrations (ie the concentration that would be exceeded on one per cent of the days) has been used to remove the influence of the short-term spikes or peaks in monitoring data associated with PM generating natural events. The average maximum one-hour mean was used for CO.

Background pollutant concentrations used for assessment purposes are shown in **Table 21-5.**

Table 21-5 Background pollutant concentrations used in the assessment

Pollutant	Averaging period	Concentration (µg/m^3)
Nitrogen oxides (NO_x) (for NO_x to NO_2 conversion)	Annual	9.2
	1-hour	170
Particulate matter (PM_{10})	Annual	15.0
	24-hour	40.5
Fine particulate matter ($PM_{2.5}$)	Annual	6.8
	24-hour	16.6
Carbon monoxide (CO)	1-hour	3.67

21.5 Existing health of population

When considering the health of a local community there are many factors to consider. The health of the community is influenced by a complex range of interacting factors including age, socio-economic status, social networks, behaviours, beliefs and lifestyle, life experiences, country of origin, genetic predisposition and access to health and social care. While it is possible to review existing health statistics for the local areas surrounding the project and compare them to NSW, it is not possible or appropriate to be able to identify a causal source, particularly individual or localised sources.

The study area is within the Mid North Coast Local Health District. The population of the Mid North Coast Local Health District have higher rates of long-term risk alcohol consumption, smoking, insufficient physical exercise, overweight and obesity as well as higher rates of adequate fruit and vegetable intakes compared with NSW.

Appendix Q, Human health risk assessment provides the rates of the key mortality indicators (such as cardiovascular disease, lung cancer and chronic obstructive pulmonary disease (COPD)) and hospitalisation indicators for the study area compared to other regional NSW local health districts as well as NSW as a whole. In summary:

- The rate of mortality for the indicators presented in the Mid North Coast Local Health District are similar to NSW for respiratory disease, including COPD, but higher for cardiovascular disease and all causes
- The rate of hospitalisations for the indicators presented in the Mid North Coast Local Health District is similar to NSW for diabetes and asthma but higher than NSW for cardiovascular disease and COPD.

21.6 Assessment of potential impacts

21.6.1 Construction

Particulates and emissions

During construction, the main air quality impacts would be primarily due to dust generation (including elevated PM_{10} concentrations due to dust generating activities), and exhaust emissions from diesel-powered construction equipment.

Based on the IAQM guidance, the potential for dust emissions during the construction stage of the project has been assessed to be large for demolition (as the volume of structures to be demolished is greater than 50,000 m^3) and large for all other activities (as earthworks are likely to require the movement of more than 100,000 t of material and there will be on site concrete batching and blasting used during construction of the road).

The potential for exposure to dust emissions can depend on the type of construction work, duration and frequency of the activity in any given locality, the prevailing wind speed and direction and the relative location of nearby sensitive receivers.

There is potential for adverse dust impacts at sensitive receivers surrounding the construction footprint as winds could be capable of transporting emissions. Adverse impacts from high dust levels include health effects (from smaller particles) and soiling and amenity impacts (due to fallout of the larger particles). The impacts are generally greater during dry weather periods and high wind conditions.

For all construction activity, the aim would be to prevent significant impacts on sensitive receivers, through the implementation and use of effective mitigation measures. Given the proximity and number of sensitive receivers to the construction footprint, there is the risk that they would experience some occasional dust spoiling impacts. However, it is anticipated that impacts would be local and temporary.

Primary activities which would generate dust from the construction would include:

- Clearing of vegetation and topsoil
- Excavation and levelling of soil
- Earthworks for cut and fill areas
- Movement of soil and fill by dump trucks and scrapers
- Wind erosion from unsealed surfaces and stockpiles
- Wheel-induced dust from construction vehicles travelling on unsealed areas
- Rock crushing and screening
- Concrete and asphalt batching.

The IAQM guidance defines criteria for determining the sensitivity of an area to dust soiling effects. Based on this, the receptor sensitivity for the project was assumed to be ‘high’.

The numbers of receptors for each scenario and activity, and the resulting outcomes are shown in **Table 21-6.**

Table 21-6 Results – sensitivity to dust soiling effects

Activity	Receptor sensitivity	Number of receptors by distance from source				Sensitivity of area
		<20 m	20–50 m	50–100 m	100–350 m	
Demolition	High	2815	3265	7200	9270	High
Earthworks	High	2815	3265	7200	9270	High
Construction	High	2815	3265	7200	9270	High
Track-out	High	2815	3265	N/A	N/A	High

Impacts are likely to be higher where there are higher numbers of sensitive receptors, such as the southern and northern tie-ins of the project where residential receptors, community facilities and food handling facilities/restaurants are located along existing roads. There are also a number of ecological receptors located throughout the study area, predominantly agricultural properties (such as banana and blueberry plantations). Dust impacts can lead to discolouration and soiling of crops, as well as potentially inhibiting plant growth. The susceptibility of dust impacts on blueberry and banana farms is discussed further in **Chapter 13, Agriculture**.

Construction vehicle exhaust emissions have the potential to impact on local air quality. Vehicle exhaust emissions depend on the fuel type, fuel quality, power output and operating condition of the engine. All construction vehicles (including light vehicles) are expected to be maintained in a serviceable condition. Providing the construction vehicles are well maintained, the volume and impact of exhaust emissions during construction is expected to be substantially lower than that from vehicle emissions on existing roads.

There is the potential for cumulative effects during construction from both dust deposition and exhaust emissions from construction plant and vehicles, particularly if other projects are under construction at the same time. This is further discussed in **Chapter 25, Cumulative impacts**.

Odour

There are three ancillary sites described in **Chapter 6, Construction** that have been identified as potentially including asphalt batching plants. These locations have been selected to provide a buffer from odour generating activities and sensitive receivers where feasible. During the construction phase, there is potential for some short-term odour impacts from asphalt laying, batching plants, blasting and earthworks stabilisation. This would potentially impact receivers in very close proximity to these works and the level of impact would be dependent on meteorological conditions at the time. Any impact would be temporary, localised and short term while the activity was being carried out. Best practice management measures would be incorporated into the establishment and operation of the asphalt batching plants to avoid or minimise potential odour impacts as detailed in **Section 21.7.**

Health impacts

Overall, construction dust is unlikely to represent a serious ongoing problem. As described above, any effects would be temporary and relatively short-lived, and would only arise during dry weather with the wind blowing towards a sensitive receiver, at a time when dust is being generated and mitigation measures are not being fully effective. The likely scale of this would not normally be considered sufficient to change the conclusion that with mitigation the effects would be not significant.

With the application of environmental management measures described in **Section 21.7**, the potential for health impacts to occur as a result of dust generated during construction is considered to be low.

21.6.2 Operation

Air emissions from vehicles during operation of the project would consist of exhaust emissions, road dust, and brake and tyre wear. The assessment is based on the traffic volumes in 2024 and 2034, both with and without the project as detailed in **Chapter 8, Traffic and transport**.

The project would introduce a new road through a greenfield setting and may result in adverse impacts on local air quality. However, the project would also result in air quality improvements in Coffs Harbour CBD through improvements in traffic flow and redistribution of traffic away from the existing Pacific Highway. Overall, the project would not result in any exceedances of the relevant air quality standards.

Local air quality

The local air quality impacts from the project have been assessed by considering predicted pollutant concentrations (including background and project contributions) from the project. Results indicate no predicted exceedances of the relevant air quality standards in any of the scenarios assessed. Figures showing total pollutant concentrations across the modelled area, for comparison with the air quality standards, are provided in **Appendix P, Air quality assessment** and summarised in **Table 21-7.**

Table 21-7 summarises the background and project contributions (from tunnel portals and roads) and therefore represents the cumulative impacts of the project. Although contributions from tunnels portals and surface roads emissions would result in an increase in pollutant concentrations, the cumulative concentrations are predicted to remain well below the relevant air quality standards set out in **Table 21-3** and assessment criteria set out in **Table 21-5**.

Table 21-7 Summary of cumulative predicted concentrations compared to air quality standards

	Standard	Background (assessment criteria)	2024 (with project)		2034 (with project)	
			Tunnel portals and roads contributions	Cumulative predictions concentrations	Tunnel portals and roads contributions	Cumulative predictions concentrations
Predicted $PM_{2.5}$ concentrations (µg/m^3)						
24-hour average	*25*	*16.60*	1.71	18.31	1.61	18.21
Annual average	*8*	*6.8*	0.70	7.50	0.67	7.47
Predicted PM_{10} concentrations (µg/m^3)						
24-hour average	*50*	*40.50*	2.83	43.33	2.74	43.24
Annual average	*25*	*15*	1.12	16.12	1.14	16.14
Predicted NO_2 concentrations (µg/m^3)						
1-hour average	*246*	*170*	-	172.58	-	165.73
Annual average	*62*	*9.20*	-	15.29	-	14.06
Predicted CO concentrations (mg/m^3)						
1-hour average	*30*	*3.67*	-	4.14	-	3.75
8-hour average	*10*	*2.95*	-	3.33	-	3.25

The change in annual average $PM_{2.5}$ concentrations in the opening year of the project (2024) and 10 years after opening (2034) are shown in **Figure 21-3** and **Figure 21-4** respectively. Green areas on the figure represent a reduction in predicted concentration (improvement in air quality) and purple areas represent an increase in predicted concentration. Annual average $PM_{2.5}$ concentrations were selected to illustrate the impact of the project impact given it is a particularly sensitive pollutant parameter and the results for this parameter are consistent with the results for other parameters.

Figures showing the change in PM_{10}, NO_2 and CO concentrations for both 'with project' and 'without project' scenarios are provided in **Appendix P, Air quality assessment.** The predicted changes for all parameters due to the project are summarised in **Table 21-8** below.

Overall, pollutant concentrations are predicted to decrease along the existing Pacific Highway once the project is operational, due to reduced traffic volumes using this road as through traffic is redistributed to the project. As such, the project would improve air quality through Coffs Harbour CBD and contribute to an improved amenity.

There would be some local increase in air emission concentrations along the project, where previously roads did not exist. However, it is not expected that this increase would result in any exceedance of the air quality standards with estimated concentrations of NO_2, PM_{10} $PM_{2.5}$ and CO found to be well below the relevant EPA air quality criteria. Concentrations are predicted to reduce by 2034 due to the introduction of new vehicle technologies, in response to cleaner fuel efficiency and emission standards.

For all pollutants, the largest increases are predicted to be at the tunnel portals, as vehicle emissions concentrate as traffic leaves each tunnel. These emissions are predicted to disperse quickly and would significantly reduce in concentration as distance from tunnel portals.

There may be some redistribution of traffic to side roads at new interchanges, such as Coramba Road, but any changes in volumes would be unlikely to result in any measurable change in air quality. Improvements in traffic flow would also help to keep emissions down and reduce impacts.

Table 21-8 Change in predicted concentrations at sensitive receptors due to project

Pollutant	2024 (with project)		2034 (with project)	
	Maximum decrease in concentrations	Maximum increase in concentrations	Maximum decrease in concentrations	Maximum increase in concentrations
Predicted $PM_{2.5}$ concentrations (µg/m^3)				
24- hours average	0.8	0.5	0.7	0.4
Annual average	0.37	0.25	0.25	0.27
Predicted PM_{10} concentrations (µg/m^3)				
24- hours average	1.4	0.6	1.2	0.5
Annual average	0.6	0.34	0.51	0.35
Predicted NO_2 concentrations (µg/m^3)				
1- hours average	12.6	21.4	8.1	14.9
Annual average	3.91	6.43	1.98	5.68
Predicted CO concentrations (µg/m^3)				
1- hours average	0.4	0.4	0.2	0.4
Annual average	0.34	0.33	0.33	0.18

Regional air quality

The increase in total NO_x emissions from vehicles using the project and existing Pacific Highway in the opening year of the project has been assessed to be 34 t per year. This is due to increased vehicle kilometres travelled with through traffic travelling a longer distance on the project in the 'with project' scenario, compared with the existing Pacific Highway. However, there would also be traffic efficiencies for traffic travelling on the existing Pacific Highway due to improved traffic flow and conditions.

The increase is less than 40 per cent of the 90 t per year threshold for new development, discussed in **Section 21.1** and represents a very small proportion of total anthropogenic NO_x emissions across NSW. As such, the regional impacts of the project would be negligible, and undetectable in any ambient air quality measurements at urban background locations.

Health impacts

The potential health impacts from the assessed air pollutants are provided in **Table 21-9.**

Table 21-9 Potential health impacts from the assessed air pollutants

Pollutant	Health impacts
CO	Motor vehicles are the dominant source of CO in air (DECCW 2009). Adverse health effects of exposure to CO are linked with carboxyhaemoglobin (COHb) in blood. In addition, an association between exposure to CO and cardiovascular hospital admissions and mortality, especially in the elderly for cardiac failure, myocardial infarction and ischemic heart disease; and some birth outcomes (such as low birth weights) have been identified (NEPC 2010).
NO_2	NO_2 is the only oxide of nitrogen that is of concern (WHO 2000). NO_2 is a colourless and tasteless gas with a sharp odour. NO_2 can cause inflammation of the respiratory system and increase susceptibility to respiratory infection. Exposure to elevated levels of NO_2 has also been associated with increased mortality, particularly related to respiratory disease, and with increased hospital admissions for asthma and heart disease patients (WHO 2013). Asthmatics, the elderly and people with existing cardiovascular and respiratory disease are particularly susceptible to the effects of NO_2 (Morgan, Broom & Jalaludin 2013; NEPC 2010). The health effects associated with exposure to NO_2 depend on the duration of exposure as well as the concentration.
$PM_{2.5}$ and PM_{10}	Adverse health effects associated with exposure to particulate matter have been well studied and reviewed by Australian and international agencies. Particulate matter has been linked to adverse health effects after both short-term exposure (days to weeks) and long-term exposure (months to years). The health effects associated with exposure to particulate matter vary widely (with the respiratory and cardiovascular systems most affected) and include mortality and morbidity effects. In relation to mortality, for short-term exposures in a population this relates to the increase in the number of deaths due to existing (underlying) respiratory or cardiovascular disease; for long-term exposures in a population this relates to mortality rates over a lifetime, where long-term exposure is considered to accelerate the progression of disease or even initiate disease. In relation to morbidity effects, this refers to a wide range of health indicators used to define illness that have been associated with (or caused by) exposure to particulate matter. In relation to exposure to particulate matter, effects are primarily related to the respiratory and cardiovascular system (Morawska, Moore & Ristovski 2004; USEPA 2009b, 2018).

The assessment of health impacts related to changes in air quality during operation concluded:

- The project would not change the existing health outcomes in relation to exposures in the community to CO, either adversely or beneficially. The changes due to the project are not significant. No adverse health effects are expected in relation to exposures (acute and chronic) to CO in the area surrounding the project
- Overall, calculated risks associated with changes in NO_2 levels in the community from the project are considered acceptable. The impact of the changes in NO_2 concentrations on the health of the population (as a population incidence as presented) is very low and would not be measurable within the community
- Overall, calculated risks associated with changes in $PM_{2.5}$ and PM_{10} levels in the community from the project are considered acceptable. The impact of the changes in $PM_{2.5}$ and PM_{10} concentrations on the health of the population (as a population incidence as presented) is very low and would not be measurable within the community.

Coffs Harbour Bypass
Change in predicted annual average $PM_{2.5}$ concentrations 2024
Figure 21-3

Coffs Harbour Bypass
Change in predicted annual average $PM_{2.5}$ concentrations 2034
Figure 21-4

21.7 Environmental management measures

As discussed above, there is a risk of impacts to air quality as a result of the construction phase of the project. Management measures have been recommended for this phase, see **Table 21-10**. These are consistent with Roads and Maritime standard measures and also consider additional guidance such as the Local Government Air Quality Toolkit (EPA 2017c). There are interactions between the mitigation measures for air quality and **Chapter 18, Soils and contamination**.

As no exceedances of the air quality standards are predicted during the operational phase of the project, no management measures are required.

Table 21-10 Environmental management measures for air quality impacts

Impact	ID No.	Environmental management measure	Responsibility	Timing
Management of construction impacts	AQ01	An Air Quality Management Plan (AQMP) will be prepared and implemented as part of the CEMP. The AQMP will identify: • Potential sources of air pollution (such as dust, vehicles transporting waste, plant and equipment) during construction • Identification of all dust sensitive receivers, including banana and blueberry farms, residential dwellings, education institutions, health care facilities, places of worship, childcare facilities and open space • Air quality management objectives and criteria consistent with Approved Methods for the Modelling and Assessment of Air Quality Pollutants in NSW (EPA 2017a) • Mitigation and suppression measures to be implemented, such as using soil binders or covering exposed surfaces, provision of vehicle clean down areas, covering of loads, use of water carts and street cleaning, use of dust screens, maintenance of plant in accordance with manufacturer's instructions, spray bars on crushers • Methods to manage or stop works during strong winds or other adverse weather conditions • A progressive rehabilitation strategy for exposed surfaces • When the air quality, suppression and management measures need to be applied and who is responsible • A monitoring program to assess the effectiveness of the applied measures • Community notification and complaint handling procedures.	Contractor	Prior to construction

Impact	ID No.	Environmental management measure	Responsibility	Timing
Dust generation from building demolition	AQ02	Where buildings and structures are required to be demolished, techniques and practices will be developed to minimise dust generation such as water spraying during demolition as required, and the removal of construction debris along an approved route documented in the AQMP.	Contractor	During construction
Construction vehicle emissions	AQ03	Where practicable, construction vehicles will be fitted with pollution reduction devices and switched off when not in use.	Contractor	During construction
Odour impacts from asphalt batch plants	AQ04	Asphalt batch plants established for the project will include the following measures to minimise odour generation: • Bitumen products will be maintained at the minimum temperature possible to minimise odorous emissions • Particulate extraction equipment will be installed, operated and maintained for efficiency in minimising odour impacts • Filters and burners will be adequately maintained to minimise odour impacts • Commission testing will be carried out prior to full operation to ensure that best practice industry standards are met during the operation of the batch plant.	Contractor	During construction

CHAPTER 22

Chapter 22

Waste

22. Waste

This chapter presents an assessment of the waste generated during the construction and operation of the project and identifies mitigation and management measures to minimise and reduce these impacts. The assessment presented in this chapter draws on information from **Chapter 5, Project description**, **Chapter 6, Construction, Chapter 8, Traffic and transport**, **Chapter 17, Flooding and hydrology, Chapter 18, Soils and contamination, Chapter 19, Surface water quality** and **Chapter 20, Groundwater**.

Table 22-1 lists the SEARs relevant to waste and where they are addressed in this chapter.

Table 22-1 SEARs relevant to waste

Ref	Key Issue SEARs	Where addressed
14. Waste		
1.	The Proponent must assess predicted waste generated from the project during construction and operation, including:	
	(a) classification of the waste in accordance with the current guidelines;	Section 22.1 Section 22.2 Section 22.4.1
	(b) estimates / details of the quantity of each classification of waste to be generated during the construction of the project, including bulk earthworks and spoil balance;	Section 22.4
	(c) handling of waste including measures to facilitate segregation and prevent cross contamination;	Section 22.5 **Chapter 18, Soils and contamination**
	(d) management of waste including estimated location and volume of stockpiles;	Section 22.4 Section 22.5 **Chapter 6, Construction**
	(e) waste minimisation (particularly of unsuitable material) and reuse;	Section 22.4 Section 22.5
	(f) lawful disposal or recycling locations for each type of waste; and	Section 22.3
	(g) contingencies for the above, including managing unexpected waste volumes.	Section 22.5
2.	The Proponent must assess potential environmental impacts from the excavation, handling, storage on site, and transport and disposal of the waste particularly with relation to sediment/leachate control, noise and dust, and traffic and transport.	Section 22.4 **Chapter 8, Traffic and transport** **Chapter 9, Noise and vibration,** **Chapter 18, Soils and contamination,** **Chapter 21, Air quality** **Chapter 24, Hazard and risk**

22.1 Assessment methodology

Materials that may potentially be waste have been assessed in relation to likely sources, volumes, potential waste classification and the timing of generation during construction and operation of the project.

Potential waste streams have been classified in line with current NSW EPA guidelines (refer to **Section 22.4.2**) and would likely include:

- Special waste (eg asbestos, clinical waste, waste tyres)
- Liquid waste (eg concrete slurry)
- Hazardous waste (eg contaminated material)
- Restricted solid waste
- General solid waste (putrescible) (eg from vegetation clearance and food waste from site offices)
- General solid waste (non-putrescible) (eg from construction and demolition as well as virgin excavated natural material (VENM) and excavated natural material (ENM)).

Waste regulations, policies and guidance, as noted in **Section 22.2**, have informed the assessment of potential waste and development of management measures. Best practice waste management principles would be followed, adhering to the waste management hierarchy:

- Prevention
- Reuse
- Recycling
- Other recovery
- Disposal as a last resort.

The preferred option for management of excess materials would be to identify potential options for beneficial reuse either within the construction footprint or off-site. The proposed strategy for beneficial reuse is included in **Section 22.5**.

22.2 Policy and planning setting

22.2.1 Policy framework

NSW Government Resource Efficiency Policy

The NSW Government Resource Efficiency Policy (GREP) (OEH 2019e) aims to drive resource efficiency, with a focus on energy, water, waste and a reduction in harmful air emissions. Waste related objectives of GREP include minimising the use of non-renewable resources and minimising the quantity of waste disposed to landfill. To meet the policy intent of the GREP, resource efficiency and waste reduction initiatives for the project will include:

- Balancing earthworks as far as practicable in detailed design and construction and recovering materials (such as quarry products from cuttings) for reuse
- Using recycled materials (such as concrete and asphalt pavement)
- Reducing resource consumption through appropriate detailed design and construction methodologies.

Roads and Maritime Services Environment Policy Statement

The Roads and Maritime Services Environment Policy Statement (Roads and Maritime Services 2016b) details Roads and Maritime's commitment to carrying out business in an environmentally responsible manner. It outlines accountability, responsibility, requirements for cooperation, consultation and compliance. It also makes commitments to managing work activities to deliver continuous improvement in environmental performance.

EPA Waste Classification Guidelines 2014

The Waste Classification Guidelines (EPA 2014h) provide direction on the classification of waste. Testing and classification of waste would be undertaken for the project to determine suitability for reuse or if the material requires disposal at an appropriately licensed off-site facility.

22.2.2 Regulatory framework

Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) establishes procedures for environmental control and issuing environmental protection licenses for matters such as waste, water, noise and air.

The POEO Act also makes it an offence to unlawfully transport waste material (Section 143); to use the premises as a waste facility without the authority to do so (Section 144); or provide misleading information regarding waste storage, transport and disposal (Section 144AA).

The POEO Act requires certain licensed waste facilities in NSW to pay a contribution for each tonne of waste received at the facility. The 2018–19 waste levy rate for the Coffs Harbour region, which is in the regional levy area, is $81.30 per tonne of waste (EPA 2018b). This will increase by the Consumer Price Index to $82.70 per tonne for the 2019-20 financial year. The levy would apply to wastes from the project in addition to operational fees charged by the landfill operator.

Clause 49 of Schedule 1 of the POEO Act defines the following waste classifications:

- Special waste
- Liquid waste
- Hazardous waste
- Restricted solid waste
- General solid waste (putrescible)
- General solid waste (non-putrescible).

Protection of the Environment Operations (Waste) Regulation 2014

The Protection of the Environment Operations (Waste) Regulation 2014 (Waste Regulation) regulates matters such as licensing for waste transport and tracking requirement obligations of producers and agents, transporters, and receivers of waste. Under the Waste Regulation it is an offence to transport waste generated in NSW more than 150 km from the place of generation for disposal, unless the disposal location is the closest or second closest place that can be lawfully used for the disposal of that waste. The Waste Regulation provides exemptions from some requirements for certain waste and resource recovery activities where it can be demonstrated that waste reuse would not cause harm to human or environmental health. Under these provisions, the EPA requires two separate applications, either or both of which may be applicable to a project:

- A Resource Recovery Order made under clause 93 of the Waste Regulation, which covers the requirements for the generation and/or processing of waste material for reuse
- A Resource Recovery Exemption made under clauses 91 and 92 of the Waste Regulation, which relates to the consumption of waste materials for reuse.

The following general resource recovery exemptions are most relevant to road construction projects:

- Excavated natural material (Excavated Natural Material Exemption 2014 (EPA 2014b))
- Excavated public road material (Excavated Public Road Material Exemption 2014 (EPA 2014c))
- Raw mulch (Raw Mulch Exemption 2016 (EPA 2016b))
- Reclaimed asphalt pavement (Reclaimed Asphalt Pavement (RAP) Exemption 2014 (EPA 2014d))
- Recovered aggregate (Recovered Aggregate Exemption (EPA 2014e))
- Stormwater (Stormwater Exemption (EPA 2014f))
- Treated Drilling Muds (Treated Drilling Mud Exemption (EPA 2014g)).

The Waste Regulation classifies VENM as general solid (non-putrescible) waste. When assessing whether a waste is VENM the following aspects needs to be determined:

- The historical and current land use at the site where the waste was generated
- The waste is not contaminated with manufactured chemicals or with process residues, as a result of industrial, commercial, mining or agricultural activities
- The waste does not contain any sulfidic ores or soils
- That waste does not contain any other waste
- The waste does not contain asbestos in any form.

Where an excavated material cannot be classified as VENM, it may be eligible for reuse under the excavated natural material order or excavated public road material order.

Waste Avoidance and Resource Recovery Act 2001

The *Waste Avoidance and Resource Recovery Act 2001* (WARR Act) aims to ensure that waste management options are considered against the following waste management hierarchy:

- Avoidance of unnecessary resource consumption
- Resource recovery (including reuse, reprocessing, recycling, and energy recovery)
- Disposal.

The Waste Avoidance and Recovery Strategy 20142021 (WARR Strategy) set under the WARR Act, presents the following targets relevant to the project for 2021–2022:

- Increasing waste diverted from landfill to 75 per cent
- Increasing recycling rates to:
  - 70 per cent for municipal solid waste (MSW)
  - 70 per cent for commercial and industrial waste
  - 80 per cent for construction and demolition waste.

The Roads and Maritime Services Environmental Sustainability Strategy 2019–2023 (Roads and Maritime Services 2019a) also sets recycling targets for ‘clean’ construction and demolition waste. However, the project will set waste recovery targets to meet the WARR Act requirements.

Environmentally Hazardous Chemicals Act 1985

The *Environmentally Hazardous Chemicals Act 1985* provides the EPA with the authority to declare chemical substances as chemical wastes and to make Chemical Control Orders relating to those substances that are declared as chemical wastes. Chemical Control Orders are made when chemicals or chemical wastes pose serious threats to the environment and there are challenges in their management. Chemicals must be handled in accordance with the relevant Chemical Control Order.

There are currently five Chemical Control Orders in place in NSW:

- Aluminium smelter wastes containing fluoride and/or cyanide
- Dioxin-contaminated waste materials
- Organotin waste materials
- Polychlorinated biphenyl (PCB)
- Scheduled chemical wastes chemical control order 2004 (a list of 24 chemicals including a number of organochlorine pesticides which are no longer registered for use (eg DDT, Dieldrin, heptachlor) as well as some industrial waste by-products).

Hazardous wastes arising from activities such as the disposal of soils containing organochlorine pesticides, will be managed in accordance with the requirements of applicable chemical control orders in the Technical Guide Management of Road Construction and Maintenance Wastes, Issue No. 1 (Roads and Maritime Services 2016e). Previous and existing agricultural land uses such as banana plantations may have used organochlorine pesticides. Further investigations and sampling for the presence of organochlorine pesticides is discussed in **Chapter 18, Soils and contamination.**

22.3 Existing environment

22.3.1 Existing waste and contaminated sites

A preliminary soil contamination assessment was completed as detailed in **Chapter 18, Soils and contamination**. Potential contaminated sites may contain restricted solid, hazardous or special wastes which would limit the amount of suitable material for reuse on-site. Should off-site resource recovery or disposal be required, material would be classified in accordance with the Waste Classification Guidelines: Part 1 Classifying Waste (EPA 2014h).

There are known sources of agricultural and residential contamination within and adjacent to the construction footprint as a result of agricultural land uses (use of pesticides and potential Panama disease locations). There are also areas of infrastructure and industry which may cause contamination. These sites include the North Coast Railway, flood detention basins and a transport depot. More information is available in **Chapter 18, Soils and contamination**.

22.3.2 Recycling and disposal infrastructure

Under the Waste Regulation (clause 71) it is an offence to transport waste generated in NSW more than 150 km from the place of generation for disposal unless the disposal location is the closest or second closest place that can be lawfully used for the disposal of that waste. **Table 22-2** and **Figure 22-1** identify the existing recycling and waste disposal facilities within 150 km of the project.

Table 22-2 Waste facilities within 150 km of the construction footprint

Facility	Location	Proximity to the site	Site history	Accepted waste	Facility type
The Coffs Coast Resource Recovery Park/Coffs Harbour Community Recycling Centre	31a Englands Road, Coffs Harbour	1.2 km west of the construction footprint by road, just south of Englands Road	The Coffs Coast Resource Recovery Park (CCRRP) is operated by Coffs Coast Waste Services (CCWS) who have a regional partnership with Coffs Harbour City Council. There are a number of facilities located at the CCRRP. A Materials Recovery Facility is located on site for the processing of recyclables. A Biomass Solutions facility which separately processes organics and mixed waste is located here. A Glass Processing Facility also recovers, and processes broken glass. CHCC own and operate the landfill site. The CCRRP accepts concrete waste including concrete slabs, concrete roof tiles, bricks and pavers.	Construction waste types: Construction waste, general waste and concrete waste (concrete slabs, concrete roof tiles, bricks and pavers) Demolition waste types: Polystyrene, paper and cardboard, recyclables (glass, plastics, steel and aluminium and tetra packs), hazardous household items such as paint, chemicals, gas bottles, fluorescent globes, e-waste, scrap metals, building and tyres, asbestos and car parts. This facility accepts green waste for composting.	Landfill, materials recovery facility (MRF), hazardous waste (including hydrocarbons)
Nambucca Waste Management Facility (landfill and transfer station)	711 Old Coast Road, Nambucca Heads	45 km south of the project by road, just west of Nambucca Heads	The Nambucca Waste Management Facility is owned and operated by the Nambucca Shire Council. This facility accepts construction and demolition (C&D) waste including concrete and bricks. This facility also accepts asbestos and clean fill (Coffs Coast Waste Services 2018).	Construction waste: Green waste, concrete, clean fill, cardboard, and paper. Demolition waste: All types of vehicles accepted - concrete and bricks, asbestos and clean fill, green waste, recyclable materials including cardboard, paper, polyethylene terephthalate (PET) & high-density polyethylene (HDPE), scrap metal, car bodies, batteries and specified e-wastes.	Landfill, MRF

Facility	Location	Proximity to the site	Site history	Accepted waste	Facility type
Raleigh Waste Management Centre (landfill and recycling)	146 Short Cut Road, Raleigh	24 km south of the construction footprint by road, just west of the Pacific Highway in Raleigh	The Raleigh Waste Management Centre is owned and operated by the Bellingen Shire Council (Bellingen Shire Council 2014). This site has been used for solid waste disposal since 1978. This landfill received 733 tonnes of C&D waste and 569 tonnes of MSW in 2012-2013, with a total of 2496 tonnes of accepted waste. It does not accept C&I waste or contaminated soil. There is a resource recovery facility which collects and sorts items of value that may be sold back to the public and avoid going to landfill.	Construction waste: General construction waste, green waste, cardboard and paper. Demolition waste: Asbestos, tyres, e-waste, green waste, household chemicals and timber. Recyclable materials including cardboard, paper, and scrap metal, car bodies, batteries and specified e-wastes.	Landfill, MRF
Grafton Regional Landfill and Resource Recovery Centre	704 Armidale Road, Elland	80 km north of the construction footprint by road, west of the Pacific Highway in Grafton	The Grafton Regional Landfill is owned and run by the Clarence Valley Council. This facility accepts C&D waste and asbestos (Coffs Coast Waste Services 2018).	Construction waste: Clean fill, concrete, general solid waste Demolition waste: Asbestos pipes, clean fill, concrete, clean soil – VENM, commercial quantities of household hazardous waste, dead animals, green waste, general solid waste, mixed building & demolition waste, mixed commercial and industrial waste, mixed waste, recyclables, sorted scrap metal, sorted mixed waste and tyres.	Landfill, MRF, Hazardous

Coffs Harbour Bypass
Waste management facilities
Figure 22-1

22.4 Assessment of potential impacts

This section assesses the potential environmental impacts of waste generation from construction and operation of the project and the impacts on local/regional waste management infrastructure.

22.4.1 Resource use

Construction

The main construction materials and resources to be used for the project include earthworks material, concrete, asphalt, steel, water, fuel and electricity. Materials consumed by the project would include:

- **Earthworks material** – around 378,000 m^3 of imported select fill material from external sources may be required depending on the construction method. Not all material can be won from site due to the quality of the material being cut. Where possible, the imported select fill would be sourced from existing, approved or potential quarries near the project
- **Concrete** – around 218,000 m^3 would be used for construction of the road and pavements, kerbing, retaining walls, drainage structures, bridges and tunnel structures. A concrete batching plant(s) is proposed to be established for the project as identified in **Chapter 6, Construction**. Cement and fly ash would likely be imported by rail and road from Newcastle, Sydney or Brisbane
- **Asphalt** – around 53,000 m^3 would be used for construction of road surfaces. Should an asphalt batching plant be established for the project, bitumen would likely be sourced from refineries in Sydney or Brisbane
- **Steel** – around 36,200 t would be used for construction of fencing, steel pipes, bridges and tunnel support. This would likely be supplied from accredited steel suppliers in either Wollongong, Sydney or Brisbane
- **Water** – a number of activities would require water use during construction. A concrete batching plant would use around 200 kL of potable water per day. Additional water uses include around 70 kL per day of non-potable water for dust control, 60 kL per day for drilling, 18 L/m^3 for earthwork compaction and 70 L/m^3 for earthwork stabilisation.

The resource quantities required for the project's construction are unlikely to be affected by resource availability.

Operation

Ongoing resource use during operation would be minimal and include water (for landscaping), electricity (for road and traffic lights), asphalt and concrete (for road surface maintenance) and fuel (for maintenance vehicles). The tunnels would also require an ongoing supply of electricity (for tunnel lighting, fire and life safety systems, traffic control devices and communications), water (for deluge) and fuel (for a back-up generator to pump water and supply electricity). Resource supply impacts during operation are unlikely.

22.4.2 Waste generation

Construction

The project could generate a number of waste streams as a result of construction activities including:

- Special waste
  - Asbestos, waste tyres
- Liquid waste
  - Concrete slurry

  - Wastewater, including sewage form site compounds
  - Chemical spills
- Hazardous waste
  - Contaminated excavated material
- Restricted solid waste
- General solid waste (putrescible)
  - Timber and green waste
  - MSW
- General solid waste (non-putrescible)
  - VENM
  - Excavated natural material
  - Concrete, steel and plastic from demolition
  - Concrete and asphalt from construction
  - Packaging materials
  - Vehicle maintenance waste.

The estimated quantities of waste from construction activities is listed in **Table 22-3.** The estimated amount of waste generated has been determined using the Arup Waste Forecast Tool with reference to quantities identified in **Chapter 5, Project description**.

Table 22-3 Estimated waste materials that would be produced by the project

Material	Estimated waste (tonnes)
Concrete	11,800
Asphalt	1800
Steel	1850
General waste	550
Other (bridge deck surface, dense graded base)	2500
Green waste	54,000

Excavation material

Excavated material would comprise of VENM and excavated natural material. As far as practicable, earthworks material generated from the project would be reused for the construction of embankments, noise barriers, in subgrade pavement layers and as verge material. During detailed design, the earthworks balance would be further refined to source as much material as required for the project.

The required general fill for the project is around 4.2 million cubic metres. As described in **Chapter 6, Construction**, the current earthworks balance estimate indicates that there would be a deficit of 181,000 m^3 of general fill, as shown in **Table 22-4**. About 378,000 m^3 of higher-grade material would also be required for the project for pavement subbase and base and would need to be imported to site.

There is the possibility that these amounts may change depending on the detailed design and the specific geotechnical issues encountered at the site (eg wet ground conditions). These quantities would be refined during design and before construction.

Table 22-4 Excavation quantities (cut and fill balance) for whole construction footprint.

Construction zone	Cut material* (m^3)	General fill (m^3)	Select fill (m^3)	Cut surplus (m^3)	Fill deficit (m^3)
1	1,202,000	1,082,000	138,000	120,000	-
2	1,758,000	1,939,000	268,000	-	-181,000
3	1,266,000	1,031,000	146,000	235,000	-
Total	**4,226,000**	**4,052,000**	**552,000**	**174,000**	**-**

*Value includes bulking factor of 21.5% (factor determined based on geotechnical data for the project).

There are a number of potential impacts from excavated material when it is stockpiled on site, including:

- Risk of surface water run-off from contaminated stockpiles impacting the surrounding environment
- Producing dust if stockpile is not properly dampened or at an inappropriate height
- If excess spoil cannot be reused on site or beneficially reused offsite then it would require disposal in landfill
- Amenity impacts associated with dust generation and noise impacts if significant amounts of excess spoil require transportation.

There is the potential for contaminated soils to be exposed during construction. Previous and current agricultural land use may have resulted in soil contamination from remnants of pesticides or Panama disease. Other potential sources of soil contamination include industrial land uses, the waste facility on Englands Road, the existing Pacific Highway, the North Coast Railway corridor and from illegal dumping. Further information is discussed in **Chapter 18, Soils and contamination**.

Timber and green waste

Green waste would be produced from removal of vegetation. As far as practicable, all green organic material generated from the project would be reused on site as mulch, for landscaping purposes, fauna connectivity structures and habitat enhancement measures. The project would remove around 77 ha of vegetation (45.91 ha of native vegetation and around 31.01 ha of non-native vegetation). This equates to around 54,000 tonnes of green waste material.

Due to the presence of Panama disease in nearby banana plantations, it is highly unlikely that any cleared vegetation from these plantations will form part of the material to be mulched or reused on site. To limit the risk of spreading Panama disease, cleared vegetation from these plantations will be managed in accordance with the Panama Disease Control Management Plan, as detailed in **Chapter 13, Agriculture**.

Mulch produced on site would be used in landscaping and soil and erosion control measures for the project. Tannin rich leachate could occur as a result of raw mulch being stored on site. Mulch stockpiles will require appropriate management to prevent tannins from impacting the water quality of surrounding water resources. The management of tannins is discussed in **Chapter 19, Surface water quality**.

Demolition waste

Waste would be generated from the demolition of existing structures such as buildings, road pavement, utilities and redundant services. About 110 structures would need to be demolished for the construction of the project, with a combined area of around 3 ha. These calculations would be refined during detailed design and it is anticipated that this quantity could be lower. Expected waste materials that would be generated include steel, concrete, asphalt, green waste, general waste, plastics, spoil, cardboard, glass, asbestos, bricks, plasterboard and gravel.

Hazardous building materials

Through demolition of existing structures there is the potential of uncovering hazardous building materials, such as asbestos, lead paint or other sources of hazardous contamination. This may present a health risk to workers and the surrounding community or result in indirect impacts on the environment. An asbestos survey would be undertaken of buildings to be demolished prior to their demolition. Removal of asbestos containing materials (ACM) would be undertaken by suitably qualified experts in accordance with an Asbestos Management Plan. All ACM would be suitably disposed of at an appropriately licensed waste facility. This is discussed further in **Table 22-5.**

Wastewater

Wastewater includes liquid waste from sewage and surface water runoff. As there are contaminated soils and a risk of acid sulfate soils within the construction footprint, surface water runoff into the existing environment has the potential to impact on the surrounding water resources and environment if not managed appropriately.

Wastewater types could include:

- Tannin affected water
- Turbid water captured in excavations and sedimentation basin
- Sewage from site compounds
- Contaminated groundwater inflows from cuttings and tunnels
- Water runoff from construction activities, eg concrete curing.

For further information on management measures for wastewater refer to **Chapter 19, Surface water quality** and **Chapter 20, Groundwater**.

In circumstances where it is reasonable and feasible, the project will seek to reuse wastewater for dust suppression, landscape establishment and for earthworks compaction and stabilisation.

Construction waste and packaging materials

Construction waste may include materials such as timber, concrete and asphalt, steel, metal, chemicals, piping and conduits. Where reasonable and feasible, surplus concrete could be crushed and reused for pavements and access tracks. Packaging waste may result from excess material delivered to site including timber, cardboard, plastic and paper. Opportunities to buy in bulk would reduce excess packaging material. Where cost effective and fit for purpose, material would be sourced from companies that use sustainable, recycled and recyclable packaging.

Plant and equipment maintenance and site compounds

Waste may be produced from vehicles and equipment maintenance, lubrications, oils, fuels, tyres. General solid waste from site compounds may include food scraps, glass, paper and cardboard, plastic, metal (including aluminium cans) and glass. If not appropriately managed, these wastes could result in water pollution and soil contamination. Appropriate waste collection, management and recycling facilities would be provided at site compounds.

Operational waste

Although limited in quantity, the main waste generated during operation of the project would include:

- Small quantities of green waste produced during maintenance activities including roadside vegetation control and general maintenance of the entire road corridor
- General solid waste produced from debris and litter along the project
- Contaminated waste which may result from any traffic accidents, spills and fuel leaks
- Excess concrete and asphalt from maintenance activities of the road or road surface

- Vehicle oils and greases from vehicles using the highway
- Washdown water, wastewater, surface water runoff, silt and sediment.

Waste quantities during operation of the project would be minor, and maintenance would be in accordance with the Technical guide, Management of road construction and maintenance wastes (Roads and Maritime Services 2016e). Any waste produced during operation would be managed in accordance with the waste hierarchy, classified according to the Waste Classification Guidelines (EPA 2014h) if required and be reused, recycled or disposed of at suitable facilities.

22.5 Environmental management measures

22.5.1 Waste storage

The contractor would be responsible for the control of waste generation and management during construction. Suitable areas within the ancillary sites described in **Chapter 6, Construction** or in other appropriate areas within the construction footprint are to be identified and allocated prior to construction to provide adequate space and access for:

- Separated storage of building materials
- Separated storage of construction waste
- Separated sorting of construction waste
- Separated storage of known contaminated or hazardous waste materials and contingency for unknown contaminated materials.

Undercover waste storage for certain waste types would be investigated to prevent the spread of litter or contamination from wind, rain, animals or vandalism. For other waste types, receptacles and bins would be covered where possible. All waste management locations would be kept tidy and well maintained. The ancillary sites being used for stockpiling and storage of construction materials would have contingency space to allow for unexpected excess materials.

22.5.2 Waste transfer to licenced waste facility

Clause 70 of the Waste Regulation requires that:

- Waste must be transported in a manner that avoids the waste spilling, leaking or otherwise escaping
- Waste must be covered during transportation unless the waste consists solely of waste tyres or scrap metal
- The motor vehicle or trailer used to transport the waste must be constructed and maintained so as to avoid the waste spilling, leaking or otherwise escaping from the motor vehicle or trailer.

In addition to meeting the requirements of clause 70 the following management activities will be carried out:

- Records detailing waste types, volumes and destinations
- Verification that the transporter and facility is licensed to handle the material designated conducted prior to transporting waste materials to off-site facilities
- Verification that the transporter has an environmental license when transporting higher risk wastes such as hazardous and liquid wastes
- Wastes tracked in accordance with Part 4 of the Waste Regulation
- Waste tyres and asbestos waste tracked in certain circumstances (ie more than 100 kg or 10 m^2 of asbestos sheeting, or more than 200 kg or 20 tyres).

If ACM are identified, an Asbestos Management Plan will be developed and implemented, including procedures to manage, handle and dispose of asbestos to meet work health and safety and environmental legislation requirements (see **Chapter 18, Soils and contamination**).

22.5.3 Excess spoil management

Spoil would be managed according to the following hierarchy where feasible:

- Review alignment and profile refinements during detailed design
- Assess opportunities to reuse excess spoil in works such as landscaping and noise barriers within the construction footprint or in adjacent land (subject to landowner agreement and/or any project approval or POEO Act requirements)
- Beneficial reuse within the construction footprint for rehabilitation of ancillary sites used for the project (where it is within the requirements of the project approval)
- Transfer to other nearby Roads and Maritime projects for immediate use, where possible, pending construction of other projects or for use on future projects or routine maintenance
- Transfer to a Roads and Maritime approved site for reuse on concurrent private/local government projects (with appropriate approvals as required, eg a section 143 notice under section 143(3A) of the POEO Act)
- Disposal at an approved materials recycling or licensed waste disposal facility.

Proposed locations for stockpile areas are detailed in **Chapter 6, Construction**. Excavation quantities are provided in **Table 22-4** and indicate a surplus of around 174,000 m^3 of material which would be managed according to the hierarchy nominated above.

22.5.4 Environmental management measures

A summary of management measures relating to waste are provided in **Table 22-5**. There are interactions between the mitigation measures for waste and **Chapter 18, Soils and contamination**, **Chapter 19, Surface water quality**, **Chapter 20, Groundwater** and **Chapter 24, Hazard and risk**. Together these measures would ensure appropriate management of waste to minimise the potential for impacts to the community and environment.

Table 22-5 Environmental management measures for waste

Impact	ID No.	Environmental management measure	Responsibility	Timing
Waste management	WM01	A Waste Management Plan (WMP) will be prepared and implemented as part of the CEMP. It will provide specific guidance on measures and controls to be implemented to support minimising the amount of waste produced and appropriately handle and dispose of unavoidable waste. It will also address the importation of recycled materials to site for use in undertaking the project. The WMP will be prepared taking into account the Roads and Maritime Environmental Procedure - Management of Wastes on Roads and Maritime Services Land (2014c) and will include, but not necessarily be limited to: • Measures to avoid and minimise waste associated with the project • Classification of wastes generated by the project and management options	Contractor	Prior to construction

Impact	ID No.	Environmental management measure	Responsibility	Timing
		• Classification of wastes received from off-site for use in the project and management options • Identification of any statutory approvals required for managing both on and off-site waste, or application of any relevant resource recovery exemptions • Procedures for storage, transport and disposal • Monitoring, record keeping and reporting, including any documentation management obligations arising from resource recovery exemptions.		
Management of excess spoil	WM02	Spoil would be beneficially reused as part of the project before alternative spoil disposal options are pursued. Any excess spoil would be managed using the following order of priorities: • Review alignment and profile refinements during detailed design • Assess opportunities to reuse excess spoil in works such as landscaping and noise barriers within the construction footprint or in adjacent land (subject to property owner agreement and/or any project approval or POEO Act requirements) • Beneficial reuse within the construction footprint for rehabilitation of ancillary sites used for the project (where it is within the requirements of the project approval) • Transfer to other nearby Roads and Maritime projects for immediate use, where possible, pending construction of other projects or for use on future projects or routine maintenance • Transfer to a Roads and Maritime approved site for reuse on concurrent private/local government projects (with appropriate approvals as required, eg a section 143 notice under section 143(3A) of the POEO Act) • Disposal at an approved materials recycling or licensed waste disposal facility.	Contractor	During construction
Waste storage	WM03	Prior to construction, suitable areas within the ancillary sites or in other appropriate areas within the construction footprint would be allocated which provide adequate space and access for: • Separated storage of building materials • Separated storage and sorting of construction waste • Removal of construction waste for recycling, reuse or disposal • Separated storage of known previously contaminated materials and contingency for unknown contaminated materials.	Contractor	Prior to and during construction

Impact	ID No.	Environmental management measure	Responsibility	Timing
Hazardous materials – risk to human health	WM04	A hazardous materials assessment would be carried out of the buildings and structures to be demolished before demolition to identify presence of hazardous materials and ensure appropriate controls are implemented for the demolition, storage and disposal of materials.	Roads and Maritime / Contractor	Detailed design
Asbestos – risk to human health	WM05	If the hazardous assessment investigations identify asbestos containing materials, an Asbestos Management Plan will be developed and implemented. The plan will include: • Identification of potential asbestos on site procedures to manage and handle any asbestos, including potential areas where asbestos may be found within soils • Procedures to manage asbestos if encountered during construction • Measures to minimise the total volume of asbestos contaminated material that is generated. These would include separate stockpiling to ensure that asbestos contaminated material is not mixed with clean stockpile material • Procedures for disposal of asbestos in accordance with NSW EPA guidelines, Australian standards and relevant industry codes of practice.	Roads and Maritime / Contractor	Detailed design
Wastewater	WM06	Where reasonable and feasible, water captured within the construction footprint will be prioritised for reuse as construction water or dust suppression.	Contractor	During construction
Operational waste	WM07	All operational waste will be managed in accordance with the Roads and Maritime waste management procedures and Environmental Management System.	Roads and Maritime	Operation

Chapter 23

Sustainability

23. Sustainability

This chapter explains how sustainability aims and objectives would be implemented in design, construction and operation of the project and includes:

- A review of the sustainability policy framework, and how it relates to the development of sustainability principles and objectives adopted during the concept design of the project
- Sustainability management measures that deliver the sustainability objectives during design, construction and operation of the project.

The assessment presented in this section draws on information from a number of chapters as discussed further in **Table 23-2** and **Table 23-3.**

Table 23-1 lists the SEARs relevant to sustainability and where they are addressed in this chapter.

Table 23-1 SEARs relevant to sustainability

Ref	Key Issue SEARs	Where addressed
15. Sustainability		
1.	The Proponent must assess the sustainability of the project in accordance with the Infrastructure Sustainability Council of Australia (ISCA) *Infrastructure Sustainability Rating Tool* and recommend an appropriate target rating for the project.	Section 23.3
2.	The Proponent must assess the project against the current guidelines including targets and strategies to improve Government efficiency in use of water, energy and transport.	Section 23.2 Section 23.3

23.1 Sustainability overview

There are many definitions of sustainability or sustainable development. In 1987, the World Commission on Environment and Development (WCED) published Our Common Future (commonly referred to as the Brundtland Report), which defined sustainable development as *'development which meets the needs of the present without compromising the ability of future generations to meet their own needs'* (WCED 1987).

In 1992, the Commonwealth Government defined Ecologically Sustainable Development (ESD) as *'using, conserving, and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased'* (Commonwealth of Australia 1992). The four principles to assist achievement of ESD are defined in the POEA Act, with the EP&A Act requiring assessment of proposals with regards to these principles:

- The precautionary principle
- Intergenerational equity
- Conservation of biological diversity and ecological integrity
- Improved valuation and pricing and incentive mechanisms.

Chapter 28, Project justification and conclusion details how the project addresses these four principles of ESD.

The Infrastructure Sustainability Council of Australia (ISCA) defines sustainable infrastructure as that which is '*designed, constructed and operated to optimise environmental, social and economic outcomes over the long term'* (ISCA 2016).

23.2 Sustainability policy framework

There are many drivers for sustainability in the NSW Government's sustainability policy framework including:

- Roads and Maritime Services Environmental Sustainability Strategy 2019 – 2023 (Roads and Maritime Services 2019a)
- Office of Environment and Heritage (OEH) NSW Government Resource Efficiency Policy (G-REP) (OEH 2019e)
- NSW Government Climate Change Framework (OEH 2016a)
- Future Transport 2056 Strategy (TfNSW 2018a)
- NSW Sustainable Design Guidelines Version 4.0 (TfNSW 2017)
- NSW Waste Avoidance and Resource Recovery Strategy 2014-2021 (EPA 2014a)
- Transport for NSW Transport Environment and Sustainability Policy Framework (TfNSW 2013c)
- NSW Aboriginal Participation in Construction Policy (NSW Government 2018a).

Together, these documents define the sustainability principles that inform the design of the project and against which the construction and operation of the project would be measured in terms of sustainability.

A review is provided in **Section 23.2.1** of the Roads and Maritime Services Environmental Sustainability Strategy 2019 – 2023 (Roads and Maritime Services 2019a) detailing the sustainability focus areas and how the project is consistent with the strategy. **Table 23-3** shows how the project is consistent with the other relevant NSW Government policies.

23.2.1 Roads and Maritime Services Environmental Sustainability Strategy 2019 – 2023

The Roads and Maritime Services Environmental Sustainability Strategy 2019 – 2023 (Roads and Maritime Services 2019a) outlines ten sustainability focus areas for integrating sustainability into Roads and Maritime's road operations and services and aligns with the Transport Environment and Sustainability Policy Framework (TfNSW 2013c).

Table 23-2 presents the sustainability focus areas and outlines how the project is consistent with these.

Table 23-2 Project consistency with Roads and Maritime sustainability focus areas

Sustainability focus area	Sustainability objective	Project consistency
Energy and carbon management	Minimise energy use and reduce carbon emissions without compromising the delivery of services to our customers	The project design sits low in the topography and minimises fuel usage and carbon emissions as described in **Chapter 4, Project development and alternatives**. An energy efficiency and carbon emissions strategy would be prepared as part of the project's Sustainability Management Plan (SMP) during detailed design (refer to **Section 23.4**). The strategy would identify initiatives to be implemented during design and construction of the project to reduce carbon emissions, energy use and embodied life cycle impacts. A key target from the NSW Government Resource Efficiency Policy (OEH 2019e) is that a minimum of 6% of electricity purchased should be from renewable energy sources.

Sustainability focus area	Sustainability objective	Project consistency
Climate change resilience	Design and construct transport infrastructure to be resilient to climate change impacts	The design has considered sea level rise and storm intensity due to climate change. See **Chapter 17, Flooding and hydrology**. An assessment of climate change risk during both construction and operational phases of the project has been completed. See **Chapter 24, Hazard and risk**.
Air quality	Minimise the air quality impacts of road projects and support initiatives that aim to reduce transport-related air emissions	The project would result in lower pollutant concentrations on the existing Pacific Highway due to reduced traffic volumes using this road. The project would allow traffic to flow constantly, reducing the stop-start conditions which are worsened by the 12 sets of traffic signals and multiple property accesses. This would reduce transport-related air emissions. There would be some local increase in concentrations along the project, but it is not expected that this would result in any exceedance of air quality standards. See **Chapter 21, Air quality**.
Resource use and waste management	Minimise the use of non-renewable resources and minimise the quantity of waste disposed to landfill	During construction of the project, unnecessary resource consumption would be avoided by making accurate predictions of the required quantities of resources such as construction materials. The management of construction waste would include reuse, recycling, and reprocessing of waste, where possible. See **Chapter 22, Waste**.
Pollution control	Minimise noise, water and land pollution from road and maritime construction, operation and maintenance activities	A noise and vibration assessment has been prepared for the project to identify and mitigate potential noise impacts. See **Chapter 9, Noise and vibration**. An assessment of the project's potential impact on soil and water has been prepared. The project would also include measures for the abatement, avoidance and/or containment of pollution as detailed in **Chapter 18, Soils and contamination** and **Chapter 19, Surface water quality**.
Biodiversity	Improve outcomes for biodiversity by avoiding, mitigating or offsetting the potential impacts of road and maritime projects on plants, animals and their environments	A biodiversity assessment has been prepared for the project to identify and consider measures to avoid and minimise potential impacts on biodiversity. Project impacts would be managed in accordance with the mitigation and management measures detailed in **Chapter 10, Biodiversity**.
Heritage – Aboriginal and non-Aboriginal	Manage and conserve cultural heritage according to its heritage significance and contribute to the awareness of the past	Items of Aboriginal and non-Aboriginal heritage significance were identified early in the project design and assessment. Impacts on these items have been minimised, avoided and mitigated where practicable and management measures to be implemented throughout construction of the project have been provided. See **Chapter 15, Aboriginal cultural heritage** and **Chapter 16, Non-Aboriginal cultural heritage**.

Sustainability focus area	Sustainability objective	Project consistency
Liveable communities	Provide high quality urban design outcomes that contribute to the sustainability and liveability of communities in NSW	The project would contribute to reducing traffic on the existing road network and improve congestion issues in Coffs Harbour. See **Chapter 8, Traffic and transport**. The project would provide and facilitate improvements in pedestrian and cyclist connections, creating new active transport linkages and linking existing active transport networks with new connections. The project would also facilitate an improvement in the amenity of streetscapes by CHCC. Opportunities from this include increasing publicly accessible open space and future urban renewal. See **Chapter 8, Traffic and transport**, **Chapter 11, Urban design, landscape and visual amenity, Chapter 12, Land use and property** and **Chapter 14, Socio-economic**.
Sustainable procurement	Provide goods, services, materials and works for infrastructure development and maintenance projects that over their lifecycle deliver value for money and contribute to the environmental, social and economic wellbeing of the community	A project specific SMP and Infrastructure Sustainability (IS) Implementation Plan would be prepared to guide the implementation of sustainability throughout the design and construction phases, and to facilitate the achievement of an ISCA IS rating of 'Excellent'. See **Section 23.3.2.**
Corporate sustainability	Communicate sustainability objectives to employees, contractors and other key stakeholders, and foster a culture which encourages innovative thinking to address sustainability challenges.	The project specific SMP would be prepared to communicate sustainability objectives and foster a culture of sustainable thinking and innovation. Roads and Maritime would continue to communicate its sustainability objectives through consultation with stakeholders and the community. See **Chapter 7, Consultation.**

23.3 Project sustainability assessment

23.3.2 Infrastructure Sustainability Rating Scheme

The IS rating scheme was developed by and is administered by ISCA. The IS rating scheme is a comprehensive rating system for evaluating sustainability across the design, construction and operation of infrastructure. The IS rating scheme applies a point score across 15 sustainability themes, including water and energy use, materials, management, climate change, heritage, stakeholders, biodiversity and innovation. The ISCA themes and credits align with the proposed sustainability objectives and the policy framework for the project. Under the IS rating tool, points are achieved by providing verified evidence of performance, and totalled to achieve an overall project rating. The project would target IS Design and As-Built ratings of 'Excellent' under Version 1.2 of the tool.

23.3.3 Project assessment

Sustainability workshops and meetings were held during EIS and concept design development to assess and progress initiatives and targets to meet the IS Design and As-Built rating criteria. Opportunities to enhance sustainability during detailed design were also identified. Targets and actions were established to nominate sustainability commitments for implementation during detailed design, construction and operation. Targets and actions align with respective ISCA credits and the recommended sustainability objectives for the project. The Contractor would be responsible for ensuring that the project achieves an IS ‘Excellent’ rating. A project specific SMP would be prepared to guide the implementation of sustainability throughout the design and construction phases, and to facilitate the achievement of the IS rating.

A summary of the project’s consistency with the recommended project sustainability objectives and relevant NSW Government sustainability policies is outlined in **Table 23-3**.

Table 23-3 Project consistency with recommended project sustainability objectives and policy instruments

Recommended sustainability objectives	NSW Government's sustainability policies	Project consistency
Demonstrate sustainability leadership and continual improvement	• Future Transport 2056 Strategy (TfNSW 2018a) • NSW Government Resource Efficiency Policy (OEH 2014e) • NSW Sustainable Design Guidelines Version 4.0 (TfNSW 2017) • Transport Environment Sustainability Policy and Framework (TfNSW 2013c) • Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a)	• An IS rating of at least 'Excellent' would be targeted for the design and as built phases of the project, as nominated in the SMP for the project (see **Section 23.4**). The SMP for the project would drive the achievement of sustainability outcomes during the design and construction phases. The project contractor's systems would also be structured to support the achievement of an 'Excellent' rating • Risk and opportunity management is routinely undertaken on Roads and Maritime projects. The Contractor would establish systems for risk and opportunity management • The project would adopt organisational structures, roles and responsibilities that allow for regular review of sustainability issues on the project. The Contractor would undertake quarterly project progress reports during design and six-monthly project progress reports during construction. Annual reporting on sustainability issues would be undertaken during the design and construction phases • Sustainability would be embedded in management plans and auditing procedures as recommended by Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019) • Senior management meetings would periodically discuss and review sustainability performance. The Contractor would share responsibility for demonstrating public reporting and sharing information with community groups for the project • During the design and construction phases, processes to share knowledge and lessons learnt internally to the project and externally as relevant would be established • The business case for the project included a cost benefit analysis in its options assessment • Innovation opportunities have been investigated during the concept design phase for the project. Ongoing design would further consider innovation opportunities.

Recommended sustainability objectives	NSW Government's sustainability policies	Project consistency
Increase the sustainability of the project supply chain through consideration of whole of life environmental, social and economic impacts in procurement decision making	• Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a) • Transport Environment Sustainability Policy and Framework (TfNSW 2013c) • NSW Sustainable Development Guideline v4 (TfNSW 2017) • NSW Aboriginal Participation in Construction Policy (NSW Government 2018a).	• The SMP would be prepared to guide the implementation of sustainability throughout the design and construction phases, and to facilitate the achievement of an 'Excellent' rating (see **Section 23.4**). This would include incorporating sustainability criteria into project contracts and tender evaluation criteria to support the NSW Government requirements for sustainable procurement • The SMP would consider opportunities for Aboriginal and Torres Strait Islander participation and employment in accordance with the NSW Government Policy on Aboriginal Participation in Construction (NSW Government 2018a). It would consider diverse and inclusive workforce participation and local employment opportunities.
Increase resilience to the effects of climate change	• NSW Climate Change Policy Framework (OEH 2016a) • Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a)	• Potential climate change risks have been reviewed for the project to identify risks and adaptation opportunities to improve the project's resilience to future climate change. See **Chapter 24, Hazard and risk**. • Potential climate change impacts on the project, related to sea level rise and increased rainfall intensity, have been reviewed through flooding assessments. Further assessment during detailed design would confirm the requirements for any additional and/or refined design mitigation measures. The assessment would be undertaken in accordance with the Practical Considerations of Climate Change – Floodplain Risk Management Guideline (DECC 2007). See **Chapter 17, Flooding and hydrology**.
Minimise energy use and reduce greenhouse gas emissions	• Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a) • NSW Government Resource Efficiency Policy (OEH 2014e) • NSW Sustainable Development Guideline v4 (TfNSW 2017)	• An energy efficiency and greenhouse gas emissions strategy would be prepared as part of the SMP (see **Section 23.4**). The strategy would identify initiatives to be implemented during design and construction of the project to reduce carbon emissions, energy use and embodied life cycle impacts • The project would use energy efficient equipment where fit for purpose for construction activities (see **Section 23.4**).

Recommended sustainability objectives	NSW Government's sustainability policies	Project consistency
Minimise water consumption	• Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a) • NSW Sustainable Development Guideline v4 (TfNSW 2017)	• Water efficiency would be achieved through water savings initiatives, water recycling and reuse, and maintaining a focus on monitoring and reporting of water consumption during construction (Roads and Maritime Services 2019). • The use of non-potable water over potable water would be prioritised during construction (Roads and Maritime Services 2019). See **Chapter 22, Waste**.
Optimise resource efficiency and reduce resource consumption of construction materials	• Roads and Maritime Services Environmental Sustainability Strategy 2019 – 2023 (Roads and Maritime Services 2019a) • NSW Government Resource Efficiency Policy (OEH 2014e) • NSW Sustainable Development Guideline v4 (TfNSW 2017)	The project would assess the following options during detailed design and construction: • Consideration of locally sourced materials • Prioritisation of prefabricated assets where possible • Avoiding unnecessary resource consumption during construction by making accurate predictions of the required quantities of resources • Maximising the use of resources with low environmental impact • Minimising the use of non-renewable resources • Requiring certified products in project delivery contracts.
Minimise noise, vibration, light, water and land pollution from construction, operational and maintenance activities	• Roads and Maritime Services Environmental Sustainability Strategy 2019 – 2023 (Roads and Maritime Services 2019a)	• Construction activities would be managed in line with the mitigation measures outlined in the EIS to avoid impacts to surface water quality, air quality, and impacts to surrounding sensitive receivers in terms of noise and vibration and light pollution (see **Chapter 18, Surface water quality**; **Chapter 21, Air quality**, **Chapter 9, Noise and vibration** and **Chapter 11, Urban design, landscape and visual amenity**).

Recommended sustainability objectives	NSW Government's sustainability policies	Project consistency
Minimise the project's impact on current and future land use and value	• Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a)	• Sustainability related aspects of land use and assessment would be addressed during detailed design. **Chapter 22, Waste** provides further detail on reuse options • The project has undertaken an assessment of current and future land use in **Chapter 12, Land use and property** • **Chapter 18, Soils and contamination** provides an assessment of soil quality. However, further investigation is required to determine whether soil quality would require improvement for reuse on-site • A flood assessment has been undertaken for the project (see **Chapter 17, Flooding and hydrology**) which considers potential impacts on adjacent urban release areas • A traffic and transport assessment has been undertaken for the project (see **Chapter 8, Traffic and transport**) which considers potential access impacts on nearby urban release areas within the Coffs Harbour LGA.
Reduce waste generation and divert waste from landfill	• NSW Government Resource Efficiency Policy (OEH 2014e) • NSW Waste Avoidance and Resource Recovery Strategy 2014 – 2021 (EPA 2014a) • Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a) • NSW Sustainable Development Guideline v4 (TfNSW 2017)	• The project would seek to reuse or recycle excess materials through preparation and implementation of the Waste Management Plan (see **Chapter 22, Waste**) • The material balance for the site would be confirmed during detailed design. Beneficial reuse of spoil would be the preferred approach to managing any excess materials however further assessment would be required to confirm feasibility (see **Chapter 18, Soils and contamination** and **Chapter 22, Waste**).

Recommended sustainability objectives	NSW Government's sustainability policies	Project consistency
Protect the natural environment	• Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a) • NSW Sustainable Development Guideline v4 (TfNSW 2017)	• Construction activities would be managed in line with the mitigation measures outlined in the EIS to avoid and/or minimise impacts to biodiversity (see **Chapter 10, Biodiversity**) • A biodiversity assessment report has been prepared in accordance with the Framework for Biodiversity Assessment (OEH 2014a) and the NSW Biodiversity Offset Policy for Major Projects (OEH 2014b). The biodiversity assessment report outlines measures to avoid and/or minimise impacts on biodiversity (see **Appendix H, Biodiversity assessment report**). Development of detailed design would target further avoidance or minimisation of potential impacts to biodiversity values.
Contribute to liveable communities (ease congestion, connect communities, integrate land use and transport planning and facilitate urban revitalisation through high quality urban design outcomes)	• Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a) • Future Transport 2056 Strategy (TfNSW 2018a) • NSW Sustainable Development Guideline v4 (TfNSW 2017)	• The project would contribute to reducing traffic on the existing road network and improve congestion issues in Coffs Harbour, resulting in a reduction in travel times. This would improve amenity within Coffs Harbour CBD. There would also be air quality benefits to the Coffs Harbour CBD by reducing heavy vehicle traffic (see **Chapter 11, Urban design, landscape and visual amenity, Chapter 21, Air quality** and **Chapter 14, Socio-economic**) • The project is intended to improve road safety and incorporate appropriate design measures to improve safety and the built environment (see **Chapter 8, Traffic and transport** and **Chapter 11, Urban design, landscape and visual amenity**) • Urban design and landscaping plans have been developed for the project (see **Chapter 11, Urban design, landscape and visual amenity**).
Ensure cultural heritage is conserved and managed according to its heritage significance and that it contributes positively to awareness of the past	• Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a)	• Construction activities would be managed in line with the mitigation measures outlined in the EIS to manage impacts to local heritage (see **Chapter 15, Aboriginal cultural heritage** and **Chapter 16, Non-Aboriginal cultural heritage**) • Detailed design would include consideration of heritage values, to further avoid or minimise potential impacts.

Recommended sustainability objectives	NSW Government's sustainability policies	Project consistency
Engage with the community and stakeholders to better understand the real and perceived impacts and benefits of the project and to build a culture of sustainable thinking	• Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019a)	• The project has commenced engagement with stakeholders and the community and has committed to ongoing engagement to understand actual and/or perceived impacts and benefits of the project and to communicate sustainable objectives (see **Chapter 7, Consultation**).

23.4 Environmental management measures

To document the project's sustainability objectives and targets and allow them to be considered throughout design, a SMP would be prepared and implemented. The SMP would integrate all sustainability considerations such as the vision, policy requirements, project objectives and targets through the establishment of governance structures, processes and systems during the detailed design and construction phases of the project. During the detailed design, it would be the responsibility of the Contractor to further develop and implement the SMP.

The SMP principles would be embedded within all management disciplines and the Contractor's project team throughout each stage of the project, from detailed design and construction through to operation. This would allow for the consideration of environmental, social and economic costs and benefits in the decision-making process over the whole life of the project.

The SMP would be a component of the integrated management system for implementation on the project. This Plan would be regularly reviewed to reflect design refinement and sustainability initiatives through each of the project phases.

Table 23-4 outlines the recommended sustainability management commitment for the project.

Table 23-4 Environmental management measures for sustainability

Impact	ID No.	Environmental management measure	Responsibility	Timing
Sustainability	S01	A SMP will be developed to establish governance structures, processes and systems that ensure integration of all sustainability considerations (vision, commitments, principles, objectives and targets), initiatives, monitoring and reporting during the detailed design and construction phases of the project. The SMP will include commitments detailed in **Table 23-3** including but not limited to: • Key sustainability management roles and responsibilities • Targets for diverse and inclusive workforce participation and local employment opportunities • An energy efficiency and greenhouse gas emissions strategy • A sustainable procurement strategy • Water savings initiatives • Monitoring and reporting requirements for sustainability initiatives and performance.	Contractor	Detailed design, construction and operation

Chapter 24

Hazard and risk

24. Hazard and risk

This chapter presents an assessment of the impacts of the project on hazards and risks and identifies mitigation measures to minimise and reduce these issues. The hazard and risk assessment for this project will inform the detailed design, construction and operational phase to avoid, to the greatest extent possible, risk to public safety and the environment and is resilience to the future impacts of climate change.

Table 24-1 lists the SEARs relevant to hazard and risk and where they are addressed in this chapter and the EIS.

Table 24-1 SEARs relevant to hazard and risk

Ref	Key Issue SEARs	Where addressed
16. Safety and risk		
1.	The proponent must assess the likely risks of the project to public safety, paying particular attention to: • Pedestrian safety • Subsidence risks • Bushfire risks • Storage, handling and use of dangerous goods.	**Section 24.3** **Chapter 8, Traffic and transport**
2.	The proponent must assess the risk and vulnerability of the project to climate change in accordance with the current guidelines.	**Sections 24.3** **Chapter 17, Flooding and hydrology**
3.	The proponent must assess the bio-security risk of the project to minimise the inadvertent spread of disease and pathogens affecting horticultural activities, vegetation and threatened fauna.	**Chapter 10, Biodiversity** **Chapter 13, Agriculture** **Chapter 18, Soils and contamination**

24.1 Assessment methodology

24.1.1 Bushfire risk

The assessment of bushfire risk for the project involved a desktop review of spatial datasets and available literature, including:

- NSW Bushfire Prone Land Map Tool (NSW Rural Fire Service 2016)
- Guide for Bushfire Prone Mapping Version 5b (NSW Rural Fire Service 2017)
- Climate data for Coffs Harbour (BoM 2018a)
- Draft Bushfire Risk Management Plan (MNCBMC 2017)
- Fine-scale vegetation map for the Coffs Harbour Local Government Area (OEH 2012)
- Ground-truthed plant community types mapped for the project.

The NSW Bushfire Prone Land Map Tool was reviewed to identify where the project corridor intersects bushfire prone lands. Existing land uses, based on spatial data and aerial photography, were also assessed to determine the potential bushfire risk on properties.

Consultation with NSW Rural Fire Service (RFS) was carried out on 15 June 2018 to obtain background information on past bushfires in and around the project, key risks and design considerations requiring further assessment, such as connections with fire trail networks and firebreaks.

24.1.2 Dangerous goods

Under current standards, vehicles carrying dangerous goods cannot travel through tunnels.

In order to understand the risk to the project arising from vehicles carrying dangerous goods, an assessment was carried out by the project team, with some elements of this assessment ongoing.

The assessment of dangerous goods risk for the project involves the following:

- A desktop review to identify potentially dangerous and hazardous goods required during construction and operation of the project and assessment of risks associated with their handling, storage and use
- An ongoing comparative dangerous goods risk assessment to assess and compare the risk associated with dangerous goods vehicles travelling along the project compared to the existing Pacific Highway. The assessment is focussed on the life safety risk of the affected population (eg road users, people located in adjacent residential and commercial areas and maintenance personnel) from exposure to hazardous materials due to an event involving a dangerous goods vehicle
- The risks to roads users and the public arising from a fire and/or explosion involving a vehicle carrying dangerous goods in the confined space of a road tunnel
- The assessment includes:
  - Traffic surveys to understand frequency of dangerous goods vehicles on the existing Pacific Highway
  - Risk assessment using the Quantitative Risk Assessment Model to assess the likelihood of a dangerous goods event occurring for the project or existing Pacific Highway. An event is defined as the likelihood of a dangerous goods vehicle crash leading to people being exposed to hazardous materials
  - Ongoing consultation with EPA, SafeWork NSW and FRNSW.

Dangerous goods transport legislative framework

The Australian Code for the Transport of Dangerous Goods by Road & Rail (National Transport Commission, 2017) sets out detailed technical specifications, requirements and recommendations applicable to the transport of dangerous goods in Australia by road and rail. Each state and territory implement the Code and associated updates to their dangerous goods transport legislation and regulations separately.

Substances (including mixtures and solutions) and articles subject to the Code are assigned to one of nine classes according to the hazard or the most predominant of the hazards they present.

The relevant legislation in NSW for the transport of dangerous goods are:

- *Dangerous Goods (Road and Rail Transport) Act 2008*
- Dangerous Goods (Road and Rail Transport) Regulation 2014.

Under the *Dangerous Goods (Road and Rail Transport) Act 2008*:

- SafeWork NSW and EPA are both Competent Authorities for Classes 2-9, excluding Class 7
- SafeWork NSW takes responsibility for premises-based activities such as packaging, classification and labelling
- EPA takes responsibility for transport-related activities such as licensing and vehicle inspections

Under the NSW *Explosives Act 2003*, SafeWork NSW is the regulator for all activities involving Class 1. The main authority for Class 7 is the Australian Radiation Protection and Nuclear Safety Agency.

Dangerous goods policy development

The carriage of dangerous goods in road tunnels is the subject of national policy development through Austroads. TfNSW and Roads and Maritime are directly involved in this process and projects which involve the construction of road tunnels, such as the Coffs Harbour Bypass, are being considered in the policy development process.

24.1.3 Climate change

The assessment of risk and vulnerability of the project to climate change has been informed by the assessments in **Chapter 19, Surface water quality** and **Chapter 21, Air quality** and consideration of the following policies and guidelines:

- AS 5334:2013 Climate change adaptation for settlements and infrastructure – a risk-based approach (Standards Australia 2013)
- TfNSW Climate Risk Assessment Guidelines (TfNSW 2016a)
- CSIRO’s Climate Change in Australia Projections Cluster Report – East Coast (CSIRO & BoM 2015)
- Australian Government’s Climate Change Impacts and Risk management – A guide for business and government (DEH 2006)
- North Coast NSW Climate Change Snapshot (OEH 2014b).

Chapter 17, Flooding and hydrology has assessed potential impacts from the project on flood behaviour, considering sea level rise and storm intensity due to climate change.

24.1.4 Subsidence risk

The risk of subsidence (surface settlement) for the project is only considered relevant at the three tunnel locations. The two potential causes of subsidence at the tunnels could be due to:

- Soil consolidation (soil shrinkage) due to groundwater drawdown – discussed in **Chapter 20, Groundwater**
- Tunnelling through the major ridges.

The potential for surface settlement impacts arising from tunnelling through the major ridges was assessed as part of the Coffs Harbour Bypass Tunnels – Surface Settlement Impact Assessment (Aurecon 2019) which involved:

- A desktop review of the nearby buildings (both residential and commercial) which could be affected by subsidence from construction and operation
- Consideration of geotechnical investigations and interpretive reports undertaken for the project
- Assessment of the settlement impacts on the existing access roads above the three tunnels including modelling of the staged excavation and lining installation of the tunnel profile; analysis of the final and total settlement contours; and associated settlement impact assessment.

24.2 Existing environment

24.2.1 Bushfire risk

Bushfire season for the Coffs Harbour region is typically from August to December with most fires a result of arson, irresponsible or illegal burning off, lightning strikes and car dumping (MNCBMC 2017).

The project is located in areas defined as a bushfire prone area in bushfire mapping prepared by RFS (RFS 2018). The RFS maps areas of bushfire risk based on vegetation type. There are currently two vegetation categories determining risk of bushfire:

- **Category 1** – highest risk for bushfire, due to high combustibility and likelihood of forming fully developed fires
- **Category 2** – lower risk of bushfire due to lower combustibility and potential for forming fully developed fires.

Areas of Category 1 vegetation are associated with riparian areas surrounding creeks (such as Boambee Creek and Newports Creek) as well as the vegetated areas east of Boambee State Forest; south of Ulidarra National Park and near Kororo Nature Reserve.

Category 2 vegetation is predominately in the northern part of the project, south of Coramba Road, north and south of Treefern Creek, south of Ulidarra National Park, and where the project ties in with the existing Pacific Highway at Korora.

Each category is surrounded by a buffer zone (100 m for Category 1 and 30 m for Category 2). These buffer zones are also considered to be bushfire prone land. **Figure 24-1** provides the areas of bushfire risk categories in relation to the project.

Advice from the RFS indicated an historical pattern of fires/ignitions to the west of Roberts Hill, associated with the McCanns Fire Trail which runs along the crest of Roberts Hill ridge to the west (see **Figure 24-1**). The McCanns Fire Trail is identified in the RFS Draft Fire Trail and Fire Access Plan [n.d.] and is the only fire trail close to the project. However, the RFS advised they do not plan to maintain this trail. There are currently no Strategic Fire Advantage Zones in the vicinity of the project and RFS does not undertake any regular controlled or prescribed burning in this area to reduce the amount of ground vegetation.

Coffs Harbour Bypass
Bushfire risk (NSW Rural Fire Service)
Figure 24-1

24.2.2 Dangerous goods risk

Storage, handling and use of dangerous goods

The Australian Dangerous Goods Code lists all dangerous goods and notes their classification. Each of the dangerous goods are assigned a specific United Nations number and are divided into classes, based on their predominant hazard.

Based on typical construction methods and maintenance requirements for similar projects, the dangerous and hazardous goods listed in **Table 24-2** would potentially be used during construction and operation of the project.

Table 24-2 Dangerous goods and hazardous substances likely to be stored and/or transported during construction and operation

Dangerous goods	Hazardous substances
• Explosives • Distillate fuel • Petrol • Oils, grease and lubricants • Additives (eg plasticizers and preservatives) • Gases (eg oxygen and acetylene) • Asbestos • Bitumen	• Cement • Fly ash • Paints • Epoxies • Solvents and thinners • Lime

Transportation of dangerous goods

The transport of dangerous goods is critical to modern day society. Although several options are available, the most common approach is transport via road. However, transport on the road network can be contentious, especially when transport involves sensitive infrastructure such as bridges and tunnels (Austroads 2019).

The tables below provide results from traffic surveys undertaken as part of the comparative dangerous goods risk assessment. **Table 24-3** provides results from a survey undertaken between 19 September 2018 to 28 September 2018. The survey recorded number of vehicles per day that used the existing Pacific Highway at two locations:

- South of Coffs Harbour CBD (about 200 m south of the Pacific Highway/Englands Road intersection)
- North of Coffs Harbour CBD (adjacent to the Big Banana Fun Park, near the Pacific Highway/Diggers Beach Road intersection).

Table 24-3 Average daily traffic volume from 2018 survey

	South of Coffs Harbour CBD	North of Coffs Harbour CBD
Average daily traffic volumes	33,412	36,440

Table 24-4 provides results from a survey carried out in 2019 that focussed on dangerous goods vehicles over a 24-hour period 26 March 2019. The survey was undertaken at the same location as the 2018 survey.

Table 24-4 Dangerous goods 2019 traffic survey

Dangerous goods classes	South of Coffs Harbour CBD	North of Coffs Harbour CBD
1 Explosive substances and articles	0	0
2.1 Flammable gases	17	15
2.2 Non-flammable, non-toxic gases	5	2
2.3 Toxic gases	0	0
3 Flammable liquids	13	17
4.3 Substances which, in contact with water, emit flammable and/or toxic gases	0	1
5.1 Oxidizing substances	1	2
6 Toxic and infectious substances	1	1
7 Radioactive material	0	0
8 Corrosive substances	3	4
9 Miscellaneous dangerous substances and articles	9	3
Mixed load	14	24
Total	**63**	**69**

Due to the period it was carried out over, the 2019 survey may not reflect some fluctuations in the weekly cycle of distribution/delivery of dangerous goods. It is also unlikely to capture seasonal fluctuations such as may be required by the agricultural industry. However, taking the figures from **Table 24-4** and dividing through the average daily traffic volumes from the 2018 survey it can be determined that dangerous goods vehicles make up around 0.19 per cent of all vehicles for Coffs Harbour.

It should be noted that Coffs Harbour itself is a destination for dangerous goods deliveries such as Class 2.1 (flammable gases) and Class 3 (flammable liquids). Therefore, during operation of the project, a significant number of dangerous goods vehicles would continue to use the existing Pacific Highway in order to service customers in the Coffs Harbour CBD.

24.2.3 Climate conditions

Climate change is a well-recognised issue occurring on a global scale, with specific trends in certain regions, as outlined by the Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report (AR5) (IPCC 2014). In recognition of the impact of climate change on the management of Australia's natural resources, the Australian Government developed the Regional Natural Resource Management Planning for Climate Change Fund (CSIRO & BoM 2015), which has facilitated the preparation of the Climate Change in Australia Projections Cluster Reports (CSIRO & BoM 2015).

The East Coast Cluster Report outlines two climate change projection periods: 2030 and 2090. **Table 24-5** details the climate change trends for the East Coast region. The East Coast region includes six coastal

Natural Resource Management regions from Queensland (Fitzroy, Burnett Mary and South East Queensland) and NSW (formerly Northern Rivers, Hunter-Central Rivers and Hawkesbury-Nepean).

Table 24-5 East Coast Cluster Report predicted change in climate projections

Trend	2030	2090
Higher temperatures	Mean warming is around 0.4 to 1.3° above the 1986–2005 levels	Mean warming is between 1.3 and 4.7°C
Hotter and more frequent hot days, less frost:	An increase in the frequency of hot days and duration of hot spells and corresponding decrease in frequency of frost risk days by 2090.	
Less rainfall in winter in the south	Decrease in winter rainfall is projected	
Increased intensity of heavy rainfall events	The intensity of heavy rainfall events would increase. However, the magnitude of change and the time when any change may be evident against natural variability cannot be reliably predicted.	
Some decrease in winter wind speed, and fewer east coast lows	Wind speed in winter is expected to decrease (associated with a southward shift of storms). Tropical cyclones are projected to become less frequent but there would be increases in the proportion of intense storms.	
Little change in solar radiation and reduced humidity throughout the year	• Little change in projected solar radiation • Little change in relative humidity	• Little change in projected solar radiation • Potential decrease of -3.5 to 1.9 % of relative humidity
Increased evaporation rates and reduced soil moisture	Potential increases in evapotranspiration rates in all seasons by 2090, however, soil moisture projections and runoff are less certain.	
A harsher fire-weather climate in the future:	Harsher fire-weather climate in the future. However, the magnitude of change is uncertain.	
Higher sea levels and more frequent sea level extremes	Range of sea level rise is 0.08–0.18 m above the 1986–2005 level	Rise of 0.30–0.88 m is expected.
Warmer and more acidic oceans in the future	pH is projected to fall by up to 0.08 units in the coastal waters.	Decreases in pH of up to 0.14 are projected.

The CSIRO predicts, with very high confidence, that mean sea level will continue to rise and the height of extreme sea-level events will also increase (CSIRO 2015). The CSIRO predicts average rainfall will decrease and that wet years will become less frequent. Despite this they also predict, with high confidence, that intense rainfall events will become more frequent and extreme, while the magnitude of the increases cannot be confidently projected (CSIRO 2015).

The Coffs Harbour Coastal Zone Management Plan Final Report (BMT WBM Pty Ltd 2018) and coastal inundation risks maps for 2050 and 2100 planning horizons prepared for CHCC, show the likely extents of sea level rises for the Coffs Harbour LGA. The main risk area for the project is around the Englands Road interchange. An area in the Isles Drive industrial estate (north of the project) experiences low to high risks of inundation in the 2050 and 2100 planning horizons.

24.2.4 Ground conditions and subsidence

Subsidence is the excessive movement of the ground caused by soil compressing under weight, and soil swelling and contracting due to changes in the moisture content. The main causes of subsidence in Australia are mining, groundwater extraction, and improper ground preparation.

The main subsidence risks for the project are from excavations associated with the tunnels and groundwater drawdown. The project is not located within a mine subsidence district as administered by Subsidence Advisory NSW and subsidence from improper ground preparation is considered negligible for the project.

The project is situated within the New England Orogen in eastern Australia. The Dorrigo – Coffs Harbour 1:250,000 scale Metallogenic Map (Gillian et al. 1992) indicates the project is underlain by two geological rock units, the Carboniferous aged Coramba Beds and the Brooklana Formation of the Coffs Harbour sequence (refer to **Chapter 20, Groundwater** and **Appendix N, Groundwater assessment** for further information on the extents of bedrock geology). The mapped Coramba Beds extend beyond the southern end of the project to just north of the North Coast Rail Line; north of this point the project is underlain by the Brooklana Formation. Given the high stiffness of the bedrock, the extent and magnitude of subsidence occurring within the rock mass surrounding cuttings and tunnels is anticipated to be small.

The existing groundwater environment and risk to the project is described in **Chapter 20, Groundwater**.

24.3 Assessment of potential impacts

24.3.1 Construction impacts

Bushfire risk

Construction works may increase risk of bushfire from accidental ignition from construction equipment, fuels and chemicals. The clearing of vegetation within the construction footprint would assist with providing a fire break and reduce the potential risk.

Should a bushfire incident occur during construction, there may be delays to emergency services reaching their destination because of changed road conditions. Similarly, the changed road conditions may impact residents evacuating a bushfire area. During construction of the tunnel at Roberts Hill, McCanns Trail may be temporarily closed during certain times, eg during blasting or utility adjustments. Appropriate management measures including staging of construction activities, signposting and advertising detours and changed road conditions would be implemented to minimise this risk.

Dangerous goods risk

The storage and handling of dangerous goods and hazardous materials have the potential to impact the surrounding community and environment if leaks and spills occur, resulting in the potential contamination of air, soils, surface water and/or groundwater.

During construction, dangerous goods and hazardous substances are likely to be transported to and from the construction site. Consideration of these movements would be included in the development of a Traffic Management Plan for the project.

During construction, dangerous goods or hazardous substances would be stored within the site compounds identified within **Chapter 6, Construction**. Storage of dangerous goods would be in accordance with the manufacturers' requirements and EPA guidelines, including NSW Government Storage and Handling of Dangerous Goods Code of Practice (NSW Government 2005b). Hazardous substances would be handled, stored and processed in accordance with the Hazardous waste storage and processing: Guidance for the liquid waste industry (EPA 2016a). Procedures would be developed as part of the CEMP to ensure correct handling and storage of dangerous goods and hazardous substances and that contingency measures are in place.

Climate change risk

During construction, climate change could affect the project by:

- Seasonal water shortages for construction
- Increased dust generation during drier weather
- Increased construction delays due to high intensity rainfall
- Increased rainfall resulting in increased flow events in watercourses, temporary flooding and risk of failure of erosion and sediment controls
- Increased erosion and sediment loss from construction areas
- Increased fire risk during severe fire weather
- Reduced work capacity from extreme weather events and increased risk of heat stress for workers.

Impacts from the above issues have been considered within the EIS and various technical assessments, eg dust impacts in **Chapter 21, Air quality**, erosion and sedimentation in **Chapter 18, Soils and contamination** and flooding in **Chapter 17, Flooding and hydrology**. It is anticipated that potential impacts would be managed through the application of environmental management measures detailed in **Chapter 26, Summary of environmental management measures**.

Subsidence risk

As described in **Chapter 5, Project description**, twin tunnels are proposed to cross the three major ridges. The depth of rock above these tunnels is provided below:

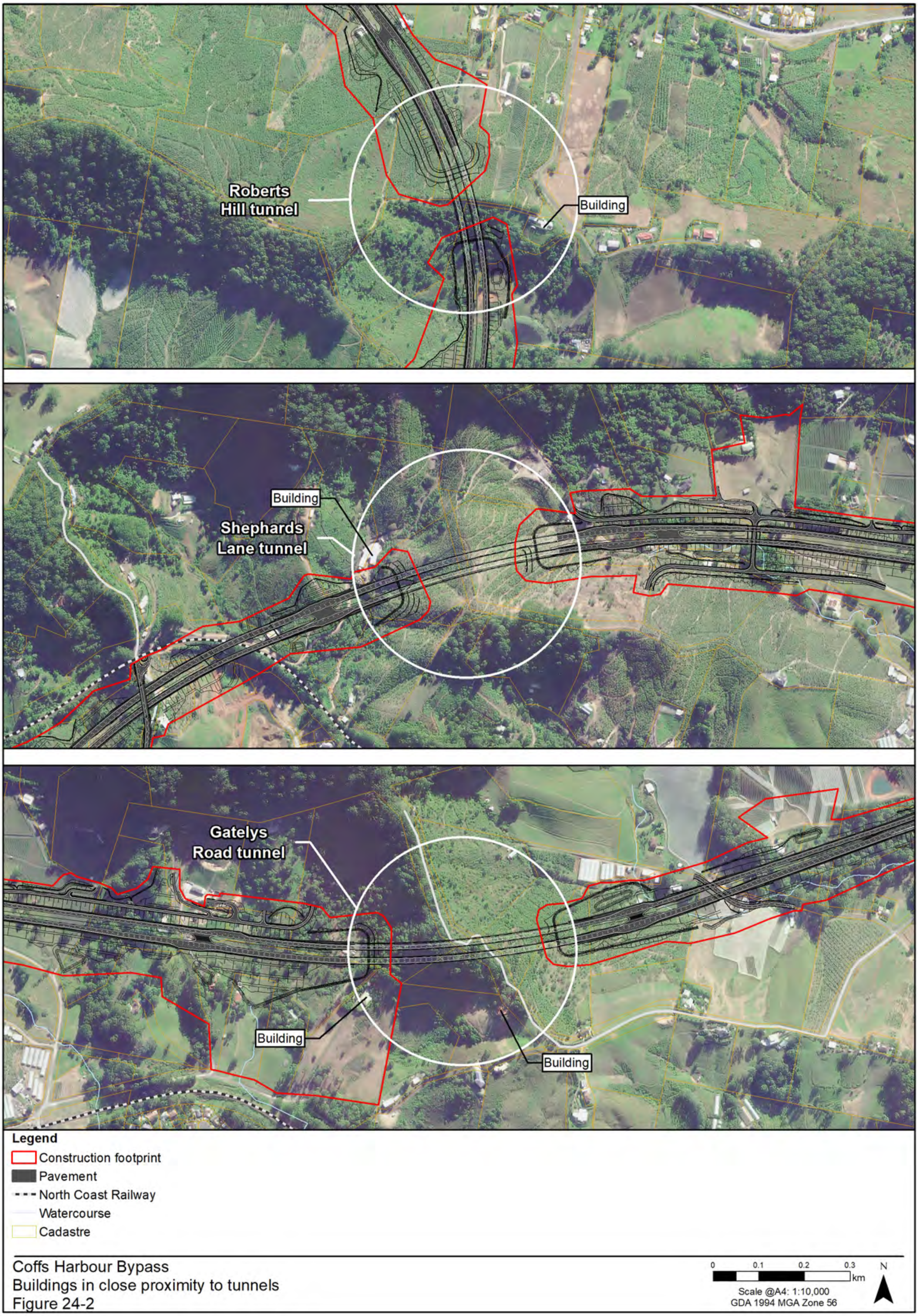
- Roberts Hill tunnel – the depth of rock above the tunnel varies from about five metres at the tunnel portal to a maximum depth of 32 m to existing ground surface
- Shephards Lane tunnel – the depth of rock above the tunnel varies from about five metres at the tunnel portal to a maximum depth of 55 m to existing ground surface
- Gatelys Road tunnel – the depth of rock above the tunnel varies from about five metres at the tunnel portal to a maximum depth of 67 m to existing ground surface.

There are a number of buildings in close proximity to the tunnels (outside of the construction footprint) that may be impacted by subsidence from construction of the tunnels (see **Figure 24-2**). These buildings include:

- One residential building east located on the ridgeline east of Roberts Hill tunnel
- One commercial building north of the southern portal of Shephards Lane tunnel
- One residential building immediately south of the southern portal of Gatelys Road tunnel and another residential building located on the ridgeline south of the tunnel.

As shown in **Figure 24-2**, buildings are typically located to one side of the tunnel portal and/or tunnel alignment.

Results from the subsidence modelling show that settlement impacts would be minimal and typically in the range below six millimetres. These settlement magnitudes would be difficult to pick up by survey since they can easily be absorbed by the survey noise which is typically in the range of +/-5 mm. Surface settlement towards the portal would increase with decreasing rock cover. However, as the buildings identified above are located outside the zone of influence (ie not located above the tunnel portal and/or tunnel alignment), settlement impacts are expected to be negligible.



Coffs Harbour Bypass
Buildings in close proximity to tunnels
Figure 24-2

24.3.2 Operational impacts

Bushfire risk

Bushfires may occur as a result of car accidents or littering (eg cigarette butts). However, landscape treatments would be appropriately designed along the road corridor to reduce this potential fuel risk, including use of low combustibility vegetation and regular maintenance (through slashing).

There is potential for fire regimes to change following the project as a result of vegetation clearing and the project effectively creating a firebreak in some locations. This may reduce the incidence of natural bushfires. The nature life cycle of populations of existing native vegetation rely on naturally occurring bushfires as part of their regeneration process. It is considered unlikely that the project would significantly impact the life cycle of populations of existing native vegetation in this regard.

The clearing of vegetation as part of the project would result in a reduced risk of bushfires to residential areas located to the east of the project. With vegetated areas (ie Boambee State Forest, Ulidarra National Park, Orara East State Forest), located to the north and west of the Coffs Harbour region, the road corridor would create an additional buffer, thus reducing the potential spread of bushfires into populated areas. In the case of a bushfire, sections of the Pacific Highway (including the project) may be closed for safety. The existing Pacific Highway through Coffs Harbour CBD (which would no longer be classified as Pacific Highway following opening of the project) would potentially provide an alternate route and allow for traffic to continue travelling.

While RFS has advised that they would not seek maintenance of McCanns Trail along the top of Roberts Hill ridge, access would not be impacted by the operation of the project.

Dangerous goods risk

Design investigations have included a dangerous goods risk assessment, some elements of which are ongoing. Under current standards, vehicles carrying dangerous goods, particularly Classes 1 and 2.1, would not be able to travel on the project.

Both the St Helena Tunnel on the Pacific Highway at Ewingsdale and the Tugun Bypass tunnel exclude Class 1 (explosive substances and articles) and Class 2.1 dangerous goods (flammable gases). The Tugun Bypass tunnel also excludes mixed loads, ie more than one class of dangerous goods carried on the one vehicle not including Class 1 and Class 2.1. The determination to allow these goods to be transported through both St Helena and Tugun Bypass tunnels followed a comprehensive risk assessment process carried out during the respective project development phases.

The comparative risk assessment process for Coffs Harbour Bypass is ongoing and is being undertaken in consultation with the NSW Dangerous Goods Competent Authorities (EPA, SafeWork NSW) and FRNSW to determine what classes of dangerous goods may be able to be carried on the project. However, it is noted that some dangerous goods vehicles would continue to use the existing Pacific Highway to service the Coffs Harbour CBD.

Climate change risk

During operation, potential impacts from climate change include:

- Increased temperature resulting in potential damage (shortened useful life) to infrastructure
- Increased frequency and severity of extreme rainfall events resulting in damage to infrastructure and/or overtopping of drainage infrastructure
- Increased frequency and severity of extreme storm, hail and wind events leading to debris, fallen trees and branches impacting infrastructure and road users
- Rise in sea level resulting in increased levels in tidal creeks downstream of the project
- Potential decreased diversity of vegetation communities and structural integrity along the project

- Change in the distribution of pests and disease along the project contributing to a greater biosecurity risk across the region
- Potentially increased fire risk during severe fire weather resulting in a threat to life and property.

During operation, routine inspections as part of the Roads and Maritime maintenance program would be carried out to ensure any of the above issues are identified and appropriately managed. In addition, climate change resilience recommendations detailed in Roads and Maritime Services Environmental Sustainability Strategy 2019-2023 (Roads and Maritime Services 2019) will guide future phases of the project.

Potential impacts from climate change have been modelled as part of **Appendix O, Flooding and hydrology** assessment. In conjunction with sea level rise, a sensitivity assessment of the 1 per cent AEP event was undertaken to include a 10 per cent and 30 per cent increase in rainfall for 2050 and 2100 scenarios:

- 2050 climate: 0.4 m sea level rise and 10 per cent increase in rainfall intensity
- 2100 climate: 0.9 m sea level rise and 30 per cent increase in rainfall intensity.

Refer to **Chapter 17, Flooding and hydrology** for further details and impacts from the above modelled scenarios on the project.

Subsidence risk

The potential risk associated with tunnel induced subsidence would only occur during the construction phase and no impacts are anticipated to occur during operation of the project.

24.4 Environmental management measures

Hazard and risk impacts have been identified during construction and operational phases of the project. There are interactions between the mitigation measures for hazard and risk and **Chapter 10, Biodiversity, Chapter 17, Flooding and hydrology, Chapter 18, Soils and contamination** and **Chapter 20, Groundwater**. Expected impacts, environmental management measures, responsibilities and timing have been summarised in **Table 24-6**.

Table 24-6 Environmental management measures for hazard and risk impacts

Impact	ID No.	Environmental management measure	Responsibility	Timing
Climate change – risk treatments	HZ01	Hydrological and hydraulic assessments undertaken during detailed design would consider the climate change related flood risks to the project and flood impacts from the project. The assessment would confirm the requirements for any additional management measures. The assessment would be undertaken in accordance with the Practical Considerations of Climate Change – Floodplain Risk Management Guideline (DECC 2007).	Contractor	Detailed design
Emergency access	HZ02	Consultation with emergency services, including the RFS and Fire and Rescue NSW would be undertaken during construction to ensure emergency access is maintained during and after construction.	Contractor	Detailed design and during construction
Bushfire risk	HZ03	The CEMP would include a Bushfire Management Plan prepared in accordance with the Planning for Bush Fire Protection 2006 (Rural Fire Service 2006).	Contractor	Prior to and during construction

Impact	ID No.	Environmental management measure	Responsibility	Timing
		Measures to be implemented to manage bushfire risk include: • Consultation requirements for community notifications in the event of a bushfire • Maintaining equipment in good working order • Ensuring plant and equipment are fitted with appropriate spark arrestors, where practicable • Ensuring site workers are informed of the site rules including designated smoking areas and putting rubbish in designated bins • Obtaining hot work permits and implementing total fire bans as required • Implementing adequate storage and handling requirements for potentially flammable substances in accordance with the relevant guidelines.		
Hazardous material storage	HZ04	All fuels, chemicals and other hazardous materials will be stored in a roofed, fire-protected and impervious bunded area at least 50 m from waterways, drainage lines, basins, flood-affected areas or slopes above 10%. Bunding design will comply with relevant Australian Standards and should generally be in accordance with guidelines provided in the EPA Authorised Officers Manual. Appropriate on-site signage will be provided to identify the materials stored.	Contractor	During construction
Spills and accidents	HZ05	Appropriate spill containment equipment will be provided on-site and located at strategic, accessible locations.	Contractor	During construction
Subsidence	HZ06	A surface settlement monitoring program will be prepared and implemented prior to and during construction to identify whether the project is resulting in adverse subsidence impacts. In the unlikely event that subsidence as a result of the project is deemed to cause building and/or property damage, the damage would be repaired at no cost to the owner.	Contractor	Prior to and during construction
Transportation of dangerous goods	HZ07	Consultation with EPA, SafeWork NSW and FRNSW will continue to confirm if the project would be able to accept any classes of dangerous goods during operation. To support the consultation, an absolute risk assessment will be carried out with the purpose to demonstrate that risks have been reduced so far as is reasonably practical. The absolute risk assessment will also consider appropriate infrastructure design and operational mitigation measures to reduce risk and the consequence of any event occurring.	Roads and Maritime	Detailed design

Chapter 25

Cumulative impacts

Chapter 17
Chapter 18
Chapter 19
Chapter 20
Chapter 21
Chapter 22
Chapter 23
Chapter 24
Chapter 25

25. Cumulative impacts

Cumulative impacts are incremental environmental and community impacts caused by past, present or reasonably foreseeable future activities. When considered in isolation, the environmental impacts of any single project upon any single receiver or resource may not be significant. However, when individual impacts are considered in combination with other projects, significant impacts may result.

Cumulative impacts can be defined as successive, incremental and combined impacts (both positive and negative). This chapter presents an assessment of the potential cumulative impacts of the project when considered together with other developments and activities occurring near the project.

Table 25-1 lists the SEARs relevant to cumulative impacts and where they are addressed in this chapter.

Table 25-1 SEARS relating to cumulative impacts

Ref	General SEARs	Where addressed
2. Environmental impact statement		
	The EIS must include, but not necessarily be limited to, the following: (n) an assessment of the cumulative impacts of the project taking into account other projects that have been approved but where construction has not commenced, projects that have commenced construction, and projects that have recently been completed;	**Section 25.1** **Section 25.2** **Section 25.3**

25.1 Assessment methodology

This cumulative impact assessment focuses on the known environment, social and economic issues associated with the construction and operation of the project, which have been cumulatively assessed in conjunction with other projects occurring in the region.

Other projects in this assessment were selected based on:

- Project location – proximity of other projects within 10 km of the construction footprint and whether any other projects may potentially physically interact with the project
- Project timeframe – when construction of other projects would be undertaken, and whether this would overlap with construction of the project
- Project outputs – any changes as a result of other projects that would interact with the project, such as increase population or traffic flows.

The following websites were searched (May 2019) for recent or proposed projects that have been approved within the last five years or are in the pre-approval phase that could interact with the project:

- DPIE, Major Projects Register/NSW Planning Portal
- Roads and Maritime/TfNSW
- Australian Rail Track Corporation
- CHCC
- Northern Joint Regional Planning Panel
- NSW Health.

Consultation has also been ongoing with CHCC Planning Department to understand proposed developments and future land release in the area. Based on these considerations, projects that may contribute to cumulative impacts are listed in **Table 25-2.**

25.2 Identified projects

Projects in the surrounding area that are, approved or an application has been lodged or are in development, and have the potential to interact with the project are discussed in **Table 25-2** and shown on **Figure 25-1**.

Table 25-2 Projects considered for the cumulative impact assessment

Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
Moonee Beach Residential Subdivision	This subdivision site is located 6 km north of the project, on the eastern side of the existing Pacific Highway. The site is around 13 ha and forms part of the Moonee Beach urban growth area. The proposed development includes 103 residential lots, four new public roads and associated public infrastructure, 2 ha of conservation land providing a buffer to Moonee Creek and a pedestrian / cycleway linking the site to the north and south along the collector road. The proposal was declared State Significant Development (SSD) and following a Response to Submissions report (May 2017), an updated Environmental Assessment was submitted in April 2019 and is in the process of being assessed.	• Aboriginal heritage – investigations identified an artefact scatter of interest. However, these were considered poor examples of Aboriginal objects, and knowledge holders did not attribute any special significance to the artefacts • Soils – likelihood of ASS occurring on the site is considered high. Testing identified that most soils are likely in-situ acidic soils • Biodiversity – threatened species identified during surveys included glossy-black cockatoo, osprey, squirrel glider and koala. The site also includes secondary habitat that could support koalas • Flooding and water quality – the site is located adjacent to Moonee Creek and close to the Solitary Islands Marine Park • Operational traffic – it is anticipated that the operation of the development would result in around 80 two-way vehicle movements during morning and afternoon peak periods. However, it was determined that the existing road network would cater for this additional traffic • Construction disturbance – including noise, traffic and dust.	Not yet approved. High potential for construction to occur in the same timeframe as the project.

Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
Korora Urban Release Area	The Korora Urban Release Area is adjacent to the project and located to the west of the existing Pacific Highway at Korora, covering an area extending from Bruxner Park Road to Sapphire Beach.	A development application and/or environmental impact assessment has not been prepared for this area. However, the environmental investigations have been undertaken as documented in the Korora West Sapphire Moonee Large Lot Residential Investigation Area: Environmental Studies (Eco Logical Australia 2016). It is noted that this document included consideration of urban release areas in Korora, West Sapphire and Moonee however CHCC only supported progressing rezoning within the Korora Basin in March 2017. The Environmental Studies (Eco Logical Australia 2016) noted the following constraints: • Biodiversity – including endangered ecological communities, threatened flora species and koala habitat • Soils – presence of ASS • Flooding – the site is mapped as flood prone and comprises 16 catchments draining to culverts or bridges under the Pacific Highway. However, the development is not expected to result in any flooding impacts • Aboriginal heritage (notably 38 PADs).	Low potential that construction of individual subdivisions may occur in the same timeframe as the project as no development application has been prepared.

Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
Korora Residential Subdivision	Located on Plantain Road, Korora, this subdivision was originally approved late in 2005 for 85 community strata title lots. However, Modification No. 1 reduced this to 52 torrens title lots with design and construction of four dwellings and one mixed use building. Stages 1 and 2 are complete, and stages 8 and 9 are under construction.	• Construction impacts - temporary disturbance to the locality including noise, traffic, dust, sedimentation and erosion. • The site currently has infrastructure in place for housing development including roads, water and sewer mains, electricity and telecommunications conduits, and stormwater management system which were constructed in accordance with the terms of previous development consents, and has been cleared of native vegetation for the previous stages of construction.	There is moderate potential that construction associated with the later stages of development would be occurring in the same timeframe as the project.
Sunset Ridge Estate, Shephards Lane	This site is located adjacent and south of the project, near Shephards Lane. The staged development involves subdivision of 57 residential lots. This development has been approved by CHCC and the later stages of development are currently under construction.	• Biodiversity – the site has high conservation value land in the middle of the site, which is important for ecological connectivity • Construction impacts - temporary disturbance to the locality including noise, traffic, dust, sedimentation and erosion.	There is moderate potential that construction associated with the later stages of development would be occurring in the same timeframe as the project.
Seniors Housing, Arthur Street	This site is located about 5 km to the east of the project and involves 120 bed residential care facility, 183 self-contained dwellings, community centre, landscaping, parking, community facilities and other associated works. The project was approved in August 2017 by the Northern Joint Regional Planning Panel.	• Biodiversity – removal of some remnant vegetation, however this was not considered to result in unacceptable impacts • Flooding – the site is mapped as flood prone, but the development is not expected to result in any flooding impacts • Operational traffic – the development will generate additional traffic movements in the locality however it is considered that the existing road network has sufficient capacity to cater for this • Construction impacts- temporary disturbance to the locality including noise, traffic, dust, sedimentation and erosion.	Early stages of construction observed on the site in September 2018, and therefore it is anticipated that there is a low potential for construction to overlap with the project, as construction may be completed prior to construction of the project.

Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
Coffs Central Shopping Centre Extension	This site is located about 3.5 km to the east of the project at the corner of Harbour Drive and Gordon Street. It involves construction of an 80-room hotel with restaurant, pool, recreation area, parking, and expansion of the existing commercial/retail area. The project was approved in July 2017 by the Northern Joint Regional Planning Panel.	• Soils – while the site is mapped as ASS, this development did not involve any disturbance to soils or water table changes • Traffic – additional traffic generation was determined to have negligible impacts on the road network • Socio-economic – this development is anticipated to have a range of benefits including street activation, reduced reliance on cars due to increased use of pedestrian and cycleway networks, improved cultural and recreational resources and potential tourism benefits.	Works on the shopping centre expansion have been completed, however, works on the hotel have not yet commenced. Construction of the hotel is likely to overlap with the project.
Coffs Harbour Health Campus Expansion	The Coffs Harbour Health Campus site is located 700 m north-east of the Englands Road interchange. The development involves refurbishment of parts of the existing hospital building and construction of new five story clinical services building and associated roadworks. The development was declared SSD with SEARs issued in January 2018. An EIS was submitted in June 2018 and approved on 28 February 2019.	The EIS noted that environmental impacts would be limited given the site context and development consisting of an expansion to the existing hospital. The following general land and development constraints are noted: • Bushfire prone land • Soils – presence of ASS • Biodiversity – an isolated Endangered Ecological Community (Swamp Sclerophyll Forest on Coastal Floodplains) that is also likely to contain other threatened species is in proximity to the hospital but not impacted by the proposed expansion.	Approved with construction of the new building expected to start in early 2019, and to be complete by the end of 2020. Refurbishment of the existing building expected to start in mid-2021 and be completed within three to six months. It is likely that construction would be undertaken simultaneously with the project.

Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
North Boambee Valley Urban Release Area	This area includes the Highlands Estate development and The Lakes Estate development. It is located to the east of project between North Boambee Drive and Lakes Drive. The Lakes Estate is a 198 lot residential subdivision and the Highlands Estate is a 23 lot residential subdivision.	• Soils – contamination associated with past banana plantations • Biodiversity – presence of primary or secondary koala habitat, significant habitat and vegetation linkages and presence of endangered ecological communities.	Later stages of development are currently under construction. Moderate potential that later stages of The Lakes Estate and Highlands Estate developments may occur in the same timeframe as the project.
North Boambee Valley (West) Urban Release Area	This site is located to the west of the construction footprint at North Boambee Road. The North Boambee Valley (West) Urban Release Area provides for low density residential land uses to accommodate 938 lots, environmental conservation areas and three local parks and a playground. The planning proposal for the urban release area was exhibited October to November 2017 and was endorsed by CHCC in May 2019.	The planning proposal and developers' contribution plan for the North Boambee Valley (West) Urban Release Area noted the following constraints: • Biodiversity – vulnerable and endangered flora and fauna species and habitat (including koalas and koala habitat, slender marsdenia and rusty plum) • Flooding and water quality – the site is mapped as flood prone and is located in the vicinity of Newports Creek. Filling in some areas will be required along with a stormwater detention basin and floodways near the head of the main tributaries • Soils – arsenic contamination and presence of ASS.	The North Boambee Valley (West) Urban Release Area currently does not have any approved subdivisions but there is high likelihood of construction occurring in the same timeframe as the project.

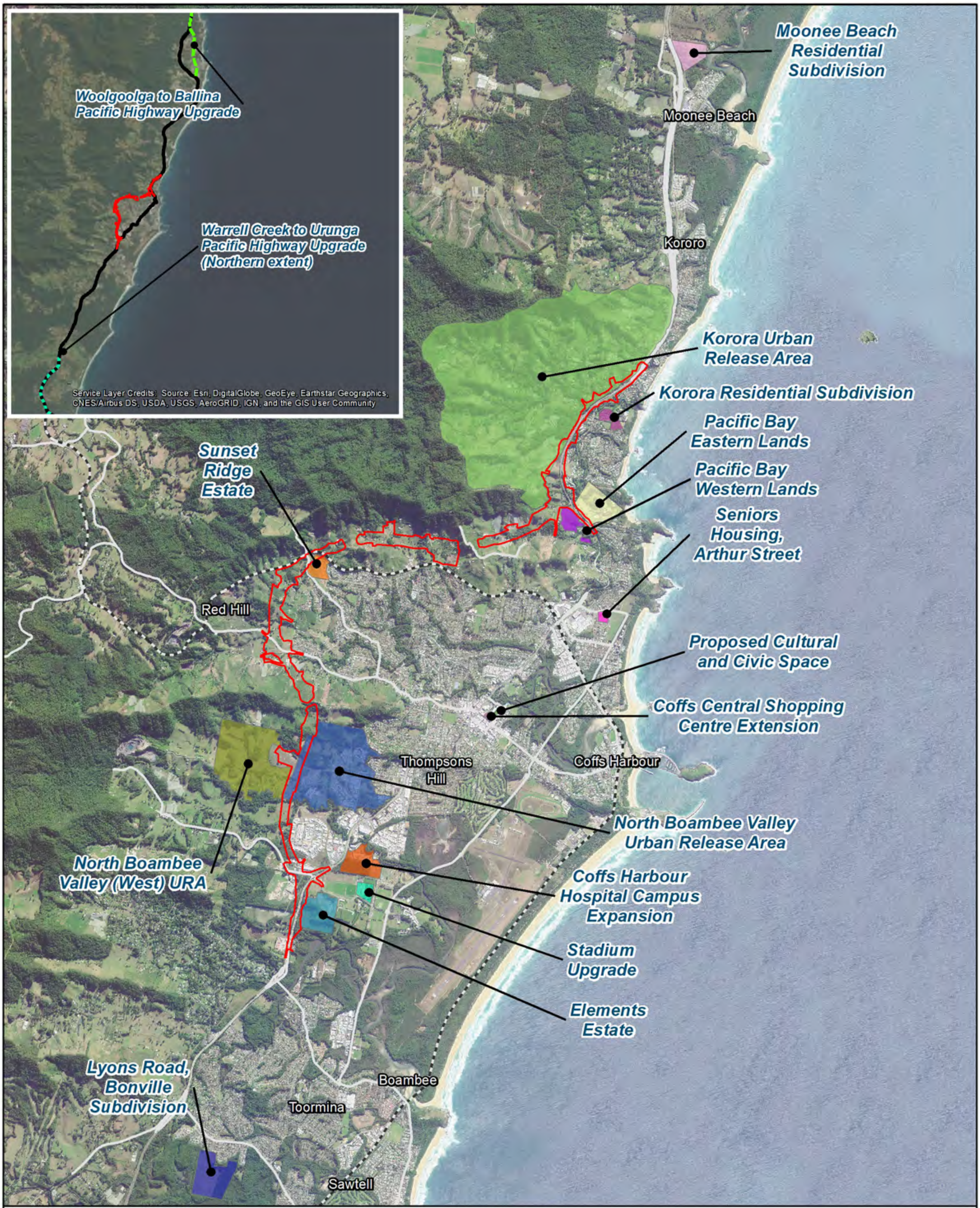
Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
Elements Estate	This site is located on the eastern side of the existing Pacific Highway on the corner of Stadium Drive, directly adjacent to the project (within the South Coffs Urban Release Area). It involves a 222 lot residential subdivision including landform modification for roads and servicing. The application was approved in September 2013 by the Northern Joint Regional Planning Panel.	• Biodiversity – the site contains areas of primary koala habitat • Aboriginal heritage – the site and adjoining areas have been identified as potentially being of Aboriginal cultural heritage significance, particularly the western side of Ted Ovens Drive and along the ridge line of the site • Operational traffic – the development is classed as being a traffic generating development • Construction impacts – temporary disturbance to the locality including noise, traffic, dust, sedimentation and erosion • Soils – contamination has been identified in a section of the site and remediation is required.	Construction has commenced on the initial stages of Elements Estate. Due to the size of the development and its multiple stages, it is anticipated there is moderate potential for construction to occur in the same timeframe as the project.
Stadium Upgrade	This site is located about 700 m to the east of the project at Stadium Drive. It involves construction of two new grandstands which will provide 950 grandstand seats, amenities, bar, kiosk, media rooms, coach rooms, lifts and accessible ramps. The application was approved in December 2017 by the Northern Joint Regional Planning Panel.	• Soils – presence of ASS • Biodiversity – however the vegetation to be removed provides limited habitat resources for native fauna species and is introduced planting as part of existing landscaping • Construction impacts – temporary disturbance to the locality including noise, traffic, dust, sedimentation and erosion	The upgrade is forecast to be complete by late 2019 prior to construction of the project starting.

Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
Lyons Road, Bonville Subdivision	This site is located about 2.5 km south of the southern extent of the project at Sawtell Road. It involves subdivision for 222 residential lots, roads, open space and associated utility services, landscaping, community facilities and drainage, and would be constructed in 11 stages. The project was approved by the DPIE in July 2013, and a recent administrative modification was approved in July 2018 to correct minor errors in the original conditions of approval. The current status of the proposal is that the property owner has progressed a construction certification application to CHCC to advance the work.	• Biodiversity – loss of vegetation of low conservation significance however there will be minor clearing of endangered ecological communities • Flooding – the site includes land that is subject to 1% AEP flood level • Operational traffic – the development is anticipated to generate 1650 new vehicle movements per day • Aboriginal heritage – five PADs and over 1300 stone artefacts and tools were recorded • Soils – presence of ASS.	Aerial imagery from April 2019 indicates that construction has not commenced yet. There is moderate potential that the construction of the subdivision could overlap with the construction of the project.
Warrell Creek to Urunga Pacific Highway Upgrade	This upgrade is located about 17 km from the southern extent of the project. While this is outside the 10 km search area, the Warrell Creek to Urunga Pacific Highway Upgrade would have an interface with the project as the most recent major upgrade to the south. This upgrade involved upgrading the existing highway to a four-lane divided carriageway. The Nambucca Heads to Urunga portion was completed and opened to traffic in July 2016. The Warrell Creek to Nambucca Heads was completed and opened to traffic in December 2017.	• Biodiversity – traverses the North Coast bioregion and required clearing of 255 ha of native vegetation • Operational road traffic noise impacts • Water quality and flooding impacts • Socio-economic – both positive and negative impacts associated with increased safety and traffic constraints, and removal of passing trade for service stations, eateries and food stores • Landscape and visual amenity impacts • Aboriginal heritage – impacts to 15 archaeological sites and five cultural sites of high sensitivity • Construction impacts – temporary disturbance to the locality including noise, traffic, dust, sedimentation and erosion.	Project complete.

Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
Woolgoolga to Ballina Pacific Highway Upgrade	This site is located over 20 km to the north of the project. While this is outside the 10 km search area, it has been included for consideration in the cumulative impact assessment as the Woolgoolga to Ballina Pacific Highway Upgrade has an interface with the project as the most recent major upgrade to the north. The upgrade involves upgrading of 155 km of highway and was approved in August 2014 and the latest environmental assessment modification (Mod 6) was approved in February 2018. Construction is currently underway, and it is due to be open to traffic by 2020.	• Biodiversity – traverses through the North Coast bioregion, including native, cleared and modified habitats. Clearing of 1800 ha of vegetation, including some clearing of endangered and critically endangered vegetation communities • Operational road traffic noise impacts • Water quality and flooding impacts • Landscape and visual amenity impacts • Aboriginal heritage – impacts 39 sites (including isolated artefacts and artefact scatters, scarred trees and midden sites), 11 cultural places and one PAD • Non-Aboriginal heritage – direct and indirect impacts to 20 items • Construction impacts – temporary disturbance to the locality including noise, traffic, dust, sedimentation and erosion.	Construction work is expected to be completed by the end of 2020. There may be some overlap with construction of the project.
Coffs Harbour Cultural and Civic Space	This site is about 2.5 km from the project on the eastern side of the Pacific Highway. The proposal includes a regional gallery, central library, regional museum, multi-purpose meeting rooms, co-working space, shop, café, function space, customer service area, Council staff office accommodation and underground carparking. The project has been declared as SSD with SEARs issued in May 2019.	An EIS has not yet been released, however a scoping report identifies the following possible constraints: • Soils – presence of ASS • Flooding • Aboriginal heritage – near a significant fig tree • Non-Aboriginal heritage – two adjacent buildings have heritage significance.	Not yet approved. High potential for construction to occur in the same timeframe as the project.

Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
Pacific Bay Eastern Lands	The site is located adjacent the Korora Hill interchange on the eastern side of the existing Pacific Highway as part of the Pacific Bay Resort on the eastern side of the Pacific Highway. The development forming the Pacific Bay Eastern Lands includes a mix of residential, recreational and tourist facilities. The site is subject to various development applications and a master plan approved in 2005 (and amended in 2010) under the former State Environmental Planning Policy No 71 – Coastal Protection. Key developments within the site which haven't commenced construction include: • Residential development (Lot 5E) consisting of 30 residential lots as approved by the Northern Joint Regional Planning Panel in February 2011 • Residential development (Lot 7) consisting of 80 apartments in an eight-storey building. Consultation with the proponent has indicated that the further proposals are being investigated.	• Biodiversity – the site contains areas of koala habitat and native vegetation • Flooding and water quality – the site is located close to the Solitary Islands Marine Park and would be subject to flooding • Construction impacts – temporary disturbance to the locality including noise, traffic, dust, sedimentation and erosion • Soils – presence of ASS and potential contamination due to historical use of site and surrounding area for banana plantations • Operational traffic – the development is classed as being a traffic generating development.	High potential for construction to occur in the same timeframe as the project.

Project	Description	Assumed key impacts based on current knowledge	Construction timeframes
Pacific Bay Western Lands	Proposed residential development for about 110 residential lots located adjacent the Korora Hill interchange on the western side of the existing Pacific Highway. The site is located between Bruxner Park Road (northern boundary) and West Korora Road (southern boundary). An Environmental Assessment (under former Part 3A of EP&A Act) was prepared for the Pacific Bay Western Lands in 2010 but the project application has since lapsed. However, it is understood that the proponent remains in consultation with CHCC regarding a revised proposal.	• Flooding and water quality – the site is located adjacent to Jordans Creek and close to the Solitary Islands Marine Park and would be subject to flooding • Construction impacts – temporary disturbance to the locality including noise, traffic, dust, sedimentation and erosion • Soils –potential contamination due to historical use of site and surrounding area for banana plantations • Operational traffic – the development would be classed as being a traffic generating development if a revised proposal includes similar housing densities.	To date, it is not known whether a revised proposal has been submitted to CHCC. However, there is moderate potential for construction to occur in the same timeframe as the project.



Legend

Construction footprint

Future Developments

Coffs Central Shopping Centre Extension
Coffs Harbour Hospital Expansion
Elements Estate
Korora Residential Subdivision
Korora URA
Lyons Road, Bonville Subdivision
Moonee Beach Residential Subdivision
North Boambee Valley (West) URA
North Boambee Valley URA
Pacific Bay Eastern Lands
Pacific Bay Western Lands
Cultural and Civic Space
Seniors Housing, Arthur Street
Stadium Upgrade
Sunset Ridge Estate

Coffs Harbour Bypass
Projects considered in the cumulative impact assessment
Figure 25-1

25.3 Assessment of potential impacts

As shown in **Table 25-2**, some of the projects are still being assessed by approval authorities. Where construction periods are not known, predictions have been made about the likelihood of overlapping construction periods. The likely impacts of these projects will be assessed as part of the development consent process by the relevant approval authority.

The projects identified in **Table 25-2**, when considered with the construction and operation of the project may result in cumulative environmental impacts. The project would be funded by the Australian and NSW governments. Subject to project approval and funding availability, construction of the project is proposed to start in 2020 and would take about four to five years to complete, weather permitting. The likely cumulative impacts during construction and/or operation are described in **Table 25-3**.

Table 25-3 Potential cumulative impacts during construction and operation

Environmental aspect	Likely cumulative impact	Potential cumulative impacts
Traffic and transport	Minor negative short-term impact	During construction, there is potential for cumulative construction traffic impacts should other major projects be constructed within the same timeframe. However, combined increases in construction vehicles are not anticipated to impact significantly on the capacity of the Pacific Highway and other regional roads, as most projects considered in this cumulative impact assessment are not anticipated to generate significant construction traffic volumes. The Pacific Highway has been progressively upgraded between Brisbane and Sydney over many years. Recent projects include the Warrell Creek to Urunga Pacific Highway Upgrade (completed 2018) and the Woolgoolga to Ballina Pacific Highway Upgrade (due for completion in 2020). During these works, highway users have experienced reduced speeds, stoppages and construction related traffic impacts at different locations along the highway. While much of the project would be constructed offline from the existing Pacific Highway, road users would continue to be impacted by reduced speeds, stoppages and congestion where the project ties into the existing highway south and north of Coffs Harbour. This would add to the overall ‘construction fatigue’ experienced by highway users from continuous construction activities associated with the Pacific Highway upgrade. The Pacific Highway/Stadium Drive intersection currently has a level of service D (meaning there is limited stable flow of traffic and restricted ability for motorists to manoeuvre). Therefore, construction traffic from multiple adjacent projects (eg Coffs Harbour Hospital Campus Extension and Elements Estate) may further decrease its performance and level of service. While there may be a moderate negative short-term impact at this intersection in the event that all identified projects in the vicinity be constructed within the same timeframe, it is still considered that overall there would only be a minor negative short-term cumulative impact on traffic and transport. There is potential that the Pacific Bay Western Lands and Pacific Bay Eastern Lands proposed residential developments may coincide with the construction of the project. Cumulative impacts may include increased construction traffic and access to construction sites, specifically for Pacific Bay Western Lands which is located immediately south of the Korora Hill interchange. Access to the site may be restricted during the construction phase of the project. Consultation with CHCC and the proponent of the residential development will be undertaken during detailed design to ensure future access arrangements are considered as part of the project. Pacific Bay Eastern Lands is located on the eastern side of the Pacific Highway south of the Korora Hill interchange. Access to Pacific Bay Eastern Lands is provided via Charlesworth Bay Road / Bay Drive / Resort Drive. The existing intersection of Charlesworth Bay Road / Pacific Highway would not be affected by the project, however there would be an increased volume of construction vehicles within the local road network. Consultation with CHCC and the proponent of the residential development will be undertaken during detailed design to ensure future access arrangements are considered as part of the project.

Environmental aspect	Likely cumulative impact	Potential cumulative impacts
	Major positive long-term impact	Operational cumulative impacts are included in the assessment in **Chapter 8, Traffic and transport**, as the traffic model used for this assessment has taken into account future land use assumptions and predicted population and employment growth using information from CHCC and the DPIE. No further operational cumulative impacts are anticipated. Once operational, the project would provide an improved highway environment for users, consistent with other upgraded sections of the Pacific Highway. Cumulatively, these upgrades have decreased travel times and improved safety on the highway and the project facilitates wider improvements in the Coffs Harbour CBD.
Noise and vibration	Minor negative short-term impact Negligible long-term impact	Cumulative construction noise impacts are associated with the cumulative noise emissions of all the developments (including the noise emissions from the project) occurring in the same area and within the same timeframe as the project. There are several other projects near the project that have potential to result in cumulative noise and vibration impacts if construction is undertaken within the same time, such as the Elements Estate, Coffs Harbour Hospital Campus Expansion, The Lakes Estate, Sunset Ridge Estate, Pacific Bay Eastern Lands and Pacific Bay Western Lands. Construction start and end dates and details on construction staging for these developments are unconfirmed at this stage. If construction of those developments overlaps with the construction of the project, increase in noise levels at nearest receivers is likely to be experienced. Generally, construction works for the project would occur over a temporary period at one particular location then move to another, so impacts would be short-term in nature. In addition, haulage roads are likely to be shared between the project and major developments if occurring within the same timeframe. Nearby receivers are likely to notice an increase in noise levels if the same local roads are used for haulage. Cumulative operational noise impacts from the project and developments identified above are anticipated to be negligible. Noise mitigation measures such as low noise pavement, noise barriers and at property treatments identified in **Chapter 9, Noise and vibration** have considered all approved development applications close to the construction footprint.
Biodiversity	Minor negative short-term impact	Cumulative impacts to biodiversity have the potential to occur during the construction phase of the project if development of the major residential areas at North Boambee Valley and Korora occur concurrently with the project. These impacts are considered to be minor and would only occur in the short-term. Cumulative impacts to biodiversity during construction could include increased disturbance associated with noise, vibration and light spill impacting on fauna movement and behaviour. Major waterways also pass through these future urban development areas, with Newports Creek passing through the North Boambee Valley, Pine Brush Creek through the Korora Urban Release Area and Jordans Creek passing through the Pacific Bay Western Lands site. Additional development pressure in these areas could contribute to impacts to water quality, with potential reduction to the condition of aquatic habitats.

Environmental aspect	Likely cumulative impact	Potential cumulative impacts
	Moderate negative long-term impact	Cumulative impacts associated with loss of native vegetation and increased habitat fragmentation have the potential to have moderate cumulative impacts in the long-term. The projects which have the highest potential to add to the impacts associated with the project are the urban development areas at North Boambee Valley and the Korora Urban Release Area. These areas are located within lowland regions that are known to support threatened species, including EPBC Act listed fauna giant barred frog and koala. Additional loss of habitat, especially in larger, intact patches has the potential to further reduce areas of occupancy for these species within the area. The North Boambee Valley development areas are located on an identified ecological corridor which is known to be used by koalas. The east-west movement of fauna from the Coffs escarpment to the lowland coastal area is important for the maintenance of viable populations of fauna and other ecological processes in the region. To maintain this connectivity and fauna corridor, the project proposes a number of fauna connectivity structures including retaining ridgelines over tunnels, fauna crossings (at 16 locations), glider poles and dedicated and combined underpass structures. Future urban development in North Boambee Valley and Korora would also need to consider maintenance of these corridors and impacts on fauna connectivity.
Visual, landscape and urban design	Minor negative short-term impact	During construction, there is the potential for cumulative landscape impacts to arise, with particular reference to North Boambee Valley development areas, Korora Urban Release Area, Elements Estate, Sunset Ridge, Pacific Bay Eastern Lands and Pacific Bay Western Lands. Should these sizable developments be constructed simultaneously, the introduction of the project in parallel with these developments has the potential to redefine the western boundary of the CBD, further encroaching and impacting the existing rural characteristics of the landscape. The temporary construction elements, such as site compounds and construction activities, would reduce over time, although it is anticipated that the impacts on the rural characteristics would remain.
	Minor negative long-term impact	Similar to the cumulative landscape impacts, visual impacts are anticipated to arise as a result of the increased urbanisation of Coffs Harbour, redefining the western boundary to the CBD. Adverse impacts are anticipated to be increased where the composition of existing views has the potential to change from views across an undulating, rural, forested landscape, to views of sprawling development with associated infrastructure.
Socio-economic	Minor negative short-term impact	It is anticipated that there would be minor short-term socio-economic impacts on community as residents who remain in close proximity of construction may experience a range of amenity impacts such as noise, vibration, visual changes, air quality and traffic and access impact.

Environmental aspect	Likely cumulative impact	Potential cumulative impacts
	Major positive long-term impact	Within the Coffs Harbour CBD, the considerable reduction in freight passing through the CBD along with a reduction in through traffic would provide a more attractive environment. When considered in association with projects such as the Coffs Central Shopping Centre extension and Coffs Harbour Cultural and Civic Space which includes a restaurant, pool and recreation area and the Stadium Upgrade there is potential to activate the CBD area and result in an overall social and economic benefit to the Coffs Harbour CDB. Lifestyle is stated as a key reason why people choose to live in Coffs Harbour. With the Coffs Harbour population forecast to grow by around 30 per cent by 2036, the current lifestyle experience in Coffs Harbour may be challenged by this growth. To cater for close to 20,000 additional residents, new housing, commercial development and social infrastructure would be needed in Coffs Harbour such as those identified in **Table 25-2**. These projects in combination would increase the size of urban areas of Coffs Harbour. The project is another symbol of the growth and urbanisation of the region. Some people would view this favourably, while others won't want to see Coffs Harbour change. By moving the highway out of the Coffs Harbour CBD, it would provide 'space' for the city to cater for its forecast growth. For example, the reduction in traffic within the Coffs Harbour CBD may provide opportunities change built form and public open space along the current Pacific Highway. Local people would also be able to travel more freely within Coffs Harbour without mixing with highway traffic. If the highway was to remain in its current location, this coupled with Coffs Harbour's forecast population growth and associated future development, would put a great deal of pressure on the lifestyle experience within Coffs Harbour into the future. The project would place large scale road infrastructure in an area that is currently rural in nature. This may influence future planning for adjacent land uses and zoning, which may change the rural nature of the area.
Aboriginal heritage	Minor negative long-term impact	There is potential for some cumulative impacts at a regional level, due to impacts on Aboriginal cultural heritage associated with other nearby Pacific Highway upgrades such as Woolgoolga to Ballina, and Warrell Creek to Urunga. However, it is not anticipated that this would result in significant cumulative impacts to Aboriginal cultural heritage values. In addition, other developments identified in **Table 25-2** such as the Moonee Beach Residential Subdivision, Korora Urban Release Area, Elements Estate and the Lyons Road Subdivision were also noted as having impacts to Aboriginal heritage, however these are anticipated as being on a much smaller scale than the impacts associated with other road upgrade projects and therefore are also not anticipated to contribute to a significant loss of Aboriginal cultural heritage resources. The identified archaeological sites on the project were assessed as having low or moderate significance, and it is likely that many similar archaeological site types and associated landforms exist in the surrounding landscape and would not be impacted by the project. Furthermore, investigations undertaken for this project, and other projects as part of the Pacific Highway upgrade program contribute to our understanding of archaeology and Aboriginal occupation in the region (see **Chapter 15, Aboriginal cultural heritage**).

Environmental aspect	Likely cumulative impact	Potential cumulative impacts
Non-Aboriginal heritage	Minor negative long-term impact	The project would directly impact some non-Aboriginal heritage items and have visual impacts to other heritage sites and landscapes. There is potential for cumulative impacts should other projects or developments, impact on the same heritage sites, or impact other similar heritage items that contribute to the cultural or natural history of the Coffs Harbour region.
Flooding and hydrology	Minor positive long-term impact	Flood modelling for the project and approved development projects in the area have informed the design and flood impact assessment within this EIS. Cumulative impacts are not anticipated however, it is noted that future projects would need to undertake further detailed flood modelling to consider and mitigate any cumulative impacts of their project and the bypass. It is anticipated that any future subdivision in the identified urban release areas in **Table 25-2** would need to undertake detailed flood modelling and ensure the flood risk is appropriately mitigated.
Soils and contamination	Minor negative short-term impact	ASS and soil contamination associated with banana farming exists across the Coffs Harbour region. There is potential for cumulative water quality impacts if construction activities from multiple projects and developments disturb or mobilise contaminants and ASS, leading to transportation of contaminated sediments or leachate to surrounding areas such as surface water bodies, groundwater and soils. However, with the implementation of best practice construction mitigation measures (refer to **Chapter 18, Soils and contamination**), it is not anticipated that cumulative soil and contamination impacts would be significant.
Surface water quality	Minor negative short-term impacts Negligible long-term impacts	There is potential for cumulative surface water quality impacts associated with movement of sediments from construction of nearby projects into the same receiving environment. As the project extends across a significant stretch of the Coffs Harbour region, it is possible that there may be temporary surface water quality impacts over a large area for the duration of construction, and cumulative impacts may arise if other projects and developments are constructed at the same time. For example, potential impacts to water quality in Newports Creek might arise if construction of the project overlaps with other developments such as the Coffs Harbour Hospital Campus Extension or the North Boambee Valley Urban Release Area. Similarly, the Solitary Islands Marine Park may experience water quality impacts if construction of multiple projects within the catchment occur at the same time, such as Moonee Beach Residential Subdivision, Pacific Bay Eastern Lands and Pacific Bay Western Lands. It is anticipated that cumulative surface water quality impacts would be able to be avoided or appropriately managed via the management measures identified in **Chapter 19, Surface water quality**. The likelihood of cumulative impacts would depend on the phase of construction, with highest risk of impact likely to occur during initial earthworks. However, once the construction works are completed and the exposed soils are suitably covered and/or revegetated, the potential for impacts to surface water quality would decrease. Cumulative operational impacts are expected to be minor for projects that are in close proximity to the project, and negligible for projects that are located further away from the construction boundary.

Environmental aspect	Likely cumulative impact	Potential cumulative impacts
Groundwater	Minor negative long-term impact Negligible short-term impact	None of the projects in the region are likely to have a substantial long-term impact on groundwater due to the large catchment area for recharge of the groundwater resource. Those projects nearest the bypass (principally housing developments) may lead to a localised decrease to groundwater recharge to the groundwater aquifers, due to an increase in drainage and impermeable material. Where these are near to proposed cuttings or tunnels in the project, there could be a long-term decrease in groundwater levels, ongoing seepage and flow directions would be locally altered. Short-term impacts on groundwater quality during construction are expected to be managed by on-site controls for both the project and other developments likely under construction at the same time, and therefore are not anticipated to be significant.
Air quality	Minor negative short-term impact No anticipated long-term impacts	There is the potential for cumulative air quality impacts during construction from both fugitive dust emissions and exhaust emission from construction plant and vehicles from the project and developments in close proximity to the bypass. The management measures recommended for the project set out in **Chapter 21, Air quality** would assist in minimising the project's potential impact and it is expected that other construction sites in the area would apply similar management measures to minimise any impacts. Approved developments in the Coffs Harbour region have the potential to lead to increased traffic growth. This has been accounted for within the **Chapter 21, Air quality** as traffic volumes included in the dispersion model for various assessment scenarios includes growth in traffic. As such, it is not anticipated that there would be any long-term cumulative impacts to air quality.
Waste	Minor negative short-term impact Negligible long-term impacts	During construction, there is potential for cumulative demand of construction materials for all projects under construction concurrently. However, the resources required are unlikely to be in short supply and as such no significant impacts are expected. There may also be a cumulative amount of waste generated during construction of concurrent projects. The volumes of waste are not anticipated to exceed the capacity of available waste facilities and as such no significant impacts are anticipated. It is not anticipated that there would be any long-term cumulative waste impacts associated with operation of the project.

25.4 Environmental management measures

The impacts of other projects do not form part of this assessment and would be assessed separately. However, multi-party engagement and cooperation is needed to ensure all contributors to impacts are working together to minimise the effects or enhance the benefits of multiple projects occurring concurrently or consecutively.

Mitigation measures for the construction and operation of the project are detailed in **Table 25-4.**

Table 25-4 Environmental management measures for cumulative impacts

Impact	ID No.	Environmental management measure	Responsibility	Timing
Cumulative impacts	CI01	Where relevant, consultation would be undertaken with proponents of other nearby developments to increase the overall awareness of project timeframes and impacts.	Contractor	During construction
	CI02	The CEMP will be updated with any revised or new environmental management measure identified from consultation with proponents of other nearby developments, where required.	Contractor	During construction