18 Surface water and flooding

This chapter describes the potential surface water and flooding impacts associated with the project. The chapter has been informed by surface water and flooding assessments provided in **Appendix L** (Surface water technical report) and **Appendix M** (Flooding technical report). **Table 18-1** sets out the SEARs relevant to surface water and flooding and identifies where the requirements have been addressed in this EIS.

Table 18-1 SEARs - Surface water and flooding

Assessment requirements	Where addressed in this EIS
Water - Hydrology	
1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users e.g. bore water for domestic use and irrigation, and for ecological purposes and groundwater dependent ecosystems) likely to be impacted by the project, including rivers, streams, wetlands and estuaries as described in Appendix 2 of the *Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects* (OEH, 2014).	Section 18.2 discusses and maps the existing surface water hydrological regime Chapter 17 (Groundwater and geology) Chapter 12 (Biodiversity)
2. The Proponent must prepare a detailed water balance for ground and surface water including the proposed intake and discharge locations (including mapping of these locations), volume, frequency and duration for both the construction and operational phases of the project.	Section 18.3.1 and Section 18.4.1 discuss surface water balance Chapter 17 (Groundwater and geology)
3. The Proponent must assess and model 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 and floodplains that affect the health of the fluvial, riparian and estuarine systems and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity, water-dependent fauna and flora and access to habitat for spawning and refuge;	Section 18.3.1 and Section 18.4.1 discuss discharges and waterway disturbance during construction Chapter 12 (Biodiversity)
(b) impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, change in ground water levels, barriers to flows, implications for groundwater dependent on surface flows, ecosystems and species, groundwater users and the potential for settlement;	Chapter 17 (Groundwater and geology)
(c) changes to environmental water availability and flows;	Section 18.3.1 and Section 18.4.1
(d) direct or indirect increases in erosion, siltation, destruction of aquatic and riparian vegetation or a reduction in the stability of river banks or watercourses;	Section 18.3.1 and Section 18.4.1 discusses erosion, scour, siltation and bank stability impacts associated with discharges and waterway disturbance during construction Section 18.2.2 and Chapter 12 (Biodiversity) discusses impacts on riparian vegetation
(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 the existing stormwater systems where discharges are proposed through such systems or modifications are proposed to these systems; and	Section 18.3.1 and Section 18.6
(f) measures to mitigate the impacts of the proposal and manage the disposal of produced and incidental water.	Section 18.6

Assessment requirements	Where addressed in this EIS
4. The assessment must provide details of the final landform of the sites to be excavated or modified (e.g. portals and cut and cover works), including final void management and rehabilitation measures.	Chapter 13 (Landscape and visual)
5. The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	Section 18.6 Appendix L (Surface water technical report)
6. The assessment must include details of proposed surface and groundwater monitoring.	Section 18.6 Chapter 17 (Groundwater and geology)
7. The proposed tunnels must be designed to minimise impacts on aquifers and minimise impacts on groundwater flows and groundwater dependent ecosystems.	Chapter 17 (Groundwater and geology)
Water - Quality	
1. The Proponent must: (a) describe the background conditions for any surface or groundwater resource likely to be affected by the development;	Section 18.2 Chapter 17 (Groundwater and geology)
(b) state the ambient NSW Water Quality Objectives (NSW WQO) (as endorsed by the NSW Government [see www.environment.nsw.gov.au/ieo/index.htm]) and environmental values for the receiving waters (including groundwater where appropriate) relevant to the project and that represent the community's uses and values for those receiving waters, including the indicators and associated trigger values or criteria for the identified environmental values in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government;	Section 18.1 and Appendix L (Surface water technical report)
(c) 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 18.3.1 and Section 18.4.1 discuss quality and quantity of groundwater pollutants.
(d) identify the rainfall event that the water quality protection measures would be designed to treat;	Section 18.6 discusses construction of sediment basins. Section 18.4.1 discusses rainfall events
(e) assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	Section 18.3.1 and Section 18.4.1
(f) demonstrate how construction and operation of the project (including mitigating effects of proposed stormwater and wastewater management) would, to the extent that the project can influence, ensure that: – where the NSW WQOs for receiving waters are currently being met they would continue to be protected; and – where the NSW WQOs are not currently being met, activities would work toward their achievement over time;	Section 18.3.1 and Section 18.4.1 Appendix L (Surface water technical report)
(g) justify, if required, why the WQOs cannot be maintained or achieved over time;	Section 18.3.1 and Section 18.4.1
(h) 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 18.6

Assessment requirements	Where addressed in this EIS
(i) identify sensitive receiving environments (which may include wetlands/ estuarine waters upstream and downstream of the project including their catchments) and develop a strategy to avoid or minimise impacts on these environments; and	Section 18.2
(j) identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Section 18.6 Appendix L (Surface water technical report)
2. The assessment should consider the results of any current water quality studies, as available, in the project catchment.	Section 18.2 Appendix L (Surface water technical report)
3. The assessment should include concept designs for water quality treatment structures taking into account water sensitive urban design principles	Section 18.2 and Section 18.6
Flooding	
1. The EIS must map the following features relevant to flooding as described in the *NSW Floodplain Development Manual 2005* (NSW Government, 2005) including: (a) Flood prone land; (b) Flood planning areas, the area below the flood planning level; and (c) Hydraulic categorisation (floodways and flood storage areas).	Figures 18-2 – 18-4 Appendix M (Flooding technical report)
2. The Proponent must assess and model, where appropriate, the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (taking into account sea level rise and increased storm intensity due to climate change) including:	Potential flooding impacts during construction and operation are assessed in section 18.3.2 and section 18.4.2 respectively.
(a) how the tunnel entries and cut-and-cover sections of the tunnels would be protected from flooding during construction works;	Measures to manage potential flooding impacts are described in section 18.6
(b) any detrimental increases in the potential flood affectation of the project infrastructure and other properties, assets and infrastructure;	Section 18.3.2 and Section 18.4.2
(c) consistency (or inconsistency) with applicable Council floodplain risk management plans;	Section 18.4.2
(d) compatibility with the flood hazard of the land;	Section 18.2 Section 18.4
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;	Section 18.1.2
(f) whether there would be adverse effect to beneficial inundation of the floodplain environment, on, or adjacent to or downstream of the site;	Section 18.3.2 and Section 18.4.2
(g) downstream velocity and scour potential;	Section 18.3.2 and Section 18.4.2
(h) impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services and Council;	Section 18.4.2
(i) any impacts the development may have on the social and economic costs to the community as consequence of flooding;	Section 18.4.2
(j) any mitigation measures required to offset potential flood risks attributable to the project (these mitigation measures must be discussed with the State Emergency Services and Council where appropriate).	Section 18.6
3. The assessment should take into consideration any flood studies undertaken by local government councils, as available.	Section 18.1

Assessment requirements	Where addressed in this EIS
4. The EIS must assess and model the effect of the proposed development (including fill) on current flood behaviour for the 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Section 18.4.2
Environmental Impact Statement	
1. (i) a demonstration of how the project design has been developed to avoid or minimise likely adverse direct and indirect impacts during construction and operation of the project	Section 18.3, Section 18.4 and Section 18.6

18.1 Assessment approach

18.1.1 Overview

Two technical assessments were undertaken to inform the assessment of surface water and flooding impacts on the project (refer to **Appendix L** (Surface water technical report) and **Appendix M** (Flooding technical report)). Each of these assessments are summarised in this chapter.

The study area for the assessments discussed in this chapter includes the project's construction boundary and operational infrastructure footprint, as well as areas where potential surface water and flooding impacts could occur as a result of the construction or operation of the project. The layout of the construction ancillary facilities, tunnel alignment and permanent power supply alignment is presented in **Chapter 6** (Project Description) and **Chapter 7** (Construction).

Surface water

The method of assessment for surface water included:

- A desktop review and analysis of existing information to determine potential receptors, characterising the existing environment and identify potential issues
- A field assessment including collecting samples from monitoring sites to confirm and supplement the findings of the desktop analysis and refine understanding of potential issues
- Assessment of potential construction and operational impacts related to hydrology, geomorphology, water quality and water quantity, including:
  - Review of estimated surface water and groundwater inputs and construction discharge volumes
  - Qualitative assessment of how construction discharges may impact the receiving environment and the effects of physical disturbance to the waterways during construction
  - Identification of potential pollutants of concern in surface water and estimation of the quality and quantity of pollutants in tunnel groundwater to inform the qualitative assessment of the effect of the proposed discharges of treated construction water on the receiving environment
  - Water balance to estimate combined operational surface water discharge volumes and qualitative assessment of how operational discharge may impact the receiving environment
  - Modelling of the existing and proposed conditions to inform the types of stormwater treatment devices using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). See **Appendix L** (Surface water technical report) for further information and MUSIC modelling results
  - Development of a box model to simulate the mixing of treated discharges from the New M5 Motorway water treatment plant at Arncliffe with the Cooks River.
- Identifying appropriate measures to mitigate potential impacts.

Flooding

The method of assessment for flooding included:

- A review of available data and existing flood studies within the catchments that are crossed by the project
- Development of a set of hydrologic and hydraulic models (collectively referred to as 'flood models') of the catchments that are located within the study area. Rainfall-runoff modelling software packages were used to generate design discharge hydrographs for input to the hydraulic models, while flooding patterns in the vicinity of the project were defined using the TUFLOW two-dimensional (in plan) hydraulic modelling software
- Running the flood models and preparing exhibits showing flood behaviour under present day conditions for design floods with a range of Annual Exceedance Probability's (AEP), as well as the probable maximum flood (PMF). AEP refers to the frequency of floods, see **Appendix M** (Flooding technical report) for further details of flood frequency
- Assessment of the impact the project would have on flood behaviour and flood hazards for the aforementioned design flood events
- Assessment of the impact a partial blockage of major hydraulic structures would have on flood behaviour under operational conditions
- Assessment of the impact future climate change would have on flood behaviour under operational conditions
- Assessment of potential measures which are aimed at mitigating the risk of flooding to the project and its impact on existing flood behaviour and flood hazards.

Relevant guidelines and policies

The following key guidelines and policies were considered in the assessment:

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000) (the 'ANZECC Water Quality Guidelines')
- NSW Water Quality Objectives (WQOs) (NSW Department of Environment, Climate Change and Water (DECCW) 2006)
- *Managing Urban Stormwater (MUS) – Soils and Construction* series of handbooks
- *Botany Bay and Catchment Water Quality Improvement Plan* (BBWQIP) (SMCMA 2011)
- *Floodplain Development Manual* (DIPNR 2005)
- NSW government planning directions and guidelines, including the *Guideline on Development Controls on Low Flood Risk Areas and Direction 4.3 - Flood Prone Land*
- *Floodplain Risk Management Guideline: Practical Considerations of Climate Change* (DECC 2007)
- Council flood related planning controls, including *Rockdale Local Environmental Plan 2011* (RCC 2011b) and *Sydney Regional Environmental Plan No 33 – Cooks Cove*
- *Rockdale Technical Specification - Stormwater Management* (RCC 2011c).

Further details on the relevance and use of these guidelines in the assessment is provided in **Appendix L** (Surface water technical report) and **Appendix M** (Flooding technical report), in addition to a list of other relevant guidelines and policies that apply to the project.

Previous studies

A number of previous studies into various aspects of surface water and flooding in the study area have been reviewed to inform the assessment, these are listed in **Appendix L** (Surface water technical report) and **Appendix M** (Flooding technical report).

NSW Water Quality Objectives

For each catchment in NSW, the state government has endorsed the community's environmental values for water, known as the NSW Water Quality Objectives. The NSW Water Quality Objectives (WQOs) (NSW Department of Environment, Climate Change and Water (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 WQOs include qualitative and quantitative objectives related to protecting aquatic ecosystems, visual amenity, recreation and aquatic foods and are presented in full in **Appendix L** (Surface water technical report).

18.1.2 Project features

The project features relevant to surface water and flooding are summarised below. Further details can be found in **Chapter 6** (Project description) and in **Appendix L** (Surface water technical report) and **Appendix M** (Flooding technical report). The existing and proposed surface flooding and drainage system is shown in **Chapter 6** (Project description).

Surface water

During construction, the Arncliffe construction ancillary facility (C1) and Rockdale construction ancillary facility (C2) would have a construction water treatment plant to treat groundwater inflows into the tunnel. The President Avenue construction ancillary facility (C3) would have a construction water treatment plant to treat groundwater that is extracted for the cut and cover structure during excavation of the ramps at President Avenue. Each of the construction ancillary facilities would also include a groundwater pre-treatment basin. Surface runoff from unsealed surfaces would be directed to sediment basins.

During operation, the project would be located in areas where existing stormwater drainage systems presently control runoff from the surrounding urbanised catchments. As a result, it would be necessary to upgrade, alter or augment the existing stormwater drainage systems for operation of the project. This would include a new pavement drainage system along President Avenue to accommodate the proposed road widening and a new pit and pipe drainage system to control runoff from the proposed Rockdale Motorway Operations Complex (south) (MOC3). Runoff captured before entering the tunnel portals would be pumped to a water quality basin within Rockdale Bicentennial Park where it would be treated before discharge into Scarborough Ponds.

The tunnel drainage system has been designed to have a separate groundwater and surface water collection system. The tunnel groundwater collection system would capture groundwater ingress from the drained sections of the tunnel.

The tunnel surface water collection system would capture:

- Tunnel maintenance wash down water
- Fire system (i.e. deluge) water
- Water from an accidental rupture of a fire main or hydrant
- Accidental spills of fuels or other chemicals carried by vehicles using the tunnel
- Water transported into the tunnel by vehicles
- Fire system testing water.

The project would construct its own water treatment plant at Arncliffe Motorway Operations Complex (MOC1) to treat tunnel groundwater flows from the tunnels.

Figures showing the proposed tunnel and stormwater drainage concept are provided in Figure 5-2 and 5-2 for construction and Figure 6-1 to 6-4 for operation in **Appendix L** (Surface water technical report).

Flood mitigation

The following flood mitigation measures would be incorporated into the project works:

- Upgrading the existing box culvert structure that crosses President Avenue at Scarborough Ponds and raising the level of President Avenue in order to improve its level of flood immunity
- Providing flood protection barriers around, or raising the level of the tunnel portals and tunnel ancillary facilities where there is a risk of inundation from flooding
- Lowering of ground elevations in the vicinity of Rockdale Bicentennial Park in order to control major overland flow and local drainage (further discussed below).

The project has been designed to minimise changes in the conveyance and storage of floodwaters in order to minimise impacts on existing flooding behaviour. This has included provision of compensatory floodplain storage within Rockdale Bicentennial Park to offset the displacement of floodplain storage caused by the project. Further details are provided in **Appendix M** (Flooding technical report).

18.2 Existing Environment

This section provides an overview of the study area relating to the catchments, waterways and wetlands in the study area and the existing water quality, drainage infrastructure and flood behaviour in these water bodies.

18.2.1 Key water bodies

Five key water bodies are located along the route of the project, which form part of the larger Botany Bay catchment. The water bodies and catchments are shown in **Figure 18-1**. **Table 18-2** and **Table 18-3** provide a brief description of the water bodies and a summary of the water quality and patterns of main stream flooding and major overland flow under present day conditions. **Figure 18-1** shows the surface water monitoring locations. The present day flooding patterns at one per cent AEP are shown in **Figure 18-2** to **Figure 18-4**. A one per cent AEP means that there is a one per cent chance that there would be floods of equal or greater magnitude each year, giving an average recurrence interval of 100 years.

Further information can be found in **Appendix L** (Surface water technical report) and **Appendix M** (Flooding technical report).

Table 18-2 Key water bodies within the study area

Water body	Project components	Description of water quality	Existing flood behaviour
Cooks River - the Cooks River catchment covers an area of around 10,000 hectares in south western Sydney, discharging to Botany Bay at Mascot. The Cooks River catchment is highly urbanised and has a history of intensive land development with land uses ranging from residential to heavy industry. Within the catchment it is estimated that roughly 89 per cent of stormwater travels through a combination of pit and pipe networks, open concrete channels, metal sheet piled channels and rock armoured channels.	Construction • Arncliffe construction ancillary facility (C1) Operation • Northbound and southbound tunnels connecting to stub tunnels from the WestConnex New M5 Motorway • Ventilation tunnels which connect the tunnels to a surface ventilation facility on the site of the Kogarah Golf Course • Operational tunnel water which would be pumped to the New M5 Motorway water treatment plant at Arncliffe, with treated flows ultimately discharged to the Cooks River.	Surface water monitoring was undertaken as part of the WestConnex New M5 Motorway project[1]. Two monitoring points were used, represented by SW3 and SW4 as shown in Figure 18-1. Median concentrations for total nitrogen, total phosphorus, reactive phosphorus, cadmium, chromium, copper, lead and zinc were above ANZECC (2000) slightly to moderately disturbed trigger levels with nitrate, arsenic, mercury and nickel also exceeding on some occasions. It is noted that the limit of reporting for cadmium, copper and chromium was set above the slightly to moderately disturbed trigger level on some occasions. Median lead concentrations were also above the ANZECC (2000) 80 per cent species protection level and zinc consistently exceeded the aquatic foods criteria. Median concentrations of ammonia exceeded the ANZECC (2000) recreational water quality criteria with iron also exceeding the respective criteria on some occasions. The results are indicative of a highly disturbed urban waterway.	Kogarah Golf Course is affected in flood events. A ponding area forms in the northern portion of the golf course. High hazard flooding conditions and floodway areas are generally confined to the main channel of the Cooks River in the vicinity of the golf course and M5 East Motorway.

[1] AECOM, 2015, New M5 Environmental Impact Statement

Water body	Project components	Description of water quality	Existing flood behaviour
Muddy Creek - The Muddy Creek catchment covers an area of approximately 615 hectares and flows in a north-easterly direction until it meets the Cooks River. High density residential and commercial development is present along the major transport corridors, as well as the Rockdale town centre, while an industrial area is centred on West Botany Street and Lindsay Street[2]. The Muddy Creek channel has been highly modified as a result of urbanisation and consists of a series of concrete and brick lined channels and closed box culvert structures that extend from Willison Road in Carlton to Bestic Street in Kyeemagh.	Construction • The construction water treatment plants for C2 and C3 would discharge to stormwater drainage ultimately draining to Muddy Creek. Operation • The shared cycle and pedestrian pathway between Bestic Street and Bay Street for pedestrians and cyclists is located within the Muddy Creek catchment. The tunnel also passes through the catchment.	Surface water monitoring was undertaken as part of the Project (SW1 and SW2 on Figure 18-1) within Muddy Creek. Median concentrations of total nitrogen, total phosphorus, reactive phosphorus, copper and zinc exceeded ANZECC (2000) slightly to moderately disturbed trigger levels with lead, nitrate and ammonia also exceeding on some occasions. Median zinc concentrations exceeded the aquatic foods criteria and zinc, copper, lead and ammonia concentrations were also above the 80% species protection level on some occasions. Median ammonia and zinc concentrations exceeded the recreational water quality criteria on some occasions. Zinc consistently exceeded the aquatic foods criteria. The pH was below the ANZECC (2000) slightly to moderately disturbed low range level on one occasion at SW1. The results are indicative of a highly disturbed urban waterway.	A number of locations between Bay Street and Bestic Street are affected during flood event. High hazard flooding conditions are generally confined to the main channel of Muddy Creek where it runs between West Botany Street and Bestic Street, adjacent to the alignment of the proposed shared cycle and pedestrian pathway. A section of West Botany Street and Bruce Street to the south of Muddy Creek acts as a floodway during a flood event.

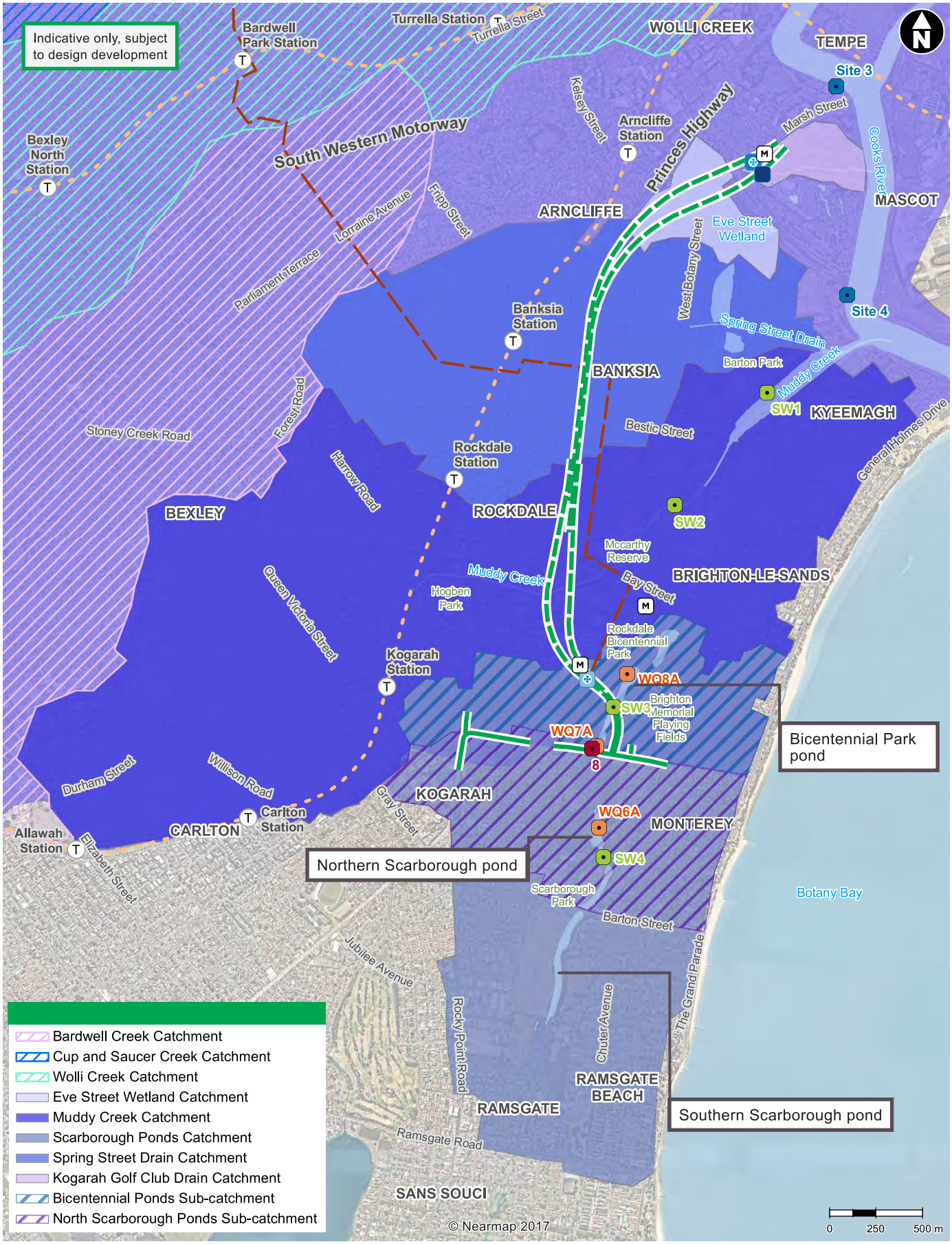
[2] Lyall and Associates, 2017, Southlink Motorway Flooding and Drainage Investigation, Volume 1 – Report

Water body	Project components	Description of water quality	Existing flood behaviour
Scarborough Ponds - Scarborough Ponds catchment covers an area of approximately 400 hectares and comprises a series of three pond systems including Rockdale wetland, the Northern Scarborough Pond and the Southern Scarborough Pond. The western and eastern sides of the catchment predominantly comprise medium density residential development with some industrial development situated around the northern edges of the Rockdale wetland. Stormwater runoff from urbanised areas is conveyed by a pit and pipe network into Scarborough Ponds via a series of piped outlets[2].	Operation • Tunnel portals with entry and exit ramps connecting the project tunnels with President Avenue • Widening and raising of President Avenue between Oakdale Avenue and O'Connell Street to accommodate the new connection • Rockdale Motorway Operations Complex (north) (MOC2) which would house the Operational Motorway Control Centre, car parking, deluge tanks, workshop, office, bulky equipment store, pump station and pump room and a work yard • Rockdale Motorway Operations Complex (south) (MOC3) which would house the Rockdale Ventilation Facility and an electrical substation • Network adjustments at the Princes Highway/ President Avenue intersection to provide additional southbound left turn and northbound right turn lanes onto President Avenue • Shared cycle and pedestrian pathway between Bay Street and Civic Avenue for pedestrians and cyclists • Operational water quality basin in the south-eastern corner of Rockdale Bicentennial Park which would discharge to Rockdale wetland • Construction access decline, deluge system and maintenance depot near West Botany Street.	Surface water monitoring was undertaken at the Rockdale wetland (SW3) and the Northern Scarborough Ponds (SW4) as part of the Project. In Rockdale wetland, median concentrations of ammonia, total nitrogen, total phosphorus, reactive phosphorus, copper and zinc exceeded ANZECC (2000) freshwater trigger levels with chromium, nitrate and lead also exceeding on some occasions. Iron and manganese concentrations also exceeded the ANZECC (2000) recreational water quality criteria. Ammonia, copper, lead and zinc concentrations exceeded the 80% species protection level on some occasions. All iron concentrations exceeded the recreational water quality criteria as did the median ammonia concentrations. In Northern Scarborough Ponds, median concentrations of total nitrogen, total phosphorus, copper and zinc exceeded the estuarine/marine trigger levels. All ammonia concentrations exceeded the recreational water quality criteria and iron concentrations exceeded the recreational water quality criteria on some occasions. The pH was outside the trigger levels range on some occasions. Some of the total nitrogen concentrations were higher than levels typical of urban stormwater inflows indicating the elevated levels are likely to be related to another source. Equatica[3] indicated that the elevated nitrogen levels in the Rockdale wetland were likely to be attributable to groundwater inflows affected by residual waste within a landfill located adjacent to the Rockdale wetland. Water quality monitoring was conducted by GHD in 2016-17 on behalf of Bayside Council, Equatica in 2012-13 on behalf of the former Rockdale City Council and in 1999 by Rockdale City Council. The key findings in relation to water quality within the receiving waters of Rockdale wetland and Northern Scarborough Pond are detailed in Appendix M (Surface water technical report). The results are indicative of a highly disturbed urban waterway. There are existing odour issues at the Scarborough Ponds associated with temperature inversions (a natural phenomenon common to lakes and waterways). Refer to section 4.1.3 of Appendix M (Surface water technical report) for further information.	Capacity constraints in the piped drainage system which runs under Rockdale Bicentennial Park results in flooding being experienced in a number of commercial / industrial properties which are located on the western side of West Botany Street for flood events. Existing commercial / industrial development located at the eastern end of Bermill Street is also impacted by flooding during storms. While existing residential development is not impacted by main stream flooding along Scarborough Ponds Creek, several properties located along the eastern and western sides of the open space corridor through which the creek runs are impacted during a flooding event. The reach of Scarborough Ponds as it runs through the Rockdale Bicentennial Park acts principally as a flood storage area for flood events. Depths of ponding along this reach of Scarborough Ponds are sufficient to result in hazardous conditions arising during a flood.

Table 18-3 Other water bodies within the study area

Water body	Project components	Existing flood behaviour
Spring Street Drain - The Spring Street Drain sub-catchment covers an area of approximately 257 hectares and flows in an easterly direction through a concrete lined channel until it meets Muddy Creek. A sub-branch of the Spring Street Drain runs in a north-easterly direction and joins the main channel approximately 160 metres upstream of West Botany Street. This sub-branch comprises a series of channel and culvert reaches, ending in a concrete lined channel where it discharges into Spring Street Drain[2].	The mainline tunnel crosses under the Spring Street Drain. No surface works are proposed within the catchment. As the project would not impact the waterway or catchment at surface, surface water impacts within this catchment have not been considered any further.	While the project is in tunnel where it crosses the Spring Street Drain catchment, it is noted that floodwater originating from the Spring Street Drain catchment discharges to Muddy Creek along Bestic Street.
Eve Street Wetland – Eve Street Wetland covers an area of approximately 28 hectares and drains to the west. The catchment is predominantly low to medium density residential development with some areas of open space in its lower reaches. Stormwater runoff from urbanised areas is conveyed by a pit and pipe network into Eve Street Wetland. Flows that surcharge the Eve Street Wetland are conveyed via a vegetated channel in an easterly direction under the bridged section of the M5 Motorway, prior to discharging into the Cooks River[2].	The mainline tunnel crosses under the Eve Street Wetland catchment. No surface works are proposed within the catchment. As the project would not impact the waterway or catchment at surface, surface water impacts within this catchment have not been considered any further.	While the project is in tunnel where it crosses the Eve Street Wetland catchment, it is noted that floodwater originating from the Eve Street wetland discharges to Muddy Creek along Bestic Street.
Kogarah Golf Club drain - An unnamed watercourse runs easterly through the Kogarah Golf Club course. The drain, an artificial, tidally affected watercourse. Its catchment is around 15 hectares receiving runoff from the southern portion of the golf course.	A portion of the stormwater runoff generated within the project operational water treatment plant would be discharged to the drain.	N/A
Other waterways	The proposed power supply connection between the Ausgrid Canterbury sub-transmission substation and the Rockdale Motorway Operations Complex south runs through the catchments of Cup and Saucer Creek, Wolli Creek, Bardwell Creek, Muddy Creek and Rockdale wetland. As the project would not impact the waterway or catchment at surface, surface water impacts within this catchment have not been considered any further.	N/A

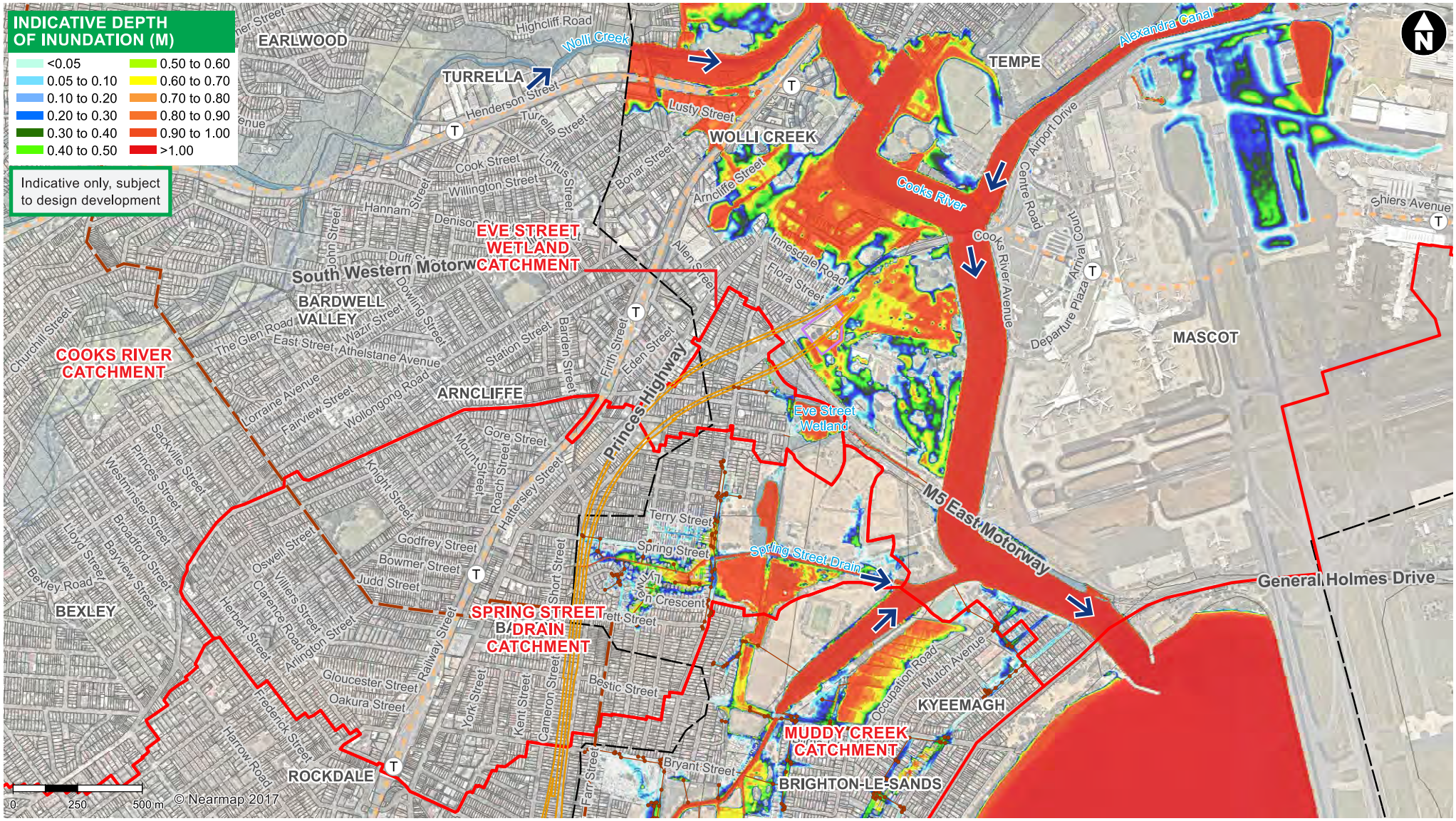
[3] Equatica, 2011. Bicentennial Park Wetland Concept Report, prepared for Rockdale City Council



LEGEND

- The project in tunnel
- The project on surface
- Permanent power supply line
- Water treatment facility
- Rockdale ventilation facility
- Motorway operations complex
- Arncliffe ventilation facility*
- * Under construction as part of the New M5 Motorway project
- F6 SW Quality Monitoring Program
- New M5 Monitoring Program
- Rockdale Water Quality Monitoring Study 2012-2013
- Scarborough and Bicentennial Ponds and Tonbridge Creek Water Quality Monitoring Study
- Railway station
- Railway line
- Waterway
- Waterbody

Figure 18-1 Surface water hydrology and monitoring locations



LEGEND

- The project in tunnel
- Motorway operations complex
- Catchment boundary
- Permanent power supply line
- Two-dimensional model boundary
- Existing drainage system
- Flow direction arrow

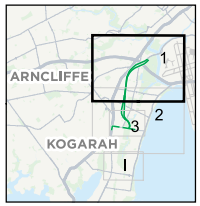
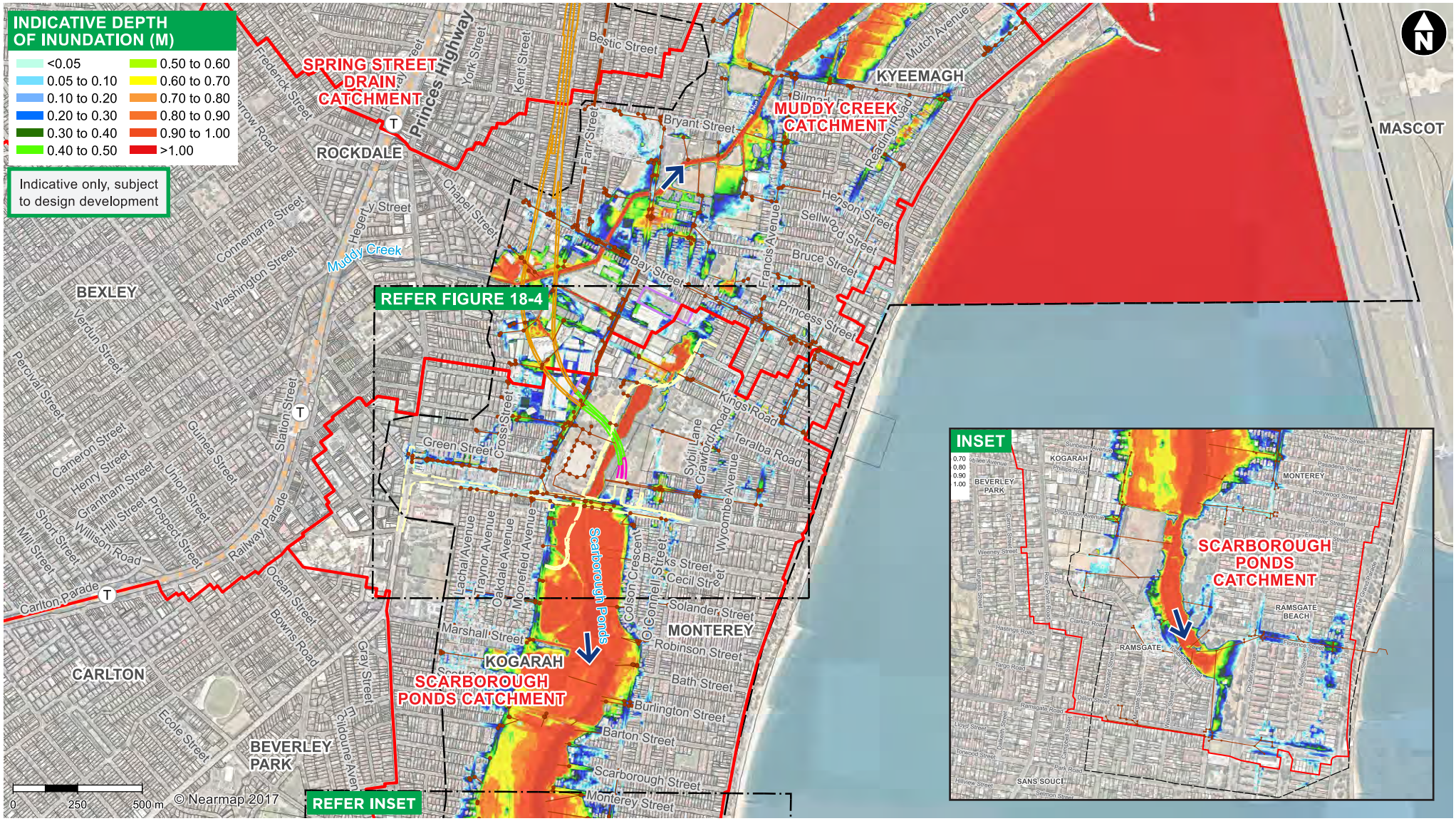


Figure 18-2 Present day flooding patterns at one per cent AEP



LEGEND

- The project in tunnel
- The project on surface
- The project as an open slot
- The project as cut-and-cover
- Motorway operations complex
- Catchment boundary
- Permanent power supply line
- Two-dimensional model boundary
- Existing drainage system
- Flow direction arrow

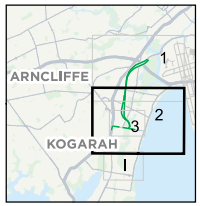
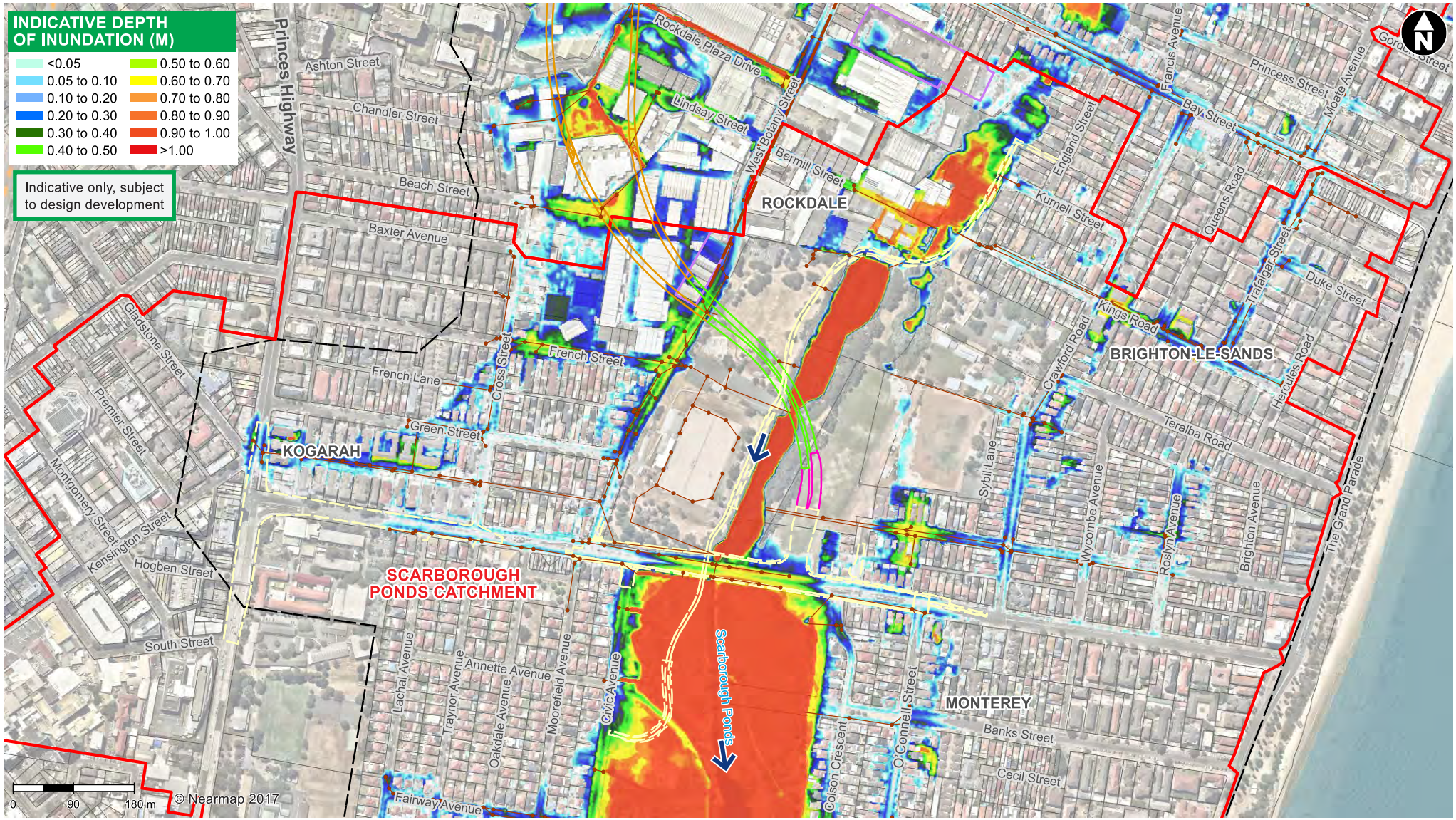


Figure 18-3 Present day flooding patterns at one percent AEP



LEGEND

- The project in tunnel
- The project on surface
- The project as an open slot
- The project as cut-and-cover
- Motorway operations complex
- Catchment boundary
- Permanent power supply line
- Two-dimensional model boundary
- Existing drainage system
- Flow direction arrow

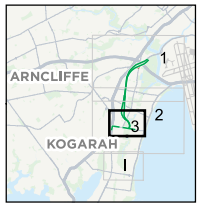


Figure 18-4 Present day flooding patterns at one per cent AEP

18.2.2 Riparian corridors

Existing riparian vegetation has been identified and assessed within EIS **Appendix H** (Biodiversity development assessment report). A summary of the riparian vegetation is provided in **Table 18-4** below.

Table 18-4 Summary of riparian vegetation

Surface water feature	Description of riparian vegetation
Rockdale wetland	Dense cover of native trees with scattered shrubs and groundcovers. Dense weeds such as *Lantana camara* (Lantana) and *Erythrina crista-galli* (Cockspur Coral Tree) occurred in patches.
Open channel between President Avenue and Northern Scarborough Pond	A dense reedland of *Typha orientalis* (Typha) and *Phragmites australis* (Common Reed) extended westward of the channel, whilst the eastern bank supported scattered *Casuarina glauca* (She Oak) trees.
Muddy Creek upstream of Bestic Street	Saltmarsh and mangroves present. High impact weeds included *Juncus acutus* (Sharp Rush) at the southern extent of the saltmarsh. Vegetation within drainage lines entering Muddy Creek included a narrow mangrove forest originating from a stormwater culvert at Cairnsfoot Special School. The other was west of the C A Redmond football field, comprised of mown lawn and reeds (*Phragmites australis*).

18.2.3 Sensitivity of receiving environments

A summary and assessment of the sensitivity of the receiving environments (including estuarine and marine environments downstream) to hydrological and water quality impacts associated with the project is provided within **Table 18-5**.

The chain of ponds which make up Scarborough Ponds are considered to be of moderate sensitivity due to having good ecological habitat despite being highly modified systems. Botany Bay is considered to be a moderately sensitive downstream environment considering its high conservation value and significant tidal exchange. Cooks River and Muddy Creek are considered to be of low sensitivity due to their limited ecological habitat and significant tidal exchange.

Table 18-5 Sensitivity of receiving environments

Surface water feature	Description of surface water feature in study area	Condition	Sensitivity
Receiving Environments			
Lower Cooks River	Estuarine, anthropogenic banks, poor water quality, limited riparian vegetation in reach within study area, key fish habitat, some recreational use.	Highly disturbed	Low
Muddy Creek	Estuarine, anthropogenic channel, poor water quality, limited riparian vegetation, some ecological value in estuarine reach, some recreational use.	Highly disturbed	Low
Rockdale wetland	Freshwater, modified open water body, poor water quality with tendency for algal blooms, provides ecological habitat and passive recreational use.	Highly disturbed	Moderate
Northern Scarborough Ponds	Tidally influenced, modified open water body, poor water quality, provides ecological habitat and passive recreational use.	Highly disturbed	Moderate
Southern Scarborough Ponds	Tidally influenced, modified open water body, provides ecological habitat and passive recreational use.	Highly disturbed	Moderate
Botany Bay	Estuarine, largely unmodified, good water quality, high ecological value, high recreational value.	High conservation value	Moderate

18.3 Potential impacts – construction

18.3.1 Surface Water

This section identifies and assesses the potential construction phase impacts to the hydrology, geomorphology, natural processes and water quality of surface waters.

Surface Water Balance

A water balance was conducted to estimate the annual volumes of surface water and groundwater that would be used and discharged during construction of the project. The water balance for each construction ancillary facility is summarised in **Table 18-6**. **Table 18-7** provides the estimated volumes of water that would be discharged during construction from each facility. The proposed construction discharge points are shown in **Appendix L** (Surface water technical report).

Table 18-6 Construction surface water balance

Construction Ancillary Facility	Surface Water inputs (ML/year)	Groundwater inputs (ML/year)	Groundwater / Surface Water losses following reuse (ML/year)	Total discharge volume (ML/year)
C1	37	193	1	229
C2	37	84	2	119
C3	140	Variable – 265 typical [1]	5	400
C4	0.9	0	Negligible	0.9
C5	0.6	0	Negligible	0.6
C6	1.8	0	Negligible	1.8

[1] Based on daily discharge volume during periods where dewatering of cut and cover tunnel works required.

Table 18-7 Construction daily discharge volumes

Construction Ancillary Facility	Daily discharge volume (ML/day)
C1	0.6
C2	Variable - 0.3 typical, up to 1.5 short term rate [1]
C3	Variable – 0.8 typical, up to 2.0 short term rate [1]
C4	0.0025
C5	0.0017
C6	0.0049

[1] Based on daily discharge volume during periods where dewatering of cut and cover tunnel works required

It is noted that groundwater discharge volumes estimated for the President Avenue construction ancillary facility (C3) reflect what is considered to be an upper bound of potential inflows as a result of dewatering of cut and cover tunnel works. Construction methods, staging and sequencing would require further consideration during detailed design to ensure that inflows are maintained at manageable levels within the constraints of the construction site.

During construction, treated groundwater and surface water would be discharged to the surface water environment from each of the construction ancillary facilities. A comparison between the discharge volumes and daily flows within the waterways is provided in **Table 18-8**.

During dry periods, water levels in the Rockdale wetland are controlled by local groundwater levels and the Rockdale wetland weir. Therefore an increased inflow from construction discharges is unlikely to significantly affect the water level within the pond with the additional flow discharging over the weir and being conveyed to the Northern Scarborough Pond.

Table 18-8 Assessment of discharge volume impacts during construction

Potential impact	Estimated mean daily flow	Estimated tidal inflow per tidal cycle
Northern Scarborough Pond	3 ML/day	< 6 ML/day
Muddy Creek	13 ML/day	76 ML/day
Cooks River	230 ML/day	2170 ML/day
C1	0.6 ML/day	Not applicable
C2	0.3 typical, up to 1.5 short term rate [1]	Not applicable
C3	0.8 ML/day up to 2.0 [1] ML/day short term rate	Not applicable
C4	0.0025 ML/.day	Not applicable
C5	0.0017 ML/day	Not applicable
C6	0.0049	Not applicable

[1] Based on daily discharge volume during periods where dewatering of cut and cover tunnel works required.

The increase in flow would likely have a minor impact on water levels within the Northern Scarborough Pond. The additional flow may increase flushing through the system which may temporarily alter stratification conditions during construction.

Due to the relatively higher sensitivity of Northern Scarborough Pond (including existing odour issues) and with consideration to the estimated discharge volumes when compared to daily flows and tidal exchange within that waterway, the continuous discharges from the construction water treatment plant at the Rockdale construction ancillary facility (C2) would instead be directed via stormwater drainage to the less sensitive Muddy Creek. Whilst volumes associated with dewatering of excavations and groundwater inflows at the President Avenue construction ancillary facility (C3), prior to sealing of the base of the cut and cover structure, are likely to be relatively minor, there is potential for short term higher inflows to occur if rock fractures are intercepted. To manage this risk, it is assumed discharges from the construction water treatment plant at the President Avenue construction ancillary facility (C3) are also directed to Muddy Creek.

Connection works in West Botany Street would be required to facilitate a pumped connection to stormwater drainage towards Muddy Creek and siting of the water treatment plant in the north west portion of the President Avenue construction ancillary facility (C3). Surface water discharges from the facility would continue to be directed to Rockdale wetland and Northern Scarborough Pond.

Discharges from the shared cycle and pedestrian pathways construction ancillary facilities (C4 and C5) would be minor only due to their relatively small footprint, with negligible hydrologic impact. There would be no change in the impervious area for the Princes Highway construction ancillary facility (C6) footprint, therefore discharges would not change from existing conditions. Discharges from other localised road and power supply connection works would also be minor due to their relatively small footprint, with negligible hydrologic impact due to the existing surfaces being primarily impervious.

Waterway disturbance

Construction activities at the President Avenue construction ancillary facility (C3) would result in the direct disturbance of a large proportion of the Rockdale wetland and a small portion of the open channel south of President Avenue (which drains to the Northern Scarborough Pond). Construction activities for the project would not directly disturb the Northern Scarborough Pond.

Diaphragm walls would be installed from the surface to form a water tight wall prior to the cut and cover excavation works commencing for the construction of the ramps and portals. The Rockdale wetland bed and banks inside the diaphragm walls would be dewatered and excavated and require complete restoration following construction. A temporary diversion channel would be provided within the Rockdale wetland to divert water flows around the disturbance footprint during construction.

The cut and cover tunnel excavation works would not commence within the pond until management measures such as a coffer dam and the water tight diaphragm wall had been installed. Therefore, with the proposed diversion channel providing hydrologic connectivity within the pond and a continuous groundwater inflow, the cut and cover tunnel construction and associated dewatering is considered to pose a negligible impact to flows through the Rockdale wetland. Impacts to water levels within areas of the Rockdale wetland outside the construction footprint are also likely to be negligible.

Hydrologic connectivity and the hydraulic control between the Rockdale wetland and Northern Scarborough Pond may be disrupted during the works to widen President Avenue. Temporary measures to drain storm flows between the Rockdale wetland and Northern Scarborough Pond would be required throughout construction.

Whilst the Rockdale wetlands bed and banks would be significantly disturbed within the coffer dam/diaphragm wall, and its surface area would be reduced, around 90% of the Rockdale wetland surface area would be retained throughout construction. Therefore geomorphic processes such as sedimentation of suspended solids conveyed in stormwater runoff would continue to occur.

Floating wetlands have been installed by Bayside Council in the southern part of Rockdale wetlands. A trash rack is also installed on the stormwater outlet located downstream of the Rockdale Bicentennial Park car park. The floating wetlands are unlikely to be directly disturbed as a result of the construction works, but would need to be protected and maintained during construction. The stormwater pipe would be diverted around the cut and cover structure and the trash rack relocated or replaced.

The pond would eventually be restored following completion of the tunnelling and shared cycle and pedestrian pathway works. Potential opportunities to incorporate improvements to the Rockdale wetland system as part of the restoration works are described in **section 18.6**.

A small portion of the open channel south of President Avenue would be filled in as part of the widening of President Avenue. However this would not result in any adverse impacts to the channel's hydraulic or hydrologic function, albeit slightly reducing its length.

The disturbance to the bed and banks of the Rockdale wetland and open channel would significantly increase the turbidity within the Rockdale wetland and open channel within the disturbance footprint temporarily during construction. If not properly managed, disturbance of the Rockdale wetland and open channel has the potential to result in erosion and mobilisation of bed and bank sediments downstream. These sediments could potentially contain toxicants and elevated nutrients.

The proposed power supply connection would cross the catchments of Cup and Saucer Creek, Wolli Creek, Bardwell Creek, Spring Street Drain and Muddy Creek. Where the power supply connection corridor crosses the watercourses of Wolli Creek, Bardwell Creek and Muddy Creek, it would be installed in a conduit attached to existing bridges. The power supply connection corridor alignment would be finalised during detailed design with the alignment realigned around (or bored under) sensitive environmental features including Bardwell Creek. With implementation of the proposed management measure listed in **section 18.6**, potential impacts to these waterways are considered to be negligible for the power supply connection.

Discharge water quality

Assessment of the potential impacts of proposed discharges of treated construction wastewater and surface water on the receiving environment included identification of potential pollutants of concern in surface water together with a qualitative assessment of the impact, with consideration to the proposed water management systems and typical management practices adopted for road and tunnel projects. Due to the high level of uncertainty in pollutant quality, pollutant quantities were not estimated for surface waters. The quality and quantity of pollutants in tunnel groundwater were estimated based on available groundwater quality data, the discharge criteria and estimated tunnel water discharge volumes during construction. Given the high level of uncertainty in pollutant generation from other sources in construction tunnel water, pollutant quantities were not estimated for the other sources. Potential pollutants of concern were identified for consideration when identifying management measures.

Construction wastewater

Wastewater generated from the following construction zones / activities is considered to be 'construction wastewater' and would be captured, tested and treated at a construction water treatment plant (if required) prior to reuse, discharge, or disposal offsite if necessary. Construction wastewater would be generated from the following sources:

- Tunnelling works
- Surface works which intercept groundwater
- Any areas within the site compound which are identified during construction to be of high risk of contaminating surface waters (e.g. vehicle refuelling areas, chemical and fuel storage areas, concrete washout areas, vehicle washdown areas).

The construction tunnelling works would result in large volumes of wastewater being generated from the following sources:

- Groundwater ingress
- Rainfall runoff in open cut tunnel portals and ventilation shafts
- Dust suppression water
- Wash down runoff
- Concrete washout.

A high proportion of the water generated from tunnelling would be collected from groundwater seepage. Natural groundwater quality along the alignment is spatially and temporally variable. The groundwater quality review indicates that groundwater inflows into the tunnel works would likely contain elevated levels of chromium, iron, nickel, zinc, total nitrogen, total phosphate and ammonia. Groundwater inflows into the cut and cover construction works in Rockdale Bicentennial Park before the base is lined are likely to contain elevated concentrations of arsenic, iron, lead, nickel, zinc, total nitrogen and ammonia, which could lead to impacts such as increased turbidity, lower dissolved oxygen levels and nutrients, increases in toxicant concentration and increased alkalinity.

The use of chemicals in the treatment and curing process of concrete as well as the concrete dust itself could result in the tunnelling wastewater having an increased alkalinity.

Rainfall runoff in excavated tunnel portals and ventilation shafts may account for loading of atmospheric pollutants such as nitrogen into the tunnel wastewater, however the loads are likely to be negligible in comparison to the respective loading from groundwater inflows.

Wastewater from vehicle refuelling areas and fuel storage areas would be captured within bunded areas, tested and then either treated within the construction water treatment plant or discharged at a licensed facility.

Wastewater generated by dewatering activities during trenching of the proposed power supply connection would be managed in accordance with Managing Urban Stormwater Soils and Construction, Volume 2A Installation of services (DECC, 2008a) to minimise potential impacts to downstream waterways.

Water quality and discharge volumes from the tunnels are likely to be highly variable due to the program of activities during construction. A high level estimate of the quantity of pollutants likely to be discharged from each treatment plant is provided in **Table 18-9**. The assumptions for this estimate are described in section **Appendix L** (Surface water technical report).

Provided that the treatment measures discussed in **Section 18.6** achieve the recommended discharge criteria, tunnel wastewater discharges during construction are likely to have a negligible impact on receiving water quality.

Table 18-9 Construction wastewater pollutant quantities at discharge locations

Pollutant	Arncliffe (C1) Groundwater discharge (DP1) (kg/yr)	Rockdale (C2) Groundwater discharge (DP2) (kg/yr)	President Avenue (C3) discharge (DP3) (kg/yr)
Arsenic	1.9	2.0	5.5
Cadmium	0.01	0.01	0.05
Chromium (III + VI)	0.1	0.1	0.4
Copper	0.1	0.1	0.4
Iron	57.6	60	78
Lead	0.1	0.1	1.9
Manganese	71.0	74	164
Mercury	0.005	0.01	0.006
Nickel	1.0	1.0	1.9
Zinc	4.2	4.4	11
Total Nitrogen	192	442	571
Total Phosphate	38	50	3.1
Ammonia	307	322	441

Construction surface water

The quality and quantity of the pollutants generated within the construction areas would be variable and subject to the soil profile, phase of works, extent of disturbance, extent of pavement and roofs, construction activities and climatic influences (e.g. rainfall).

The key pollutants of concern from unsealed construction areas would be sediment (e.g. total suspended solids), oil and grease and pH. Other pollutants (such as nutrients) may also be bound to the sediment or present in dissolved form. Their concentrations would be variable but providing appropriate erosion and sediment controls are implemented, they are considered to pose a low risk to the surface water environment and human health during the construction phase of the Project.

The tunnelling construction ancillary facilities would be paved at the commencement of the project. Water quality and the volume of surface water being discharged from the construction ancillary facilities are likely to be highly variable due to the program of activities during construction.

Provided that the management measures are implemented during construction and the discharge criteria is achieved (see **section 18.6**), short term impacts are expected to be manageable With the measures in place, the pollutant load being discharged from the project will be minor compared to the pollutant load being discharged to the receiving waterways from the wider catchment and with consideration to the tidal flushing effect which will occur within the estuarine receiving environments resulting in a negligible impacts on receiving water quality are considered to be negligible.

Assessment of potential construction impacts

The potential construction impacts on surface water hydrologic and geomorphic processes and water quality are summarised in **Table 18-10**.

Table 18-10 Potential construction impacts on surface water

Construction activities/source of pollutants	Potentially affected waterways	Potential impacts
Discharge from construction water treatment plants	Rockdale wetland North Scarborough Pond Cooks River Muddy Creek	Increase in baseflow rate to receiving waterways Impacts to ambient water quality from the presents of pollutants as a result of poorly treated discharges
Discharged of wastewater directly to receiving waterways or significant increase in discharge volume	Rockdale wetland North Scarborough Pond Cooks River	Mobilisation of sediment and scour
Construction activities associated with President Avenue interchange and shared cycle and pedestrian pathway	Rockdale wetland North Scarborough Pond	Impacts to the hydrological and geomorphic processes within Scarborough Ponds from changes to discharge volumes
Construction of surface works at President Avenue and the construction of main tunnel, ventilation tunnel and shared cycle and pedestrian pathway	Rockdale wetland North Scarborough Pond	Disturbance of Scarborough Ponds bed and banks resulting in increased erosion and sedimentation
Construction activities at the President Avenue construction ancillary facility (C3)	Rockdale wetland	Direct disturbance of Rockdale wetland and a small portion of the open channel south of President Avenue resulting in disrupted hydrologic connectivity and increased turbidity
Open cuts, batter slopes and stockpiles Direct disturbance of waterway bed and/or banks as a result of earthworks and construction of instream structures	Rockdale wetland Northern Scarborough Pond Cooks River Muddy Creek	Erosion and mobilisation of exposed soils from stormwater runoff and wind, leading to sedimentation in receiving waterways and impacts on water quality (increased turbidity, lower dissolved oxygen levels and nutrients which could lead to algal blooms and aquatic weed growth, increases in toxicant concentration and reduced visual amenity)
Dust, litter and other pollutants associated with building materials and demolition waste	Rockdale wetland Northern Scarborough Pond Cooks River Muddy Creek	Mobilisation of pollutants into waterways leading to impacts on water quality and reduced visual amenity
Leakage or spills of petroleum hydrocarbons, oils and greases from machinery, equipment or plant or during refuelling Washdown water from construction plant washing or concrete washout water Mobilisation of dust to waterways	Rockdale wetland Northern Scarborough Pond Cooks River Muddy Creek	Pollutants being conveyed to downstream waterways leading to impacts on water quality Increases in alkalinity and toxicant concentration which could lead to fish kills and other undesirable impacts
Construction activities associated with the permanent power supply installation. Open cuts, batter slopes and stockpiles	Cup and Saucer Creek Wolli Creek Bardwell Creek Spring Street Drain Muddy Creek Rockdale wetland	Impacts to ambient water quality as a result of poorly treated dewatered groundwater from power supply connection trench. Oil sheen on water surface and increases toxic concentration which could lead to fish kills and other undesirable impacts.

Measures to manage potential impacts associated with waterway disturbance, hydrological processes and construction discharges are provided in **section 18.6**. The assessment of impacts and management of potentially contaminated sediments, acid sulphate soils and salinity are provided in **Chapter 16** (Soils and contamination).

Measures to manage potential impacts include the development of discharge criteria for the construction water treatment plant at the President Avenue construction ancillary facility (C3) during construction. The criteria have been developed in accordance with ANZECC (2000) and with consideration of the NSW WQOs. The discharge criteria for the construction water treatment plant are provided in **Table 18-21**.

The proposed surface water management measures aim to minimise short term impacts on the receiving waterways during construction. With the implementation of the management measures, and in the context of the overall catchment, any potential short term impacts are unlikely to have a material impact on ambient water quality within the receiving waterways.

Therefore the project is likely to have a negligible influence on whether the NSW WQOs are protected (if currently met) or achieved (if currently not met) during the construction phase.

The likely approach to surface and tunnel water management is outlined in **Figure 18-5**.

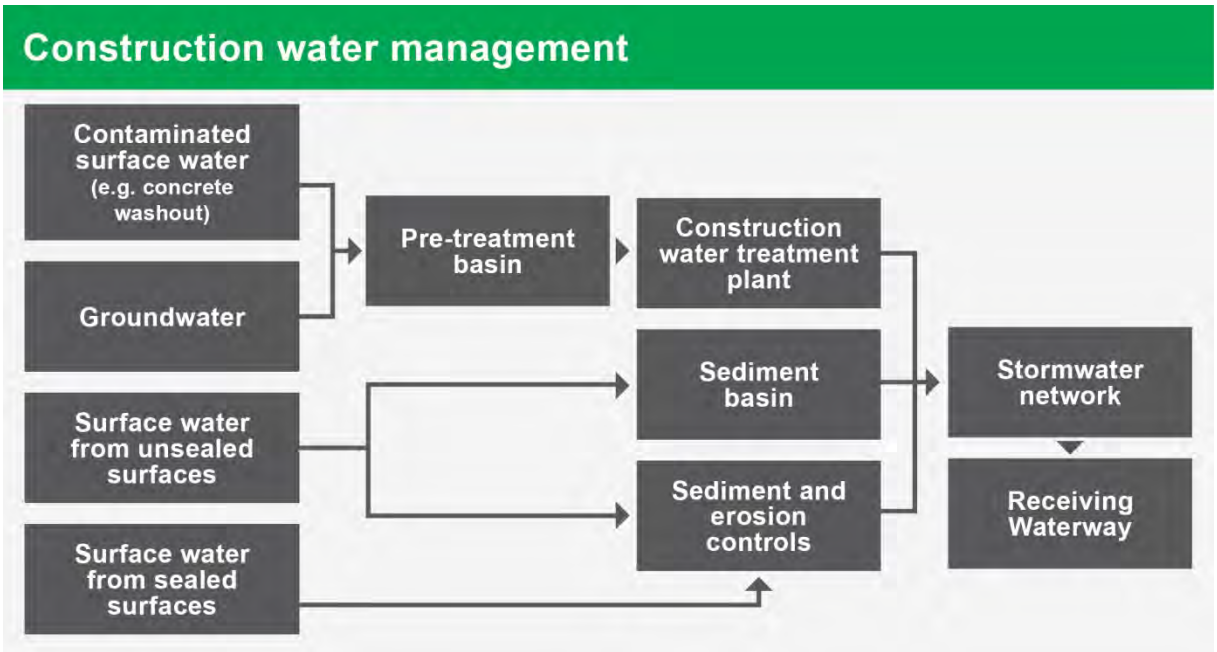


Figure 18-5 Surface water and tunnel water management during construction

18.3.2 Flooding

Construction works have the potential to change flood behaviour and impact on the surrounding environment. In addition, flooding has the potential to impact on areas within and near construction sites for the project (i.e. potential inundation of project sites).

Construction of the project would involve a range of activities at sites of both permanent and temporary occupancy. The construction activities associated with the project that could result in impacts if not mitigated include:

- A range of site facilities including offices, staff amenities, workshops and parking at the five construction ancillary facilities. Site facilities located on the floodplain could pose a safety risk to construction personnel
- The construction of the project would generate a significant amount of spoil which would need to be temporarily stored in stockpile areas. Stockpiles located on the floodplain have the potential to obstruct floodwater and thereby alter flooding patterns. Inundation of stockpile areas by floodwater can also lead to significant quantities of material being washed into the receiving drainage lines and waterways
- Tunnel excavation would likely be carried out using road headers that would be launched from Arncliffe construction ancillary facility (C1) and Rockdale construction ancillary facility (C2). While the tunnel boring arrangement would be designed to accommodate a nominal amount of stormwater runoff, the ingress of floodwater to the tunnel excavations poses a significant risk to personnel safety. It also has the potential to cause damage to machinery and delays in the project timetable
- The construction of cut and cover structures would be carried out at Rockdale construction ancillary facility (C2) and President Avenue construction ancillary facility (C3). The potential for ingress of floodwater into the open excavations poses a significant risk to personnel safety, as well as having the potential to cause damage to machinery and delays to the project timetable
- The main area of surface earthworks on the project would be the construction of the proposed interchange at President Avenue and the associated widening and raising of the existing road. Surface earthworks would also be required to construct the sections of shared cycle and pedestrian pathway that are not located on elevated structures. The inundation of the surface earthworks by floodwater has the potential to cause scour of disturbed surfaces and the transport of sediment and construction materials into the receiving waterways
- A dedicated shared bridge would be constructed over President Avenue and a section of Scarborough Park North. In order to construct the bridge it would be necessary to provide a temporary access road, as well as a series of working pads within Scarborough Park North in an area that is inundated by floodwater that surcharges to Scarborough Ponds during storms. The inundation of the access road and working pads by floodwater has the potential to cause the transport of sediment and construction materials into the receiving waterways as well as damage to machinery and delays to the project timetable. Conversely, raising the access road and working pads to reduce the potential for flooding to the work areas would have the potential to displace floodwaters and exacerbate flood behaviour in adjacent development
- The provision of temporary measures such as site sheds, stockpiles, noise walls and flood protection walls could obstruct the passage of floodwater and overland flow through, which in turn could exacerbate flooding conditions in existing development located outside the construction footprint. Potential increases in peak flood levels could have social and economic impacts on the surrounding community such as damage to residential properties and increased need for emergency response procedures from state emergency services during times of flood.
- The installation of the permanent power supply would be underground either by trenching or, where required, under-boring. The power line would be located within the existing road reserves, with the exception of where it would cross Bardwell Valley Golf Club and pass along the edge of Silver Jubilee Park. The construction site has the potential to be inundated during wet weather events, including trenches and areas of ground disturbance. Dirty floodwater has the potential to scour disturbed surfaces and transport sediment and construction materials into the receiving waterways.

Assessment of potential construction impacts

Potential impacts on flood behaviour at each site during a one per cent AEP design storm are summarised in **Table 18-11**. Further details, including figures showing flooding patterns under construction phase conditions and the increase in water level that could potentially be caused by blocking effects of the construction site, are provided in **Appendix M** (Flooding technical report). The extent to which the proposed construction activities would increase above-floor inundations is subject to further hydraulic assessment during detailed design.

Table 18-11 Potential construction impacts on flooding

Location	Proposed facilities and activities	Potential impacts on flood behaviour
Arncliffe construction ancillary facility (C1)	Site facilities Spoil management Tunnel launch and support	Potential displacement of water due to blocking effects of the construction site. Potential increase in peak flood levels at 16 residential and commercial properties and two lots currently being used for car parking to the north of Marsh Street between 20 and 400 mm. Potential increase in the depth of above-floor inundation on at least one residential property.
Rockdale construction ancillary facility (C2)	Site facilities Spoil management Cut and cover structures Surface earthworks	Potential displacement of water due to blocking effects of the construction site. Potential increase in peak flood levels in two residential properties in West Botany Street by a maximum of 120 mm. Potential increase in above-floor inundation and flood damages in the affected properties
President Avenue construction ancillary facility (C3)	Site facilities Spoil management Cut and cover structures Surface earthworks Bridge structures	Potential displacement of water due to blocking effects of the construction site. Potential increase in peak flood levels in 12 residential properties and one industrial property by a maximum of 20 mm. Potential increase in above-floor inundation and flood damages in the affected properties.
Shared cycle and pedestrian pathways east (C4) construction ancillary facilities	Site facilities Spoil management Surface earthworks	Potential displacement of water due to blocking effects of the construction site. Negligible impacts on existing flood behaviour
Shared cycle and pedestrian pathways west (C5) construction ancillary facilities	Site facilities Spoil management Surface earthworks	Potential displacement of water due to blocking effects of the construction site. Negligible impacts on existing flood behaviour
Princes Highway ancillary facility (C6)	Laydown and parking area for construction vehicles and equipment required for the construction of the President Avenue and Princes Highway intersection upgrade. The site would also include some offices, amenities and workshops	Potential displacement of water due to blocking effects of the construction site. Negligible impacts on existing flood behaviour in its immediate vicinity.
Bestic Street to Bruce Street shared cycle and pedestrian pathway	Surface earthworks (Shared cycle and pedestrian pathway)	Potential displacement of water due to temporary construction works.

Location	Proposed facilities and activities	Potential impacts on flood behaviour
England Street to Kings Road shared cycle and pedestrian pathway	Surface earthworks (Shared cycle and pedestrian pathway)	Potential displacement of water due to blocking effects of the construction site.
President Avenue to Civic Avenue shared cycle and pedestrian pathway	Surface earthworks (Shared cycle and pedestrian pathway) Bridge structures	Potential increase in peak flood levels by a maximum of 12 mm in the section of Scarborough Ponds to the south of President Avenue, as well as a significant number of properties that are located along the eastern and western sides of the open space corridor through which the watercourse runs. Potential displacement of water due to blocking effects of the construction site.
Princes Highway and President Avenue intersection upgrade	Surface earthworks	Potential displacement of water due to blocking effects of the construction site.
Permanent power supply alignment	Surface earthworks Spoil management	Potential displacement of water due to blocking effects of the construction site. The works would be localised, temporary and would involve minimal areas of disturbance. Impacts on the existing flood behaviour would be negligible.

While all ten construction sites would involve works within the floodplain that would need to be managed, the preliminary investigation found that the greatest potential for adverse impacts on flood behaviour in adjacent development is associated with Arncliffe construction ancillary facility (C1), Rockdale construction ancillary facility (C2), President Avenue construction ancillary facility (C3) and the President Avenue to Civic Avenue shared cycle and pedestrian pathways. There is also the potential for all ten construction sites to impact local catchment runoff.

While the findings of the initial assessment provide an indication of the potential impacts of construction activities on flood behaviour, further investigation would need to be undertaken during detailed design, as layouts and staging diagrams are further developed. Consideration would also need to be given to setting an appropriate hydrologic standard for mitigating the impacts of construction activities on flood behaviour, taking into account their temporary nature and therefore the likelihood of a flood of a given AEP occurring during the construction period.

Management measures which would be implemented to mitigate the potential construction related flooding impacts of the project are contained in **section 18.6**.

18.4 Potential impacts – operation

18.4.1 Surface Water

This section identifies and assesses the potential operation phase impacts to the hydrology, geomorphology, natural processes and water quality of surface waters.

Surface water balance

The project does not propose to extract surface water directly from any of the unregulated water sources within the study area during operation, discussed further in **Appendix L** (Surface water technical report).

A surface water balance was undertaken to estimate the operational impacts of the project to the annual volume of flow discharged to the surface water environment as a result of modified surface runoff and treated tunnel water discharges. A summary of the surface water balance for existing and operational conditions is provided in **Table 18-12** and **Table 18-13**. The proposed operational discharged points (ODP) are shown in Appendix L (Surface water technical report).

Table 18-12 Existing conditions surface water balance

Discharge point	Rainfall (ML / year)	Losses (ML / year)	Stormwater runoff volume (ML / year)	Treated tunnel groundwater discharge volume (ML / year)	Total discharge volume (ML / year)
ODP1	137.8	40.2	97.6	0.0	97.6
ODP2	61.1	25.2	35.9	0.0	35.9
ODP3	60.5	23.9	36.6	0.0	36.6
ODP4	169.6	72.3	97.4	0.0	97.4
ODP5	48.0	11.3	36.7 [1]	901.9 [2]	938.6
ODP6	47.1	4.2	42.8	0.0	42.8
ODP7	4.9	0.4	4.4	0.0	4.4
ODP8	21.7	17.6	4.1	0.0	4.1

Notes: 1 From existing New M5 Motorway Arncliffe construction compound; 2 From New M5 Motorway water treatment plant once operational

Table 18-13 Design operational conditions surface water balance

Discharge point	Rainfall (ML / year)	Losses (ML / year)	Stormwater runoff volume (ML / year)	Treated tunnel groundwater discharge volume (ML / year)	Total discharge volume (ML / year)	Impact to discharge volume (ML / year)
ODP1	137.8	38.7	99.1	0.0	99.1	1.6
ODP2	61.1	19.8	41.3	0.0	41.3	5.4
ODP3	60.5	23.8	36.6	0.0	36.6	0.0
ODP4	169.6	66.6	103.1	0.0	103.1	5.7
ODP5	1.3	0.1	1.2	1204.7 [1]	1205.9	268.3
ODP6	47.1	4.2	42.8	0.0	42.8	0.0
ODP7	4.9	0.4	4.4	0.0	4.4	0.0
ODP8	55.0	32.4	22.6	0.0	22.6	18.5

Notes: 1 Includes New M5 Motorway water treatment plant and F6 water treatment plant

Stormwater quality

The project includes sections of aboveground roadway, and interchanges with existing surface roads, and subsurface road tunnels. New surface roadway exposed to direct rainfall is proposed at the intersection of President Avenue and Princes Highway. The tunnel ramps at President Avenue would also generate a minor amount of surface runoff which would be captured and pumped to the surface for treatment.

Increases in impervious area (such as road pavement) exposed to direct rainfall would contribute to an increase in runoff volume and pollutant mobilisation. Runoff from road pavement would typically contain pollutants such as sediments, nutrients, oils and greases and heavy metals, from atmospheric deposition, vehicle leaks, operational wear, road wear or spills. These pollutants could potentially impact on water quality when discharged to receiving waterways.

A preliminary stormwater drainage strategy including treatment measures has been developed for the project which would be finalised during detailed design. The final selection and design of treatments would consider the sensitivity of the environment, changes in imperviousness as a result of the project, environmental, operational and hydraulic constraints and the BBWQIP objectives, which set targets for pollutant load reductions (discussed further in **Appendix L** (Surface water technical report)).

The stormwater drainage strategy would include the water quality basin to treat runoff from the tunnel portal at President Avenue. The water quality basin which incorporates biofiltration and swales are commonly used water sensitive urban design (WSUD) systems. They take into account WSUD principles by using vegetation and soil media to attenuate, filter and treat runoff prior to release to surface waters. Other opportunities to implement stormwater treatments (including passive treatments) for existing pavements and non-road pavement project elements would be investigated during detailed design.

Stormwater treatment of project elements may include:

- Landscaped areas will be suitably profiled, vegetated and stabilised to control erosion
- Passive treatment of stormwater from the shared cycle and pedestrian pathway pavement. This could include diverting stormwater to a grass or vegetated buffer adjacent to the pavement or through use of a permeable pavement system
- Incorporation of rainwater harvesting and proprietary devices to treat runoff from ancillary buildings and pavement where feasible and reasonable.

The above passive treatment and rainwater harvesting measures take into account WSUD principles by replicating a natural system through infiltration and reuse respectively to reduce runoff volumes.

Specifying a rainfall event for operational stormwater treatment measures is not considered to be appropriate. Operational measures are designed based on pollutant load reduction (rather than a rainfall event).

Tunnel water quality

The tunnels would require drainage infrastructure to capture two separate drainage streams, the first to collect groundwater ingress (tunnel groundwater) and a second to collect stormwater ingress at portals as well as spills, maintenance washdown water, fire suppressant deluge and other potential water ingress events.

The two tunnel drainage streams are expected to produce flows containing a variety of pollutants. The pre-treatment water quality of each drainage stream is expected to vary considerably, and consequently it is likely that the two drainage streams would need to be collected and treated separately as follows:

- Tunnel groundwater would be captured and pumped to the operational water treatment plant at Arncliffe.
- Tunnel surface water would be captured in the sump (pit that collects water) where it would undergo some treatment (sediment and free oil screening). The water would be tested and a determination made whether it can be:
  - pumped to surface and treated at the operational water treatment plant (if of suitable quality for the treatment plant to treat)
  - pumped to surface and discharged without further treatment
  - removed directly from the sump by tanker for treatment and disposal offsite.

Tunnel Groundwater

The groundwater quality review indicates that tunnel groundwater from the tunnel would likely contain concentrations of iron, total nitrogen and ammonia which are elevated in relation to the New M5 Motorway discharge criteria. The anticipated manganese concentration, whilst below the discharge criteria, is significantly elevated in comparison to ambient water quality within the Cooks River.

A “box model” was developed to assess how the quality and quantity of pollutants associated with treated releases from the operational water treatment plant would impact the Cooks River for two scenarios:

- Scenario 1 – The project’s treated tunnel water discharges (9.6 L/s Flow)
- Scenario 2 – Cumulative discharge of the project + New M5 Motorway + M4M5 Link treated tunnel water (38.2 L/s).

The findings are summarised in **Appendix L** (Surface water technical report).

The results indicate that impacts to ambient water quality within the Cooks River would be negligible with the exception of manganese for Scenario 2.

The adopted manganese concentration is likely to be conservative as some manganese would likely be removed during the primary sedimentation process. In any case, water quality (0.009 mg/L) would still be below both the ANZECC (2000) slightly to moderately disturbed criteria (3.6 mg/L) and recreational water quality criteria (0.1 mg/L) for manganese. No detrimental impacts as a result of the slight increase in concentration are likely to occur.

Iron, total nitrogen and ammonia treatment would likely be required to achieve the New M5 Motorway discharge criteria. The assumed zinc concentration in tunnel groundwater was only slightly above the proposed discharged criteria for Scenario 2. The benefits of treatment are considered to be negligible, therefore further investigation at detailed design would be required to determine whether zinc treatment is warranted.

Treated tunnel water discharges are likely to be fresher than the estuarine receiving waters in the Cooks River with groundwater drawdown at the tunnel potentially leading to an increase in tunnel water salinity over time (refer to Groundwater technical report (**Appendix K**)). The tunnel discharges are likely to provide a freshening effect to waters within the immediate vicinity of the outlet, which would be similar to the effect of fresh stormwater discharges occurring at the outlet. The freshening affect would diminish within close proximity of the outlet as mixing occurs. The freshening affect is also likely to diminish at the outlet overtime as tunnel water salinity increases. The box model indicates that impacts to ambient water quality within the Cooks River would be negligible due to the mixing and regular flushing of the system with the impact shown to diminish as tunnel water salinity increases.

Tunnel Surface water

The volume and quality of tunnel surface water would be highly variable. Surface water discharge volumes to the Cooks River would therefore also be highly variable with some highly polluted surface water potentially removed for treatment and disposal elsewhere. It is therefore not practical to assess the quantity of pollutants which could potentially be discharged. Tunnel surface water discharges would be intermittent and the quality would be consistent with the discharge criteria for the Cooks River. Therefore impacts as a result of tunnel surface water discharges to the Cooks River would be negligible.

The likely approach to operational water management is outlined in **Figure 18-6**.

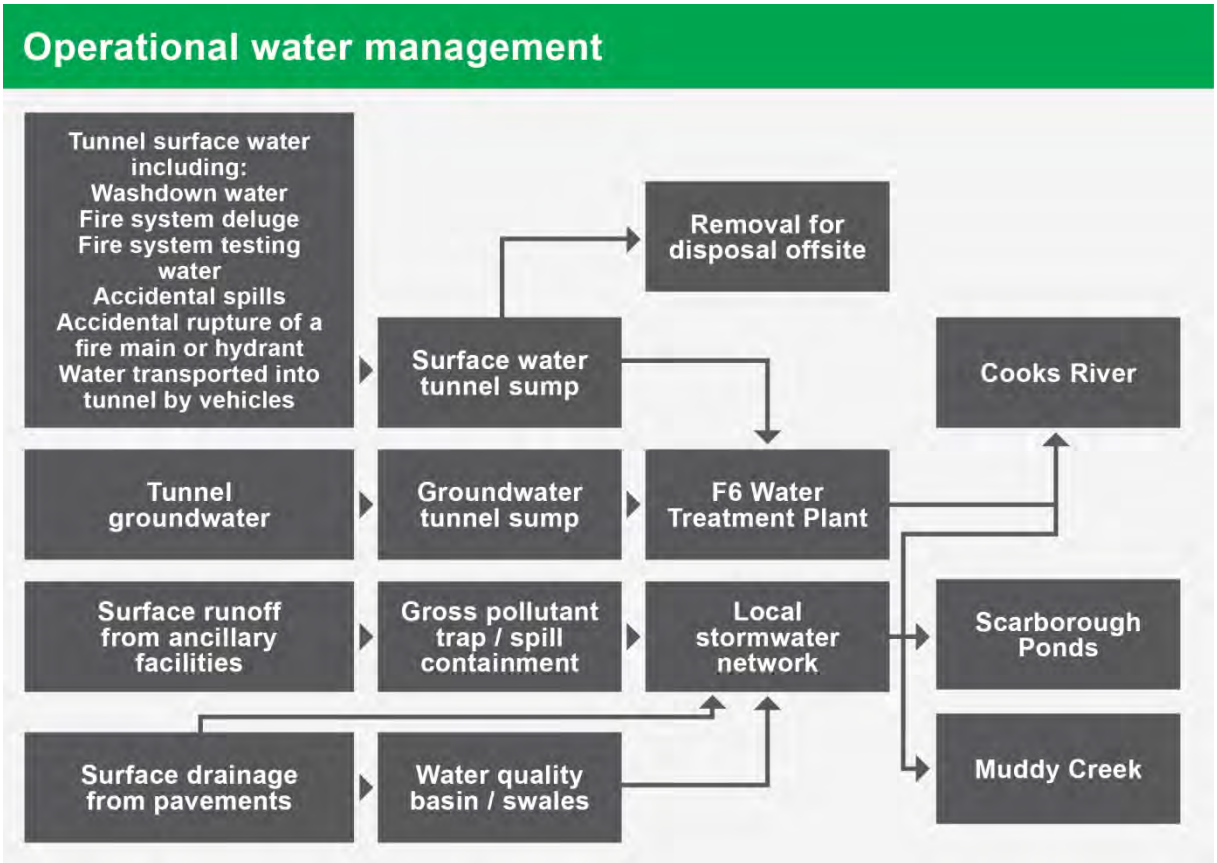


Figure 18-6 Operational water management

Spills

Spills of oils, lubricants, hydraulic fluids and chemicals could potentially occur during the operation of the project due to vehicle or plant and equipment leakages or a vehicle crash. Any contaminant spill within the project footprint has the potential to pollute downstream waterways, if conveyed to waterways via the stormwater network. The severity of the potential impact depends on the magnitude and/or location of the spill in relation to sensitive receptors, emergency response procedures and/or management controls implemented on site, and the nature of the receiving environment.

The preliminary stormwater drainage strategy and tunnel drainage strategy identified the need for spill containment facilities at the following locations:

- President Avenue water quality basin
- Mainline tunnel sump
- Ancillary facilities site at West Botany Street
- Water treatment plant site at Arncliffe

The proposed spill containment facilities would be designed to manage the potential risks to an acceptable level. Impacts to Scarborough Ponds and Cooks River are therefore likely to be minimal.

Impacts and management measures for contaminated runoff and spills are discussed further in **Chapter 16** (Soils and contamination).

Assessment of potential operational impacts

The potential operational impacts on surface water hydrologic and geomorphic processes and water quality are summarised in **Table 18-14**.

Table 18-14 Potential operational impacts on surface water

Activities/source of pollutants	Potentially affected waterways	Potential impacts
Continuous discharge from operational water treatment plant	Cooks River	Increase in baseflow rate to receiving waterways Impacts to ambient water quality as a result of poorly treated discharges
Increase in imperviousness in affected catchments	Rockdale wetland Northern Scarborough Pond	Increase in stormwater runoff volume
Discharges of wastewater at new discharge locations or where discharge volumes are significantly increased at existing locations	Rockdale wetland North Scarborough Pond Cooks River	Mobilisation of sediment and scour
Modifications to hydraulic controls and infilling to widen President Avenue	Rockdale wetland Northern Scarborough Pond	Impacts to hydrological regime
Poorly treated tunnel groundwater or surface water releases from the operational water treatment Poorly treated stormwater Spill events Increases in impervious area, such as road pavement, exposed to direct rainfall contributing to an increase in runoff volume	Cooks River Rockdale wetland Northern Scarborough Pond	Impacts to water quality (increased turbidity, lower dissolved oxygen levels and nutrients increases in toxicant concentration, increased alkalinity)

Impacts to the hydrologic and geomorphic processes, environmental water availability and flow would be negligible during operation. Management and mitigation measures are discussed in **section 18.6**.

Measures to manage potential impacts include the development of discharge criteria for the operational water treatment plant at Arncliffe. The criteria have been developed in accordance with ANZECC (2000) and with consideration of the NSW WQOs. The discharge criteria for the operational water treatment plant are provided in **Table 18-22**.

Impact on NSW Water Quality Objectives

Scarborough Ponds

The preliminary stormwater drainage strategy (which includes the water quality basin proposed at Rockdale Bicentennial Park) and proposed management measures discussed in **section 18.6** would minimise impacts to ambient water quality within Scarborough Ponds such that impacts to Scarborough Ponds are likely to be negligible.

Water quality within the Scarborough Ponds does not currently meet the NSW Water Quality Objectives.

Opportunities for the project to provide further stormwater quality improvements and to work towards achievement of the NSW WQOs for Scarborough Ponds would be considered during detailed design. MUSIC modelling (refer *Modified Treatment Opportunity*) indicates that by providing gross pollutant traps at two operational discharge points (ODP1 and ODP3), an overall reduction in pollutant loads could be achieved. As the operational surface infrastructure is only a small portion of the overall catchment, improvements to ambient water quality within Scarborough Ponds would still likely be negligible.

Ambient water quality improvements could also be achieved by incorporating measures to remove nutrients within Rockdale wetland as part of the restoration of the pond. These opportunities would be further investigated during detailed design.

Indicative discharge volumes from C3 are likely to be of a similar order of magnitude to tidal inflows in Northern Scarborough Pond. Provided the treatment measures achieve the recommended discharge criteria, impacts to toxicant and nutrient levels within Scarborough Ponds are considered to be negligible, if discharges are directed to Scarborough Ponds. Discharge of treated construction wastewater to Scarborough Ponds would increase the daily freshwater inflow to Northern Scarborough Ponds. This would alter the stratified salinity profile within the Northern Scarborough ponds in a similar way to intermittent fresh stormwater flows, although the impact would be continuous during construction. Given the receiving environment regularly receives fresh stormwater inflows, the temporary impact to the salinity profile during construction is unlikely to adversely impact the waterway.

Cooks River

Treated flows from the operational water treatment plant would increase the volume of water discharged into the Cooks River. Whilst it is unlikely that the project would have a beneficial impact on ambient water quality when increasing discharge volumes, the proposed treatment facilities would minimise the impact by treating groundwater to a quality suitable for discharge to the Cooks River. As discussed above, impacts to ambient water quality are likely to be negligible. Therefore the project is considered to have a negligible influence on stakeholder goals to achieve the NSW WQOs for the Cooks River over time.

Muddy Creek

Runoff from a portion of the shared cycle and pedestrian pathway would ultimately discharge to Muddy Creek during operation. With implementation of the proposed management measures, pollutant loading from the shared cycle and pedestrian pathway is considered to be negligible. Therefore the project is considered to have a negligible influence on stakeholder goals to achieve the NSW WQOs for Muddy Creek overtime.

18.4.2 Flooding

The flood models were used to assess the impact of flooding to the project as well as the potential for the project to exacerbate flooding conditions in areas outside the project. **Table 18-15** summarises the hydrologic standards that were adopted in this assessment. These standards would be incorporated into the design of the project. The structure of the models that were originally developed to define flood behaviour under present day conditions (based on the existing stormwater drainage system) were adjusted to incorporate details of the project under operational conditions.

Appendix M (Flooding technical report) contains a series of figures showing flood behaviour under pre- and post-project conditions for a range of storm events (between 20 per cent and 0.2 per cent in magnitude). The assessment presented in the technical report is primarily focussed on the 1% AEP storm as the impacts during this event are typically greater than more frequent storm events.

Table 18-16 identifies the potential operational impacts the various components of the project would have on flood behaviour.

Table 18-15 Summary of adopted assessment criteria and hydrologic standards

Aspect	Requirement
Flooding of tunnel portals and ancillary facilities	• Tunnel portals are to be located above the PMF level or the 1% AEP flood level plus 0.5 metres (whichever is greater). This level of security against ingress is commensurate with the consequence of flooding to the tunnels and the risk to road users and is consistent with the current standard adopted in the design of road and rail tunnels in NSW. • The same hydrologic standard would apply to operational tunnel ancillary facilities such as tunnel ventilation and water treatment plants where the ingress of floodwater would have the potential to inundate the tunnel or infrastructure that it is reliant upon for its safe operation. • The same hydrologic standard would apply to emergency facilities such as disaster recovery sites and tunnel deluge systems as well as electrical substations that are reliant for the safe operation of the motorway and its ancillary facilities.
Flooding of motorway ramps and local road connections	• A 1% AEP hydrologic standard has been adopted for motorway ramp and local road connections, where feasible, based on the extent of upgrade requirements and the hydrologic standard of the local road network (e.g. President Avenue intersection).
Modifications to existing road network	• As a minimum, modifications to existing roads are to be configured to ensure the existing level of flood immunity is maintained. Ideally, local road modifications are to provide a minimum hydrologic standard of 10% AEP.
Shared cycle and pedestrian pathways	• A 1 Exceedance per Year (EY) hydrologic standard has been adopted for shared cycle and pedestrian pathways in accordance with the current standard adopted by Roads and Maritime for cycleways and shared user paths that are separated from the road corridor. • Consideration is also to be given to the flood risk to cyclists and pedestrians during larger floods (e.g. 1% AEP event) as a result of high hazard flooding conditions.
Impact of project operation on flooding and existing development	• Floods up to 1% AEP in magnitude are to be considered in the assessment of measures which are required to mitigate any adverse impacts on flood behaviour attributable to the project. • Changes in flood behaviour under larger floods up to the PMF event are also to be assessed in order to identify impacts on critical infrastructure and vulnerable development, as well as to identify potentially significant changes in flood hazard as a result of the project.
Impact of flooding on proposed construction activities	• Construction related flood risks and impacts need to be evaluated in the context of the construction period in order to set requirements that are commensurate to the period of time that the risk exposure occurs. To this end, this report identifies the risks and impacts associated with each construction activity such that informed decisions can be made on the flood criteria that are set as part of the flood risk management plan for the construction of the project.
Impact of future climate change on flood behaviour	• The assessment of the potential impact future climate change could have on flood behaviour in the vicinity of the project was based on: – increases in 1% AEP design rainfall intensities ranging between 10 and 30 per cent in accordance with the NSW Government's *Floodplain Risk Management Guideline: Practical Considerations of Climate Change* (DECC 2007)[1]; and – rises in sea level of 0.4 metres by 2050 and 0.9 metres by 2100 in accordance with the NSW Government's *Sea Level Rise Policy Statement* (NSW Government 2009). • The assessment of the impact of the project on flood behaviour under future climate change was based on assessing the effect of the proposed works on present day flood behaviour during a 0.5 % and 0.2 % AEP event as proxies for assessing the sensitivity to an increase in rainfall intensity on the 1% AEP event due to climate change.

Table 18-16 Potential operational impacts on flooding

Location	Proposed facilities	Potential impacts on flood behaviour
Arncliffe motorway operations complex	No additional permanent surface works are proposed beyond those that are to be constructed as part of the New M5 Motorway.	Potential increase in peak flood levels in the open space of the Kogarah Golf Course and the road reserve of Marsh Street by a maximum of 11 mm.
Rockdale motorway operations complex (north)	Motorway ancillary facility comprising motorway control centre, tunnel deluge system, maintenance and storage facilities. The motorway ancillary facility would be raised relative to existing ground levels so that the openings to the motorway control centre and the tunnel deluge system are located above the PMF level.	Potential increase in peak flood levels in two residential properties in West Botany Street by a maximum of 120 mm. Potential increase in above-floor inundation and flood damages in the affected properties.
Rockdale motorway operations complex (south)	Motorway ancillary facility comprising ventilation exhaust and supply, electrical substation and disaster recovery facility. The tunnel ancillary facility would be raised relative to existing ground levels so that the openings to the elements listed above are located above the PMF level. Lowering of ground levels within an area of the Rockdale Bicentennial Park adjoining West Botany Street by an average of 1.2 m to provide compensatory floodplain storage. This compensatory floodplain storage could be provided as part of the re-establishment of Rockdale Bicentennial Park following the construction of the cut and cover structure.	Potential increase in peak flood levels along West Botany Street by a maximum of 20 mm.

Location	Proposed facilities	Potential impacts on flood behaviour
President Avenue interchange and surface works	Surface road works and tunnel portal to connect President Avenue to the F6 Extension - Stage 1 tunnels. A new pavement drainage system would intercept runoff generated by direct rainfall at the tunnel portal. A new stormwater drainage system would be provided along President Avenue to accommodate the road widening.	Potential increase in peak flood levels within the section of Scarborough Ponds to the north (upstream) of President Avenue by a maximum of 30 mm. Potential localised increase in peak flood levels by a maximum of 20 mm within the front yards of two residential properties that are located on the northern and southern side of President Avenue, to the east of the new interchange. Potential increase in above-floor inundation and flood damages in the affected properties. Potential impact on a property located on the southern side of President Avenue east of Colson Crescent due to increased flow to the east of the tunnel portals. Potential increase in PMF flood levels across the upper reaches of the Scarborough Ponds and Muddy Creek floodplains. There would be negligible change in PMF levels along the reach of Scarborough Ponds to the south of President Avenue. Potential for localised increases in flow velocities within the section of Scarborough Ponds immediately downstream of the project due to the upgrade of the stormwater drainage system and the relocation of its outlets to accommodate the proposed widening of President Avenue. Impacts to the velocities of discharge and the duration of flooding are assessed in section 6.1.4 of Appendix M (Flooding technical report). The assessment concluded that there will be a significant increase in the rate of flow discharging into Scarborough Ponds at pavement drainage outlets 1 and 2, as well as transverse drainage structure XD01. The total peak flow in Scarborough Ponds downstream of President Avenue will be slightly reduced. This is primarily due to the upgrade of transverse drainage culvert XD01 and the raising of President Avenue which will increase the early release of flow from the section of Scarborough Ponds upstream of President Avenue and prevent the relatively large rate of discharge due to the surcharge of President Avenue that occurs under present day conditions. There would be no change in the duration of flooding within the Scarborough Ponds catchment as a result of the project.

Location	Proposed facilities	Potential impacts on flood behaviour
Bestic Street to England Street shared cycle and pedestrian pathway	As the design for the section of the shared cycle and pedestrian pathway between Bestic Street and Bruce Street is at concept stage, a preliminary assessment of potential flood impacts has been carried out based on an understanding of flooding and drainage patterns under present day conditions and an initial review of the proposed alignment of the shared cycle and pedestrian pathway.	Potential to exacerbate flooding conditions in properties adjacent to sections of the proposed alignment of the shared cycle and pedestrian pathway to the north of the Rockdale Bicentennial Park and between Bruce Street and Bestic Street.
England Street to Civic Avenue shared cycle and pedestrian pathway	A new pedestrian and cyclist path within the proposed shared cycle and pedestrian pathway between England Street and Civic Avenue. A shared cycle and pedestrian bridge would be provided where the shared cycle and pedestrian pathway crosses President Avenue and a section of Scarborough Park North. A series of waterway crossings would be provided where the shared cycle and pedestrian pathway crosses the upper reach of Scarborough Ponds. For the purpose of the assessment these waterway crossings were assumed to comprise raised platform structures. A waterway crossing would also be required where the shared cycle and pedestrian pathway crosses an existing drainage line that discharges into Scarborough Ponds from Civic Avenue. Subject to detailed design, this waterway crossing may be incorporated into an extension to the length of the bridge.	No potential impacts expected.
Princes Highway and President Avenue intersection upgrade	Widening of Princes Highway and the western end of President Avenue to provide additional northbound and southbound turning lanes from the Princes Highway into President Avenue. The existing stormwater drainage system in Princes Highway and President Avenue would be upgraded to accommodate the proposed road widening. Subject to detailed design, the existing stormwater drainage line that runs from the low point in Princes Highway to the north of President Avenue, along Green Lane and West Botany Street to President Avenue, would be upgraded from a 900 mm diameter pipe to a 1200 mm diameter pipe.	Potential impacts on flood behaviour where it discharges into Scarborough Ponds to the south of President Avenue due to the increase in the capacity of the stormwater drainage system.
Permanent power supply	No additional permanent surface works are proposed beyond those that are to be constructed for the permanent power supply.	No potential impacts expected. There would be no impact on long-term flooding and drainage patters would be reinstated to a pre-construction condition at the completion of works.

While measures that are aimed at mitigating the impact of the project on flooding behaviour have been incorporated into the concept design that has formed the basis of the flood assessment for the project, the assessment identifies residual impacts at properties in:

- President Avenue to the east of the new President Avenue intersection
- West Botany Street to the east of the Rockdale motorway operations complex.

Residual impacts at these locations may result in social and economic costs to the community due to property damage, emergency services and potential loss of livelihood. Floor level survey would be required in these areas in order to confirm the extent to which the proposed works would increase above-floor inundation and flood damages in affected properties, and therefore the scope of mitigation measures that may be required.

At President Avenue the assessed increase in 1% AEP flood levels, in properties already affected by inundation, is 20 mm on a depth of inundation that is typically less than 200 mm. Given the minor nature of this increase it would be feasible to mitigate its impact through a combination of the measures listed in Table 8-3 of **Appendix M** (Flooding technical report).

At West Botany Street the assessed increase in peak 1% AEP flood levels is due to the raised level of MOC2, which displaces floodplain storage that is filled by flow that surcharges West Botany Street.

Measures to manage these potential impacts are discussed in **section 18.6**. **Appendix M** (Flooding technical report) also discusses specific measures for each location to be incorporated into the design in order to mitigate potential impacts.

Consultation has occurred with SES Sydney Southern Headquarters (20 March 2018) and Bayside Council (ongoing) (refer to **Chapter 3** (Consultation)). No concerns regarding emergency management arrangements for flooding have been raised.

Consistency with council and state government flood plans and policies

Rockdale Local Environmental Plan 2011 (RCC 2011b) sets out flood related planning controls for land that is located within the flood planning area as shown on *Rockdale Local Environmental Plan 2011 Flood Planning Map*, as well as any other land that is located below the flood planning level.

In accordance with the SEARs, a flood planning area has also been defined by the current assessment through mapping the extent of land which lies below the peak one per cent AEP flood level plus 0.5 metres under present day conditions. The flood planning area shown in **Appendix M** (Flooding Technical Report) is based on main stream flooding along the major rivers, creeks and tributaries that are crossed by the project, as well as the main paths associated with major overland flow. It should be noted that the flood modelling undertaken for the assessment was developed for the specific purpose of assessing the flood risks and impacts associated with the project. It should therefore be taken as preliminary only in terms of defining the flood planning area across the broader extent of flood prone land within the catchments that are crossed by the project.

The findings of the assessment show that the project would have only a minor impact on peak one per cent AEP flood levels. As a result, the project would have no significant impact on the extent of the flood planning area and therefore the area of land to which the flood planning controls set out in RCC 2011b would apply.

Spring Street Drain, Muddy Creek and Scarborough Ponds Floodplain Management Study (WP 2000) contains a draft floodplain management plan that sets out general non-structural and location specific structural measures with varying priority rankings to manage the flood risk associated with development on the floodplains of Spring Street Drain, Muddy Creek and Scarborough Ponds. General non-structural measures include the adoption of flood and stormwater management policies (such as RCC 2011a, RCC 2011b and RCC 2011c), the development of flood warning and response measures (such as SES 2009) and improved management and maintenance of drainage assets. Structural measures relevant to Scarborough Ponds include enlarging the outlet to Botany Bay and the flood proofing of flood liable properties. However WP 2000 notes that the low value of average annual damages within the Scarborough Ponds catchment due to the shallow depth of flooding “makes it difficult to justify any of the structural options on benefit-cost grounds”.

Given the extent of works that are proposed as part of the project and the relatively minor nature of their impact on flood behaviour under present day conditions, the project would not preclude or limit any of the measures identified in the draft floodplain management plan that is contained in WP 2000.

Rockdale City Local Flood Plan (SES 2009) provides a plan for the operation of emergency response to flooding within the Rockdale City Council LGA (now part of Bayside Council), including the catchments of the Cooks River, Spring Street Drain, Muddy Creek and Scarborough Ponds. The plan sets out the preparedness measures, the process for carrying out response operations and the coordination of immediate recovery measures from flooding.

The findings of the assessment show that the project would have only a minor impact on peak one per cent AEP flood levels. Increases in PMF levels, which would occur to a maximum of 60 millimetres on depths of flooding that exceed one metre, are also considered minor in terms of the relative increase in flood hazard. As a result, the project would have no adverse impact on the emergency response arrangements set out in SES 2009. Furthermore, the upgrade of President Avenue would improve its hydrologic standard from less than one exceedance per year under present day conditions to a minimum of one per cent AEP following the construction of the project, thereby having the beneficial effect of improving access across the floodplain during times of flood.

The assessment of flood risks to the project and its impact on the surrounding environment, as well as development of appropriate flood standards and mitigation measures has been carried out in accordance with the *NSW Floodplain Development Manual* (DIPNR, 2005), the requirements of the environmental approvals process and industry guidelines. Features relevant to flooding have been mapped in **Figure 18-2** and **Figure 18-4** in accordance with the *NSW Floodplain Development Manual 2005* (DIPNR, 2005). Refer to **Appendix M** (Flooding Technical Report) for further information regarding the consideration of the *NSW Floodplain Development Manual* (DIPNR, 2005) for the project.

Impact of future climate change on flood behaviour

The following scenarios were adopted as being representative of the likely lower and upper bound estimates of climate change impacts over the design life of the project:

- Scenario 1 – based on an assumed 10 per cent increase in currently adopted design rainfall intensities, together with a rise in sea level of 0.4 metres.
- Scenario 2 – based on an assumed 30 per cent increase in currently adopted design rainfall intensities, together with a rise in sea level of 0.9 metres.

The combinations of catchment and coincident storm tide conditions that were used to define the one per cent AEP and PMF design flood envelopes under scenario 1 and 2 climatic conditions are described in **Appendix M** (Flooding technical report).

Potential impacts of future climate change on flood behaviour for a storm with an AEP of one per cent are as follows:

- Arncliffe motorway operations complex – Peak one per cent AEP flood levels could potentially be increased by between 0.6 metres and 1.1 metres under future climate change conditions. The upper bound estimate of the one per cent AEP post-climate change flood level would still be approximately 1.0 metre below the PMF level, which sets the minimum level of the tunnel ancillary facilities
- Rockdale motorway operations complex (north) – Peak one per cent AEP flood levels could potentially be increased by between 0.1 metres and 0.6 metres under future climate change conditions which is primarily due to an increase in rainfall intensities. The upper bound estimate of the one per cent AEP post-climate change flood level would still be approximately 0.7 metres below the PMF level, which sets the minimum level of the tunnel ancillary facilities
- Rockdale motorway operations complex (south) – There could potentially be a minor increase in peak one per cent AEP flood levels of between 0.04 metre and 0.09 metres under future climate change conditions, which would still be around one metre below the PMF level, which sets the minimum level of the tunnel ancillary facilities
- President Avenue tunnel portal - There could potentially be a minor increase in peak one per cent AEP flood levels of between 0.04 metres and 0.09 metres under future climate change conditions, which would still be over one metre below the PMF level which sets the minimum level of the tunnel portal

- President Avenue road upgrade - Peak one per cent AEP flood levels could potentially be increased by between 0.3 metres and 0.7 metres under future climate change conditions. While President Avenue would be inundated to a maximum depth of 0.2 metres under the lower bound estimate, one lane would be accessible to traffic in each direction. Under the upper bound estimate, President Avenue would be inundated across its full width to a maximum depth of 0.6 m
- England Street to Bestic Street shared cycle and pedestrian pathway – Peak one per cent AEP flood levels could potentially be increased by between 0.3 metres and 0.7 metres under future climate change conditions
- Princes Highway and President Avenue intersection upgrade - There would be a minor increase in peak one per cent AEP flood levels at the low point in the Princes Highway to the north of President Avenue of between 0.01 metres and 0.02 metres under future climate change conditions.

The assessment found that peak PMF levels at the tunnel ancillary facilities (Rockdale motorway operations complex (north) and (south)) and the President Avenue tunnel portal would be increased by between 60 mm and 130 mm due to a 0.9 metres rise in sea level (Scenario 2). In order to manage the risk of flooding to the tunnels over the design life of the project, the impact of future sea level rise would need to be taken into consideration when setting the minimum level of entries to the tunnel ancillary facilities and tunnel portal. The concept design of the President Avenue interchange and surface works, includes the road level at the entry to the President Avenue tunnel portal at a level above the PMF, including allowance for an increase in the PMF level under Scenario 2.

Peak flood levels at key locations along the project for current climate conditions, as well as for the assessed climate change scenarios are set out in **Appendix M** (Flooding technical report).

Impact of the project on flood behaviour under future climate change conditions

In accordance with the SEARs, the impact that the project may have on flood behaviour under potential future climate change conditions was based on assessing its effect on present day flood behaviour during a 0.5 per cent and 0.2 per cent AEP event as proxies for assessing the sensitivity to an increase in rainfall intensity on the one per cent AEP event due to future climate change.

The impact of the project on flood behaviour during a 0.5 per cent and 0.2 per cent AEP event, adopted as proxies for assessing the sensitivity to an increase in one per cent AEP design rainfall intensities of between 10 per cent and 30 per cent due to climate change, can be summarised as follows:

- Arncliffe motorway operations complex – Increases in peak 0.5 per cent and 0.2 per cent AEP flood levels are typically 10 mm or less and occur over a significantly smaller area when compared to those during a one per cent AEP event
- Rockdale motorway operations complex (north) – There would be an increase in peak flood levels in two residential properties in West Botany Street of between 100 to 120 millimetres during a 0.5 per cent and 0.2 per cent AEP event, which is similar to those during a one per cent AEP event
- Rockdale motorway operations complex (south) - Peak flood levels in West Botany Street would increase by a maximum of 20 mm during both a 0.5 per cent and 0.2 per cent AEP event, which is similar to those during a one per cent AEP event
- President Avenue interchange and surface works – There would be an increase in peak flood levels within Scarborough Ponds by a maximum of 40 millimetres during both a 0.5 per cent and 0.2 per cent AEP event, which is similar to those during a one per cent AEP event. While increases in peak flood levels during a 0.5 per cent AEP event would be confined to the Rockdale Bicentennial Park reserve, increases in peak flood levels during a 0.2 per cent AEP event would extend into three industrial properties that are located in Bermill Street
- During both a 0.5 per cent and 0.2 per cent AEP event there would be localised increase in peak flood levels by a maximum of 30 mm within the front yards of two residential properties that are located to the north and south of President Avenue, immediately west of O'Connell Street, which is slightly greater than the increases in peak flood levels during a one per cent AEP event

- England Street to Civic Avenue shared cycle and pedestrian pathway – There would be no significant change in peak flood levels during both a 0.5 per cent and 0.2 per cent AEP event, which is consistent with the findings of the assessment for a one per cent AEP event Princes Highway and President Avenue intersection upgrade - The proposed upgrades to the stormwater drainage system would mitigate the impact of the proposed road widening on peak flood levels in adjacent properties during both a 0.5 per cent and 0.2 per cent AEP event, which is consistent with the findings of the assessment for a one per cent AEP event.

Based on the assessment of the impact of future climate change on flood behaviour, no impacts to properties for the one per cent AEP event are anticipated.

18.5 Cumulative impacts

18.5.1 Surface Water

This section presents the findings of an assessment of the potential cumulative impacts on surface water as a result of the construction and operation of the project in combination with other projects in its vicinity. **Table 18-17** summarises the cumulative impacts on surface water.

Table 18-17 Potential Cumulative impacts on surface water

Project	Assessed potential for cumulative impacts on surface water
WestConnex Stage 1 (M4 Widening / M4 East)	The M4 East and M4 widening projects have no common surface water receptors with the project and as such cumulative impacts are unlikely to occur.
WestConnex Stage 2 and 3 (New M5 Motorway and M4-M5 Link)	The Cooks River is a common receptor for the New M5 Motorway and the F6 Extension – Stage 1 projects with Botany Bay being a common sensitive downstream receptor. Whilst there are no common direct surface water receptors for the M4-M5 Link and F6 Extension – Stage 1 projects during construction or operation, the Cooks River is a downstream receptor for the M4-M5 Link project. Construction of the project is likely to overlap with the M4-M5 Link construction over the period 2018 to 2022. Discharges from the M4-M5 Link Campbell Road construction compound in St Peters would be discharged to Alexandra Canal which is upstream of the Cooks River, however the increase in flow is considered to be negligible compared to the mean flow and tidal exchange within the Cooks River. Discharges from construction water treatment plants would also be required to achieve discharge criteria such that releases would be of a suitable quality for discharge to the receiving environment. Therefore, cumulative impacts to water quality and the hydrological regime within the Cooks River due to these two projects would be negligible during construction. During operation of the project, tunnel water would be treated at a new water treatment plant at Arncliffe. Tunnel water from the New M5 Motorway and a small portion of the M4M5 Link project would be pumped to the adjacent New M5 Motorway treatment plant at Arncliffe. This would increase the total flow and pollutant load being discharged. The approved discharge criteria for the New M5 Motorway project would be adopted for the additional flows contributed by the project and therefore the cumulative impacts associated with operational discharges to the Cooks River are considered to pose a minimal impact to water quality within the Cooks River. Runoff volumes to the Kogarah Golf Club drain are likely to increase as a result of additional impervious area associated with the New M5 Motorway Operations Complex 3 and the project operational water treatment plant. This could potentially lead to some minor erosion within unlined sections of the upstream section of the Kogarah Golf Club drain. Given the Cooks River and Botany Bay are large estuarine systems, increases in stormwater runoff volume as a result of the increased imperviousness associated with the New M5 Motorway, M4-M5 Link and the F6 Extension – Stage 1 projects are considered to pose a negligible impact to the Cooks River hydrological regime.

Project	Assessed potential for cumulative impacts on surface water
King Georges Road interchange upgrade	The King Georges Road interchange upgrade project has no common surface water receptors to the project but has two common sensitive downstream receptors, the Cooks River and Botany Bay. Cumulative impacts are unlikely to occur to the sensitive downstream receptors provided the proposed management measures are implemented, maintained and monitored
Sydney Gateway	A surface water impact assessment is not yet available for the Sydney Gateway project therefore the cumulative impact with the project is unable to be fully assessed at this stage. The Cooks River could potentially be a common receptor to both projects, with Botany Bay likely to be a common sensitive downstream receptor. It is assumed that potential surface water impacts for the Sydney Gateway project would be managed in accordance with relevant legislation and guidelines, and that potential cumulative impacts with F6 – Stage 1 would be assessed in any future EIS prepared for that project.
Sydney Metro (Sydenham to Bankstown)	The Sydney Metro City and South West Sydenham to Bankstown upgrade rail corridor would run through the Cooks River catchment, a surface receptor for the project. Potential cumulative surface water impacts could affect the Cooks River and downstream sensitive environments (Cooks River and Botany Bay). The Sydney Metro City and Southwest Sydenham to Bankstown upgrade Environmental Impact Statement (Transport for NSW 2017) states that it is expected that with the appropriate mitigation measures in place, residual surface water impacts during construction and operation of that project are likely to be negligible. Providing the proposed management measures for the project are implemented, maintained and monitored, the cumulative impact to the Cooks River and the downstream sensitive receptor of Botany Bay is likely to be minimal.
F6 Extension (Kogarah to Loftus)	As future stages of the F6 Extension are not yet committed, and no surface water impact assessment has been undertaken for those future stages, potential cumulative impacts with the project is unable to be fully assessed at this time. If the potential future stages of the project go ahead, Scarborough Ponds could potentially be a common receptor and Botany Bay could be a common sensitive downstream receptor. The key potential cumulative impacts are considered to be increases in pollutant loading during construction and post development and increases in runoff volumes during operation. It is assumed that surface water impacts for potential future stages of the F6 Extension would be assessed cumulatively with F6 – Stage 1 and would be managed in accordance with relevant legislation and guidelines. Providing the proposed F6 – Stage 1 and potential future stages of the F6 Extension implement, maintain and monitor appropriate surface water management measures, the cumulative impacts to the common receptors are likely to be minimal, with the potential for some beneficial impacts if opportunities identified as part of the project to improve the water quality of Rockdale wetland are implemented.
Local residential development	Major residential developments proposed within proximity to the F6 – Stage 1 (New M5 Motorway, Arncliffe to President Avenue, Kogarah) project includes the Bayside West Precincts of Arncliffe and Banksia, development at Wolli Creek and also within the Turrella precinct. In terms of common surface water receptors with the project, Cooks River and Botany Bay are downstream of all of these urban developments, and Muddy Creek downstream of the Banksia precinct. The key potential cumulative impacts are considered to be increases in pollutant loading during construction and post development and increases in runoff volumes post development. Whilst environmental assessments have not been prepared for the various urban development projects, it is assumed that local councils would impose development conditions to ensure erosion and sediment controls are implemented during construction in accordance with the principles of the Blue Book (Landcom 2004) and that pollutant load reduction targets in accordance with the BBWQIP would be set for the developed sites. Therefore, with the implementation of the project management measures, the cumulative impacts to water quality with common receiving and downstream receptors are likely to be minimal. Given the common receptors of Muddy Creek and Cooks River are estuarine, anthropogenic environments and given the existing urbanised nature of the development zones, the cumulative increase in runoff volumes associated with the urban development is likely to pose a negligible impact to hydrology or erosion within the waterways.

Project	Assessed potential for cumulative impacts on surface water
Muddy creek naturalisation	Sydney Water has prepared a concept design for the naturalisation of Muddy Creek between West Botany Street and Bestic Street. The concept design proposes replacement of the existing concrete channel with rock banks, planted with native species, a sandstone block low flow channel and replacement of the existing channel base with new concrete. Other potential opportunities shown within the concept design include saltmarsh zones, a wetland for treating stormwater flows and an outdoor education area. The timing of the works is currently unknown. Whilst no environmental assessment has been reviewed for the Muddy Creek naturalisation project, it is assumed that surface water construction impacts would be managed in accordance with relevant legislation and guidelines, particularly to limit potential mobilisation of sediments downstream during earthworks in the channel. Whilst water quality and hydrological benefits of the naturalisation works are likely to be negligible, the works are likely to result in ecological improvements to the waterway. The project shared cycle and pedestrian pathway currently conflicts with sections of salt marsh and riparian restoration proposed as part of the Muddy Creek naturalisation concept design. Providing the proposed project management measures are implemented, maintained and monitored, the cumulative impacts to water quality within Muddy Creek and Cooks River downstream are likely to be negligible. Consultation with Sydney Water would be required during detailed design so that the shared cycle and pedestrian pathway alignment is cognisant of the Muddy Creek naturalisation works.

The projects currently under construction all incorporate surface water management measures during construction and for operation, to prevent adverse impacts to the common receiving receptors and adjoining properties. Other projects that are still in the planning stages would likely be required to implement similar mitigation measures in accordance with legislative requirements to prevent adverse impacts.

Therefore, with due consideration of the proposed management measures to be implemented as discussed in **section 18.6**, minimal adverse cumulative surface water impacts are anticipated. The residual risk to common receptors and sensitive environments downstream would be low, provided the proposed management measures are implemented, maintained and monitored.

18.5.2 Flooding

This section presents the findings of an assessment of the potential cumulative impacts on flood behaviour as a result of the project in combination with other projects in its vicinity. The assessment was based on impacts during the operation of the project only, given the short term nature of exposure to potential flood impacts together with the general requirement to manage adverse impacts on existing development during the construction of the project.

Table 18-18 Potential Cumulative impacts

Project	Assessed potential for cumulative impacts on flood behaviour
WestConnex Stage 1 (M4 Widening / M4 East)	No cumulative impacts on flood behaviour as the M4 Widening / M4 East projects are located in adjacent valleys that are remote from the project.
WestConnex Stage 2 (New M5 Motorway)	The flood model developed of the Cooks River floodplain was used to assess the cumulative impact of the project with the New M5 Motorway project as a result of the proposed extension to the Arncliffe motorway operations complex to accommodate additional tunnel ancillary facility for the project. The cumulative impact of the two projects would result in an increase in peak one per cent AEP flood levels in the Kogarah Golf Course and the road reserve of Marsh Street by a maximum of 30 mm, which is 19 mm greater than the project alone.
WestConnex Stage 3 (M4-M5 Link)	No cumulative impacts on flood behaviour as the M4-M5 Link project are located in adjacent valleys that are remote from the project.
Sydney Gateway	No cumulative impacts on flood behaviour as the Sydney Gateway project are located in adjacent valleys that are remote from the project.

Project	Assessed potential for cumulative impacts on flood behaviour
F6 Extension (Kogarah to Loftus)	Potential future stages of the F6 Extension project would likely involve works on the Scarborough Ponds floodplain that, in combination with the project, have the potential for cumulative impacts on flood behaviour. While subject to future design development and environmental approvals, the potential future stages of the F6 Extension project is likely to include an additional surface connection on the Scarborough Ponds floodplain to the south of the President Avenue interchange. Cumulative impacts would need to be assessed as part of the environmental approvals process for the potential future stages of the F6 Extension project once its details are known. However, given the minor nature of flood impacts associated with the project, it is expected that the cumulative impacts of the multiple stages can be managed through appropriate mitigation measures. Such measures may include, for example, the provision of compensatory floodplain storage within the Scarborough Ponds floodplain.

The assessment found that there would be no cumulative impacts on flood behaviour as a result of the project in combination with other projects that have preceded it.

18.6 Management of impacts

Management measures would be implemented to avoid, minimise or mitigate impacts on surface water and flooding within the study area. These management measures are outlined in **Table 18-19.** Several of the management measures contained in **Chapter 16** (Soils and contamination) would also contribute to management of surface water impacts.

Table 18-20 to **Table 18-22** set out the relevant discharge criteria referred to in the environmental management measures.

Table 18-19 Environmental management measures – surface water and flooding

Impact	Reference	Environmental management measures	Timing
Construction			
Impacts on surface water quality	SWF1	A program to monitor potential surface water quality impacts of the project will be developed and included in a Construction Soil and Water Management Plan (CSWMP). The program will include the water quality monitoring parameters (including pH, turbidity, dissolved oxygen, nitrogen and metals) and the monitoring locations (including Muddy Creek, Rockdale Bicentennial Park, North Scarborough Ponds and Cooks River) identified in Annexure G of Appendix L (Surface water technical report) Continuous surface water level and groundwater level monitoring will be undertaken within Rockdale wetland and surrounding area for at least 12 months prior to the commencement of construction. Monthly groundwater quality would also be undertaken in the surrounding area. The data would be used as a baseline to monitor impacts on surface and groundwater levels and groundwater quality within the Pond during construction. The surface water monitoring program will continue for a minimum of three years following the completion of construction, or until the affected waterways are certified by a suitably qualified and experienced independent expert as being of an equal or better condition than pre construction conditions (or as otherwise required by any project conditions of approval). In the instance that during detailed design it cannot be demonstrated that treated construction wastewater would meet the discharge criteria for Scarborough Ponds, in particular nutrient concentrations, treated construction wastewater from C2 and C3 will be discharged to the Muddy Creek stormwater catchment.	Prior to construction Construction Operation
Impacts on water bodies	SWF2	All works within watercourses or on waterfront land will be managed in accordance with the Controlled Activities on Waterfront Land guidelines (DPI 2012). The following specific measures are required to manage impacts within Rockdale wetland: • Installation of a temporary barrier to isolate the excavation works from the rest of the pond and prevent mobilisation of sediment and pollutants into adjacent areas. Water within the construction zone will be treated by the construction water treatment plant. Sediment mobilised during installation of the barrier will also be managed. • Retention of hydrologic connectivity through Rockdale wetland throughout construction.	Construction
	SWF3	A Water Reuse Strategy for the construction and operational phases of the project will be developed prior to construction. This will outline the construction and operational water requirements and potential water sources to supply the water demand.	Prior to construction

Impact	Reference	Environmental management measures	Timing
Impacts on flood behaviour	SW4	A Flood Management Strategy (FMS) will be prepared prior to construction to demonstrate how flooding risks and behaviours will be mitigated during both the construction and operational phases. The FMS will include floor level survey for identified affected properties. The FMS would be prepared prior to commencement of construction by a suitably qualified and experienced person in consultation with directly affected landowners, Sydney Water, OEH, SES and relevant councils.	Prior to construction
Impacts on flood behaviour	SWF5	Entries to tunnel excavations, including cut and cover sections of tunnel will be protected against flooding, to an appropriate flood standard. The same hydrologic standard will be applied to tunnel ancillary facilities such as tunnel ventilation buildings, operational water treatment plants, emergency facilities and electrical substations. A minimum level of flood immunity of one exceedance per year would be provided to shared cycle and pedestrian pathways within the project footprint.	Detailed design Construction
	SWF6	As a minimum, site facilities are to be located outside high flood hazard areas based on a one per cent AEP flood. For site facilities located within the floodplain, the FMS is to identify how risks to personal safety and damage to construction facilities and equipment will be managed.	Construction
Operation			
Impacts on surface water quality	SWF7	Treatment measures would be implemented within the waterbodies of Scarborough Park North and Rockdale Bicentennial Park disturbed by the project during construction, to reduce algal bloom conditions and contribute to achieving the NSW WQOs over time. Treatments would be considered in consultation with Bayside Council and shall include gross pollutant traps in drainage lines; inclusion of macrophyte zones and bank reshaping of the wetland zones; the use of solar powered devices to aerate the water column.	Detailed design
	SW8	The findings of the pre and post construction water level monitoring and relevant water quality monitoring in Rockdale wetland will be reviewed as part of an investigation by a suitably qualified and experienced independent expert to certify that the Pond has been restored to an equal or better level than pre construction conditions, in terms of its hydrology and water quality, including a review of how water quality within the downstream waters may have been affected by the restoration works.	Operation
	SW9	The project will be designed to manage the potential impacts of future climate change on flooding behaviour in accordance with the procedures set out in *Practical Considerations of Climate Change – Floodplain Risk Management Guideline* (DECC, 2007) and in *Australian Rainfall and Runoff* (GA 2016).	Detailed design

Table 18-20 Surface water discharge criteria

Parameter	Discharge criteria
pH	6.5-8.5
Oil and Grease	No visible oil and grease
Total Suspended Solids	<50 mg/L

Table 18-21 Construction Water Treatment Plant – Water Quality Discharge Criteria

Receiving waters	Environment	Toxicants	Nutrients	Oil and grease	pH	Turbidity	EC
Cooks River	Highly disturbed system with significant tidal exchange	Marine Water 80 per cent species protection level	80 per centile of reference sites	No visible oil and grease	Between 20 per centile and 80 per centile of reference site	80 per centile of reference site	NA (estuarine waters)
Muddy Creek	Highly disturbed system with tidal exchange	Marine Water 80 per cent species protection level	80 per centile of reference sites	No visible oil and grease	Between 20 per centile and 80 per centile of reference site	80 per centile of reference site	NA (estuarine waters)
Rockdale wetland	Highly disturbed system Freshwater and limited assimilative capacity for nutrients with high potential for algal blooms	Marine Water slightly to moderately disturbed protection level	Estuarine slightly to moderately disturbed trigger level	No visible oil and grease	Between 20 per centile and 80 per centile of reference site	10 NTU	80 per centile of reference site
Northern Scarborough Pond	Highly disturbed system Limited tidal exchange and limited assimilative capacity for nutrients with high potential for algal blooms	Marine Water slightly to moderately disturbed protection level	Estuarine slightly to moderately disturbed trigger level	No visible oil and grease	Between 20 per centile and 80 per centile of reference site	10 NTU	NA (estuarine waters)

Table 18-22 Operational Water Treatment Plant – Water Quality Discharge Criteria

Receiving waters	Toxicants	Nutrients	pH	Turbidity
Cooks River	ANZECC (2000) 80 per cent species protection level for estuarine waters	80 percentile of reference data as determined by New M5 Motorway project	Range between 20 and 80 percentile of reference data as determined by New M5 Motorway project	80 percentile of reference data as determined by New M5 Motorway project.

18.7 Environmental risk analysis

An environmental risk analysis was undertaken for surface water and flooding and is provided in **Table 18-23** below.

A level of assessment was undertaken commensurate with the potential degree of impact the project may have on that issue. This included an assessment of whether the identified impacts could be avoided or minimised (for example, through design amendments). Where impacts could not be avoided, environmental management measures have been recommended to manage impacts to acceptable levels.

The residual risk is the risk of the environmental impact after the proposed mitigation measures have been implemented. The methodology used for the environmental risk analysis is outlined in **Appendix O** (Methodologies).

Table 18-23 Environmental risk analysis – Surface water and flooding

Summary of impact	Construction/ operation	Management and mitigation reference	Likelihood	Consequence	Residual risk
Impacts on water quality in project catchments due to water discharge, including discharge of treated surface and groundwater.	Construction and Operation	SWF1, SWF2, SWF8, SWF9	Unlikely	Moderate	Low
Impacts to the hydrological and geomorphic processes of receiving water bodies due to increase of baseflow rates	Construction and Operation	SWf2, SWF3, SW9	Unlikely	Moderate	Low
Impacts on surrounding properties due to the potential alterations of flood levels, existing minor drainage paths and overland flows due to construction ancillary facilities and due to new operational facilities.	Construction and Operation	SW5, SW6, SW10	Unlikely	Moderate	Low
Impacts on safety and to project infrastructure due to flooding	Construction and Operation	SW5, SW6, SW7, SW10	Unlikely	Moderate	Low
Impacts on flood levels and behaviour due to sea level rise and potential increase in rainfall intensity due to future climate change	Operation	SW5, SW6, SW10	Unlikely	Moderate	Low