16 Soil and water quality

This chapter describes the environmental values relating to soils and water and identifies the potential impacts to these values as a result of the construction and operation of the project. The potential impacts on water quality resulting from the proposed water treatment plant discharge are also considered.

The Technical working paper: Surface water (**Appendix N**) and **Chapter 18** (Flooding and drainage) have been used to inform this chapter.

Other chapters of this environmental impact statement (EIS) that are relevant to soil and water quality include:

- **Chapter 17** (Contamination), which provides an assessment on the potential for the project to generate or disturb contaminated soils (specifically, **Sections 17.3.1** to **17.3.4**)
- **Chapter 19** (Groundwater) which provides an assessment of the existing groundwater environment and the impacts associated with groundwater inflow and drawdown (specifically, **Sections 19.2**, **19.3**, and **19.4**).

Table 16-1 sets out the Secretary's Environmental Assessment Requirements (SEARs) as they relate to soil and water quality and states where in this EIS these have been addressed.

Table 16-1 SEARs – soil, water and hydrology

SEARs	Section addressed
An assessment of construction and operational erosion and sediment and water quality discharge impacts, taking into account impacts from treated discharge, accidents and runoff (i.e. acute and chronic impacts), having consideration to impacts to surface water runoff, soil erosion and sediment transport, mass movement, salinity and iron levels. The assessment must include identification and estimation of the quality and quantity of pollutants that may be introduced into any waterways by source and discharge point;	Potential erosion, sediment and water quality discharge impacts are described in **Sections 16.3.1**, **16.3.2** and mitigation measures in **Section 16.4**. Surface water runoff, sediment transport, mass movement, salinity and iron levels are considered in **Sections 16.3.1** and **16.3.2**.
An assessment of water quality impacts on receiving waterways likely to be affected by the proposal (including Wolli, Cup and Saucer creeks, Cooks River and Alexandra Canal). The assessment must include existing water quality, geomorphology, riparian vegetation and rehabilitation of riparian land, and have reference to the NSW Water Quality Objectives and relevant public health and environmental water quality trigger values and criteria, including those specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000), any applicable regional, local or site-specific guidelines and any licensing requirements.	Potential water quality impacts are described in **Sections 16.3.1** and **16.3.2** and mitigation measures in **Section 16.4**. Biodiversity impacts, including impacts on riparian vegetation at Wolli Creek, are described in **Sections 21.3.1** and **21.3.2** (Biodiversity).

SEARs	Section addressed
An assessment of groundwater impacts (including ancillary facilities such as the tunnel control centre and any deluge systems), considering local impacts along the length of the tunnels and impacts on local and regional hydrology including consideration of any Water Sharing Plan and impacts on groundwater flow. The assessment must consider: extent of drawdown; impacts to groundwater quality; volume of groundwater that will be taken (including inflows); discharge requirements; location and details of groundwater management and implications for groundwater-dependent surface flows, groundwater-dependent ecological communities, and groundwater users. The assessment must include details of proposed surface and groundwater monitoring and be prepared having consideration to the requirements of the NSW Aquifer Interference Policy;	Groundwater impacts are described in **Sections 19.3** to **19.4** (Groundwater). Impacts of groundwater treatment and water treatment plan discharge on surface water quality are discussed in **Sections 16.3.1** and **16.3.2**.
Identifying potential impacts of the development on acid sulfate soils in accordance with the relevant guidelines and a description of the mitigation measures proposed to minimise potential impacts.	Refer to **Sections 16.3.1** and **16.4**.

16.1 Assessment methodology

The methodology for the soils assessment involved:

- A review of the geological context, soil landscapes, and acid sulfate soils within the project corridor, including consideration of:
  - Regional geology along the project corridor, as described in the Geological Survey of NSW 1:100,000 scale Sydney Map Sheet (sheet 9130, 1983)
  - The soil landscapes and characteristics within the project corridor, which have been determined based on the Soil Landscapes of the Sydney 1:100,000 Sheet 9130 (1989). Examination of the soil landscape maps and an interpretation of the erosion potential, and other stability issues, has been conducted in order to assess potential impacts
  - Acid sulfate soils mapping, obtained from Australian Soils Resource Information System and NSW Department of Land and Water Conservation to determine areas of higher probability
- Identification and assessment of construction and operational activities that may result in erosion or the exposure of acid sulfate soils
- Identification of environmental management measures, including the type of controls and design criteria required to mitigate potential impacts.

The methodology for the water quality assessment involved:

- Desktop assessment and review of background information
- Identification of the surface water study area
- Field assessment to assess the current state of surface water features and water quality within the surface water study area
- Consultation with relevant government agencies and stakeholders (**Sections 7.3**, **7.4** and **7.5**)
- Identification and assessment of construction and operational activities that may result in erosion and mass movement, the exposure of acid sulfate soils and impacts to the water quality of receiving environments
- Identification of environmental management measures, including the type of controls and design criteria required to mitigate potential impacts.

The methodology for the water quality assessment is presented in further detail in the following sections.

16.1.1 Surface water study area

The project is located within the lower portion of the Cooks River catchment (refer to **Figure 16-1**). The surface water study area includes the sub-catchments of the Cooks River that contain, or would potentially be influenced by, elements of the project as follows:

- The western surface works and Bexley Road surface works would be located within the Wolli Creek sub-catchment
- The St Peters interchange works and the eastern portion of the local road upgrades would be located within the Alexandra Canal catchment
- The north west portion of the local road upgrades (generally north west of the Princes Highway) would be located within the Eastern Channel sub-catchment
- The Arncliffe surface works would be located on land that drains directly to the Cooks River.

The Cup and Saucer Creek was found to be significantly upstream from the lower portion of Cooks River which does fall within vicinity of the project area. As such, while the Cup and Saucer Creek was identified for assessment in the SEARs (refer **Table 16-1**), it was not considered to be part of the overall study area for the project as it is located sufficiently upstream from the project area to not be impacted on by the project.

16.1.2 Desktop assessment

The desktop assessment involved a review of the existing surface water environment across the study area, including:

- Information available in databases relevant to surface water including water quality data sampled as part of previous assessments, flood data and information about the physical conditions of the surface water environment
- Review of information and previous studies conducted for other relevant major developments within the surface water study area, including the M5 East Motorway and other developments along Alexandra Canal. This included geomorphological and water quality studies used to inform the EIS for this project
- Other relevant studies that form part of this EIS, including groundwater, contamination, biodiversity and flood studies.

Given the availability of several existing surface water quality data sets within the study area (refer **Section 16.1.1**), no further surface water quality sampling was considered necessary to characterise the existing surface water quality of the study area.

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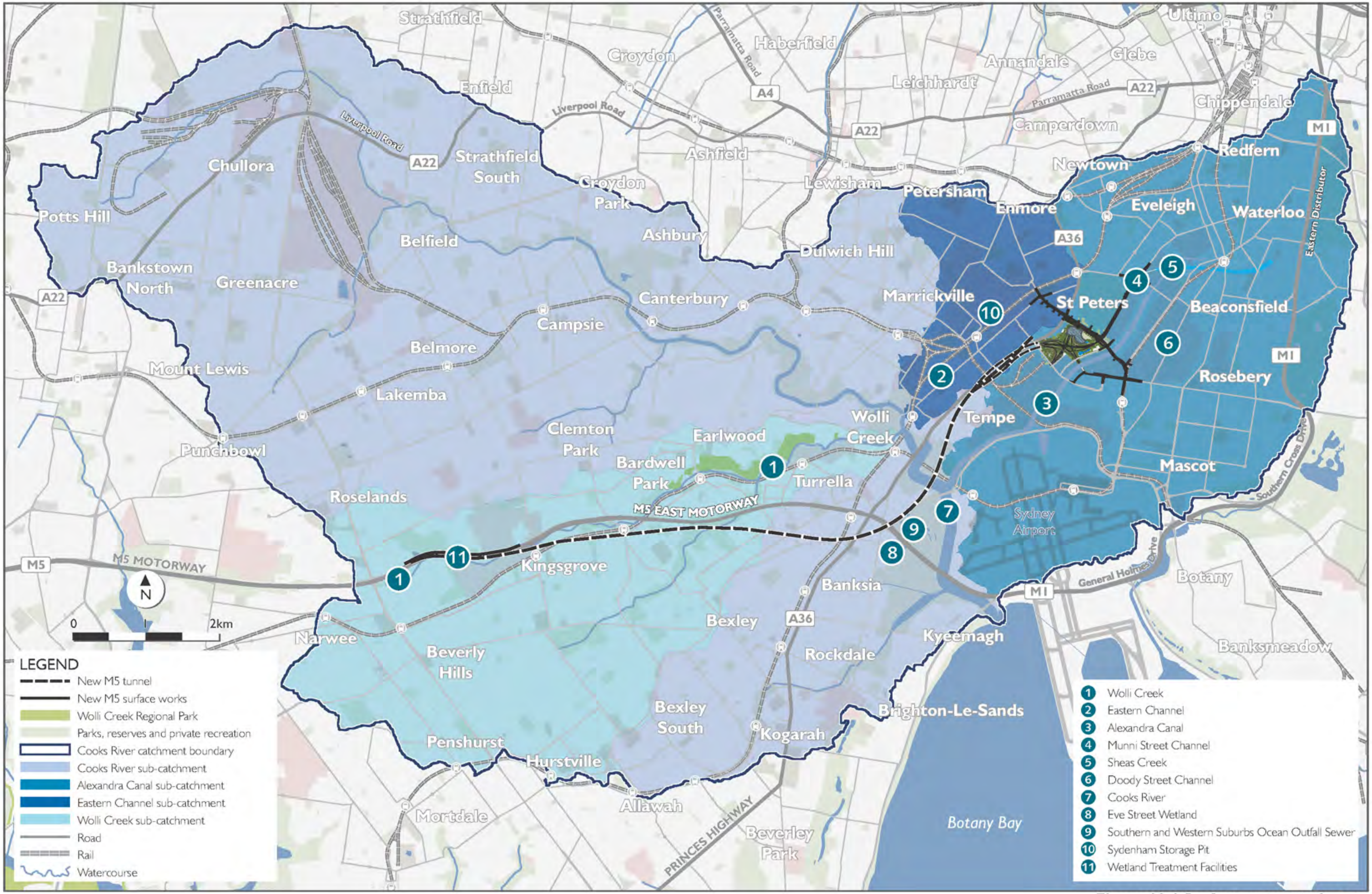

Figure 16-1 Surface water study area

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16.1.3 Field assessment

The objective of the field assessment was to determine the current state of surface water features within the study area that could be impacted on by changes to surface water flooding, hydrology or water quality. The existing flooding regime of the study area is detailed in **Section 18.2.2** in **Chapter 18** (Flooding and drainage).

Field inspections were conducted on 16, 17 and 23 April 2015. Where access was available, inspections were made to relevant sections of:

- Alexandra Canal
- Sheas Creek
- Botany Road / Doody Street Stormwater Channel
- Munni Street Stormwater Channel
- Eastern Channel
- Sydenham Storage Pit
- Lower Cooks River
- Wolli Creek
- Wetland Treatment Facilities (#1-5) along the existing M5 East Motorway alignment (refer to Figure 19 of the Technical working paper: Surface water (**Appendix N**)
- Eve Street Wetland
- South Western Suburbs Ocean Outfall System.

These locations are shown on **Figure 16-1**.

16.1.4 Identification and assessment of potential impacts

The potential impacts of the project on the water quality of receiving waters have been considered in terms of watercourse geomorphology and the potential for erosion, sedimentation and mass movement impacts, as well as uncontrolled spills and the existing water quality within the catchment.

Geomorphology

As a basis of understanding the types of watercourses present within the project corridor a geomorphic categorisation framework called River Styles (Brierley and Fryirs, 2005) was used to classify watercourses based on morphology and behaviour.

A modified version of the framework methodology that was developed for the Sydney Metropolitan Waterways Health Strategy (Earth Tech, 2007) was adopted to allow for the urbanised and modified geomorphology of the watercourses.

The River Styles classification provided the basis for determining the vulnerability of each watercourse to geomorphic impacts such as erosion and mass movement, which in turn influences water quality. The extent of potential impacts was assessed and compared to the vulnerability of the watercourses in order to determine the impacts of the project on geomorphology.

A preliminary erosion and sedimentation assessment was also conducted for the project in accordance with the Erosion and Sedimentation Risk Assessment Procedure – Appendix 1a &1b for Concept Designs (RTA, 2004).

Water quality

Baseline surface water quality data across the study area was obtained from the following previous studies:

- Sydney Water Environmental Indicators Compliance Report Volume 3 (Woodlots, 2004)
- City of Rockdale Water Quality Monitoring Study (Equatica, 2014)
- 2011 Annual Water Quality Study (Cooks River Valley Association, 2010 / 2011)
- Cooks River Stormwater Management Plan. Prepared for the Cooks River Catchment Association of Councils (PPK-WMA, 2009)
- Review of Environmental Factors for the Alexandra Canal (Stormwater Renewal Program) (GHD, 2012).

Surface water monitoring data from these previous studies has been used to characterise water quality in the surface water study area (refer to **Section 16.2.7** for more detail). Data monitoring locations are shown in **Figure 16-2**. The comprehensive nature of existing surface water quality data (in relation to timing, frequency and spatial extent) provided sufficient information to characterise the existing environment. Notwithstanding, the project specific water quality monitoring was also undertaken and the data used in the assessment of the existing environment.

Project specific water quality monitoring of waterways commenced in June 2015, and would continue through construction of the project and for 12 months post-construction or as otherwise required by the conditions of approval. The purpose of the project specific water quality monitoring is to provide a targeted baseline for locations which may be impacted by the project. The baseline would be used to confirm compliance with conditions of consent during construction and operation of the project. Details of the project specific monitoring program are described in **Section 16.3**.

Discharge criteria

The ANZECC Water Quality Guidelines are ambient water quality guidelines that have been used to classify the water quality of watercourses in the study area.

Under the guidelines classification system the watercourses within the study area have been classified as highly disturbed systems. These systems are defined as ecosystems of lower ecological value that include urban streams receiving road and stormwater runoff (ANZECC, 2000).

The NSW Water Quality and River Flow Objectives (DECCW, 2006) are consistent with the ANZECC Water Quality Guidelines and are used to maintain and improve water quality in order to support aquatic ecosystems, recreation activities, aquatic foods and / aquaculture.

The NSW Water Quality and River Flow Objectives have been developed for the Cooks River catchment and are dealt with in this EIS as follows:

- Protect aquatic ecosystems – refer to **Sections 21.2.6, 21.3.1**, **21.3.2** and **21.4**
- Protect visual amenity – refer to **Sections 14.3.1**, **14.3.2** and **14.4**
- Protect irrigation water supply – this was not considered applicable to the project as there is no agriculture within the study area
- Maintain natural flow variability – refer to **Section 16.3.2** and **Sections 21.2.6**, **21.3.1** and **21.3.2**
- Maintain natural rates of change in water levels – refer to **Table 16-12** and **Section 16.3.2**
- Minimise effects of weirs and other structures – refer to **Table 16-12** and **Section 16.3.2**.

In order to promote an improvement in water quality within the receiving environments, a local reference data set for nutrients, dissolved oxygen and pH was developed based on the existing surface water data.

The reference data set has been used to establish the criterion that pollutant concentrations within water treatment plant discharge would not exceed the 80th and / or 20th percentile values of the reference data set. Other controlled discharges in addition to those from water treatment plants are not anticipated, and so were not considered further in this EIS.

Operational Stormwater Pollutant Reduction Targets

To assess the water quality impacts of the surface runoff on the receiving environments, basic assessments incorporating Model for Urban Stormwater Improvement Conceptualisation (MUSIC) modelling was undertaken to estimate the pollutant loads and required treatment levels for stormwater runoff during the project's operation (refer **Section 16.3.2**).

These additional pollutant loads generated by surface runoff would be mitigated in accordance with:

- The project's Water Quality Reference Criteria (refer Appendix A of the Technical working paper: Surface water (**Appendix N**))
- The stormwater pollution reduction targets from the Botany Bay and Catchment Water Quality Improvement Plan (SMCMA, 2011).

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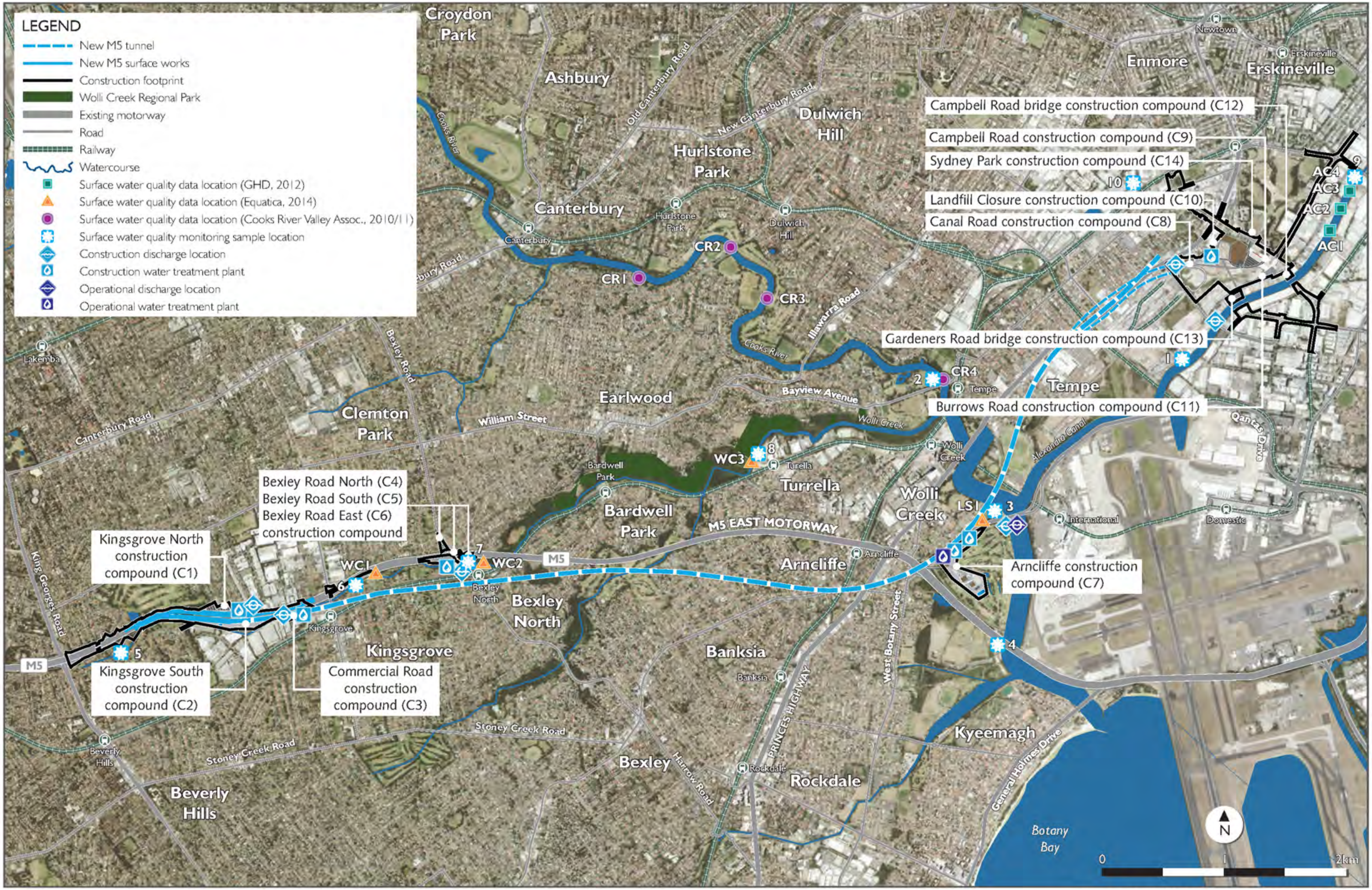

Figure 16-2 Water quality data locations

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16.2 Existing environment

16.2.1 Topography and geology

Topography

The western portion of the project corridor is relatively flat, low lying, with gentle undulating hills ranging between 30 metres Australian height datum (AHD) and 40 metres AHD, characteristic of Ashfield Shale type terrain.

The central portion of the project corridor is characterised by Wolli Creek and Bardwell Creek. These watercourses have incised gullies that pass through a subterranean sandstone and shale plateau.

The topography of the project corridor near the confluence of Wolli Creek and the Cooks River is relatively flat and low-lying (around five to 10 metres AHD) and gradually declining towards Botany Bay.

Various ridgelines have controlled the alignment of drainage features such as the Cooks River. Land within and adjoining the central and north-eastern areas of the project corridor has been substantially modified over time due to land reclamation and industrial activities. The Botany Sands are present in the vicinity of Alexandra Canal.

The eastern portion of the project corridor would include the St Peters interchange, which would be located on the former Alexandria Landfill site. The landfill site is a former brick pit, which has been progressively filled with waste materials over several decades.

Regional geology

Regionally the project area is located within the Permo-Triassic Sydney Basin which is characterised by sandstone and shale sediments. Around the eastern end of the project, the Botany Sands overlie the bedrock.

The main geological layers that are expected to be encountered across the project corridor will comprise the following from youngest to oldest:

- Anthropogenic fill
- Quaternary Alluvium (recent beneath rivers, palaeochannels and Botany Sands)
- Jurassic Intrusions (volcanics)
- Triassic Ashfield Shale (Wianamatta Group)
- Triassic Mittagong Formation
- Triassic Hawkesbury Sandstone Formation.

Figure 16-3 shows the proposed alignment in the regional geology context. A detailed geological long section showing subsurface and geological structures in relation to the vertical alignment of the tunnel is provided in **Appendix C**.

The geology along the project corridor, as described in the Geological Survey of NSW 1:100,000 scale Sydney Map Sheet (sheet 9130, 1983), and confirmed by the project-specific site investigations undertaken between September 2014 and March 2015 (refer to **Section 19.1.2** (Groundwater)), is dominated by the Wianamatta Group rocks and the Hawkesbury Sandstone Formation. These units are separated by the Mittagong Formation across the majority of the Sydney Basin area.

The Wianamatta Group Geological unit comprises Ashfield Shale, which corresponds to the ridgelines around Kingsgrove, and from Sydenham to St Peters. The Ashfield Shale layer typically extends to a depth of three to 10 metres, although has extended to depths in excess of 40 metres. The Ashfield Shale layer comprises siltstone and laminite subgroup units.

Hawkesbury Sandstone is present at depth all the way along the project alignment, at the surface from Bardwell Valley to Wolli Creek, and in areas around Tempe. The Hawkesbury Sandstone is a medium to coarse grained quartz sandstone deposited in beds around one metre to over three metres thick. The beds may be massive, or cross-bedded. Shale breccia is common at the contacts between beds and siltstone interbeds form a minor part of the unit. Siltstone interbeds are prominent within the sandstone below Rockdale and Kogarah.

The Mittagong Formation separates the Ashfield Shale from the underlying Hawkesbury Sandstone. The formation represents the transition from the fluvial or terrestrial environment of the Hawkesbury Sandstone deposition to the marine delta deposition of the Ashfield Shale. The boundary can be variable in composition and thickness. The Mittagong Formation generally comprises an upper, thin, fine grained sandstone unit (typically 0.5 metres to 1.5 metres thick) over a lower unit of fine grained sandstone and siltstone (typically one metre to three metres thick, but can be in the order of 10 metres thick).

Igneous dykes and breccia diatremes (volcanic vents filled with breccia, formed by volcanic eruptions) of Jurassic Age are sparsely distributed throughout the Sydney Region.

The Geological Survey of NSW 1:100,000 scale Sydney Map Sheet 9130 indicates the presence of 25 diatremes and over 100 dykes. Three dykes were identified during site investigations for the project, around Bexley Road, and on the north and south side of the Cooks River. The dykes in the Sydney region generally consist of linear basaltic rock bodies intruded into the surrounding country rock. The dykes are typically extremely weathered and altered to a kaolinitic clay to a depth of some 10 to 20 metres below ground level.

No faults are mapped crossing the project corridor on the Geological Survey of NSW 1:100,000 scale Sydney Map Sheet, but faulted rock and shear zones have been identified during the site investigations for the project at several locations along the alignment, including around Cooks River, Bardwell Valley, St Peters, Banksia and Rockdale. North-east to south-west trending faults have been mapped in the Sydney CBD and these faults may extend south through the project corridor.

The geology of the area was influential in determining the tunnel vertical alignment. Hawkesbury Sandstone is considered an excellent tunnelling and excavation medium and as a result, the main alignment tunnels have been designed to maximise the length of tunnel within this geological unit. The tunnel depth below the Cooks River has also been determined based on the depth of soft sediments within the Cooks River paleo-valley.

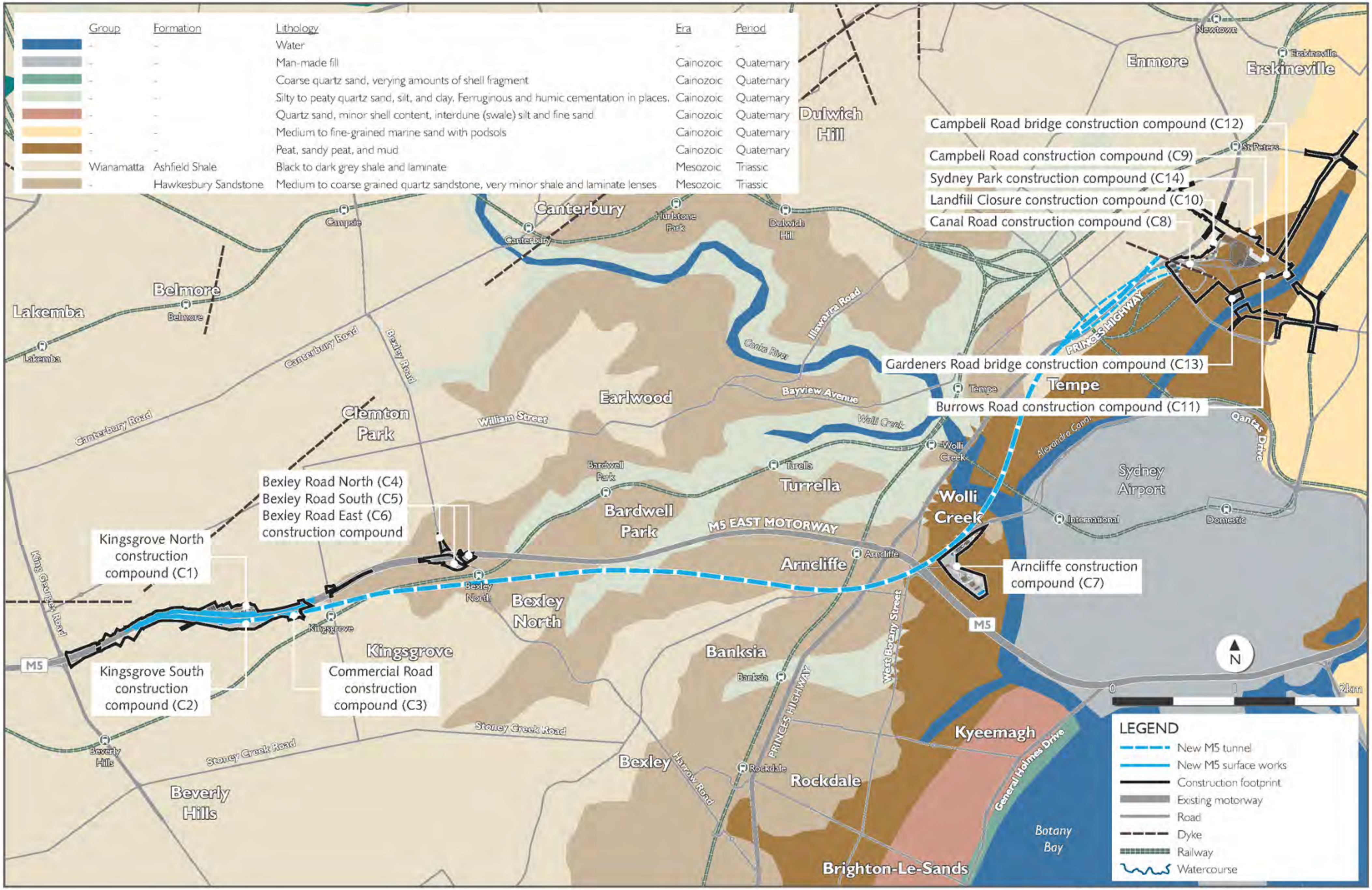

Figure 16-3 Regional geological context

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16.2.2 Soils landscapes

The Soil Landscapes of the Sydney 1:100,000 Sheet 9130 (1989) indicates that the project corridor is underlain by seven soil landscape groupings, within which there are seven soil landscapes. The Gymea soil landscape covers the majority of the project corridor in the west, with smaller areas of the Hawkesbury, Blacktown, Birrong, Warriewood and Oxford Falls soil landscapes. The eastern extent of the project corridor is largely covered by land identified as being disturbed terrain associated with Alexandra Canal and industrial land uses.

Soil landscapes within the study area are shown in **Figure 16-4**, and their key characteristics summarised in **Table 16-2**.

Table 16-2 Soil landscapes

Soil landscape	Characteristics	Erosion/mass movement potential
Residual Blacktown	• Occurs on gently undulating rises on Wianamatta Group Shales • Poorly drained, moderately reactive soil.	No appreciable erosion occurs on this unit as most of the surface is covered by tiles, concrete, bitumen or turf.
Alluvial Birrong	• Occurs on level to gently undulating alluvial flood plan draining the Wianamatta Group Shales • Saline soils, seasonal waterlogging and localised flooding.	Soil landscapes exhibit a high soil erosion hazard. However, most drainage lines have been artificially lined with concrete to prevent ongoing erosion. Minor streambank erosion has occurred along remaining natural drainage lines.
Erosional Gymea	• Occurs on undulating to rolling rises and low hills on Hawkesbury Sandstone • Localised steep slopes • High soil erosion hazard.	Severe sheet erosion occurs following bushfires that destroy or damage stabilising vegetative cover. Minor gully erosion occurs along unpaved roads and fire trails especially those frequented by four wheel drive vehicles and trail bikes.
Colluvial Hawkesbury	• Occurs on rugged, rolling to very steep hills on Hawkesbury Sandstone • Extreme soil erosion and mass movement hazard.	Severe sheet erosions often occur during storms and after ground cover is destroyed by bushfires. Minor gully erosion occurs along unpaved tracks and fire trails, especially those used regularly by four wheel drive vehicles, motorcycles and horses.
Transferral Oxford Falls	• Occurs in hanging valleys on Hawkesbury Sandstone, with occasional broad benches and scarps.	Very high soil erosion hazard perched water tables and swamps, highly permeable soil.
Swamp Warriewood	• Occurs on level to gently undulating swales, depressions and infilled lagoons in Quaternary sands • High water tables and localised flooding, highly permeable soils, compressible soils.	No appreciable erosion occurs where slopes are low and a vigorous ground cover is maintained. Isolated blowouts caused by wind erosion occur in exposed area where cover has been removed.
Disturbed Terrain Disturbed Terrain	• Terrain extensively disturbed by human activity, including complete disturbance, removal or burial of soil • Variable relief and slopes.	Erosion hazard varies markedly according to site characteristics including slope, aspect and exposure. In general, severe sheet and rill erosion often occur at quarries, gravel pits and places where unconsolidated or disturbed material remains without a protective cover of vegetation, asphalt or concrete.

16.2.3 Acid sulfate soils

Acid sulfate soils and potential acid sulfate soils are naturally occurring soils that contain iron sulfides which, on exposure to air, oxidise and create sulfuric acid. This increase in acidity can result in the mobilisation of aluminium, iron and manganese from the soils. Other impacts include the de-oxygenation of water.

A search of the Australian Soils Resource Information System indicated there is a low to extremely low probability of occurrence of acid sulfate soils for the majority of the project corridor. Land adjacent to watercourses, namely the Cooks River, Wolli Creek and Alexandra Canal were identified as having a high probability of being acid sulfate soils.

Areas showing the high and low probability of occurrence of acid sulfate soils extracted from the NSW Department of Land and Water Conservation Acid Sulfate Soil Risk Map for Botany Bay are presented on **Figure 16-5**.

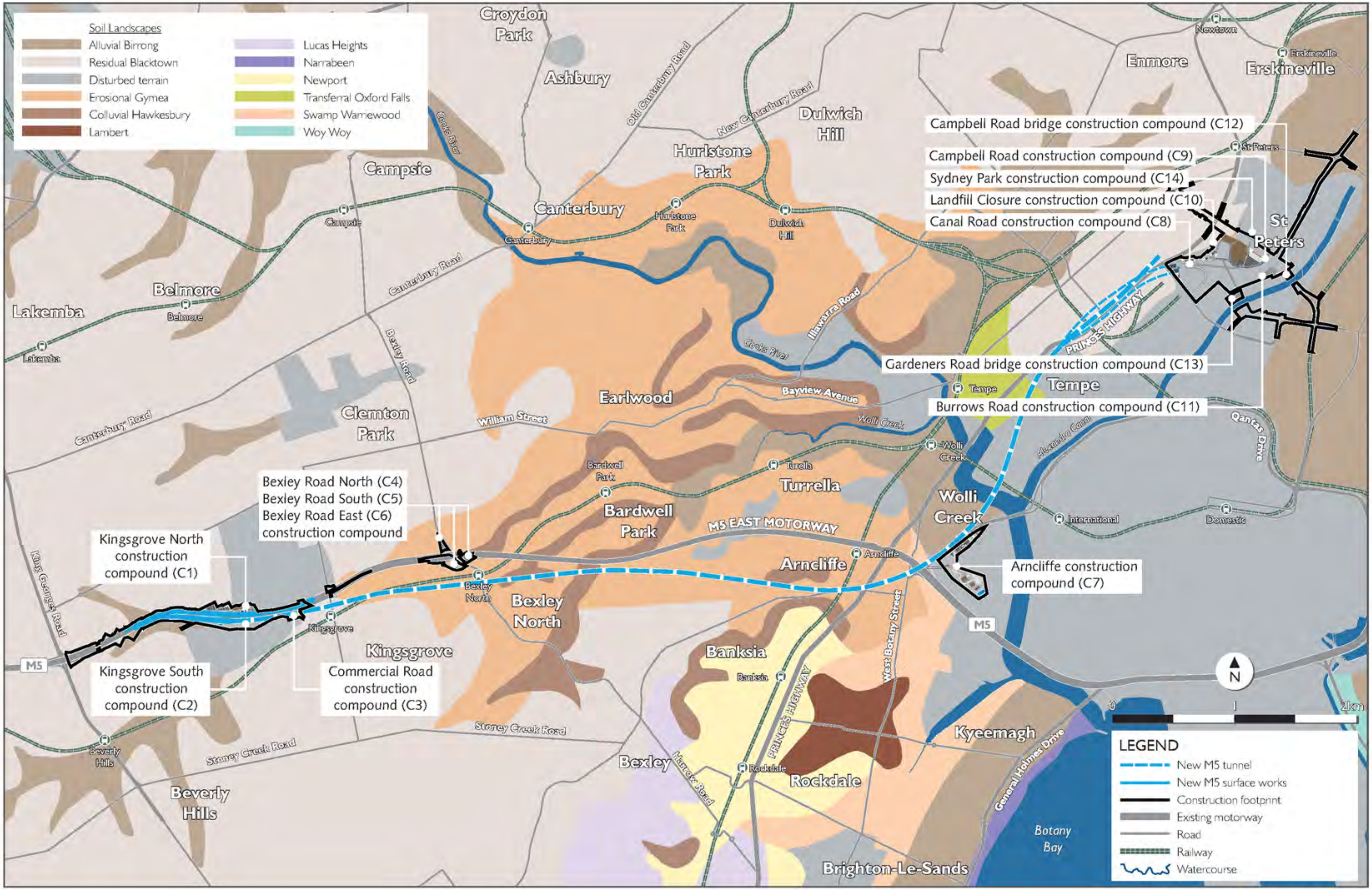

Figure 16-4 Soil landscapes

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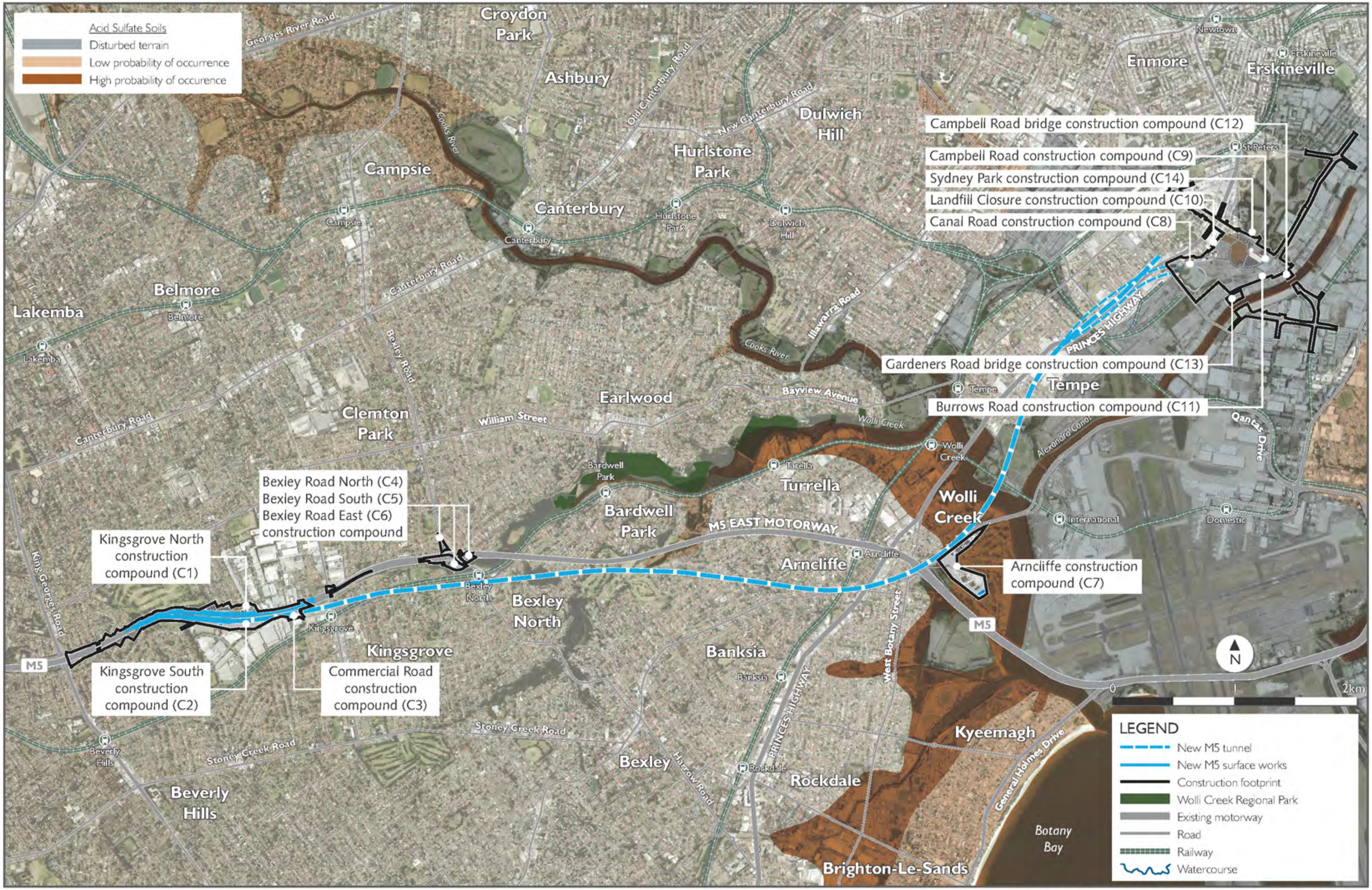

Figure 16-5 Acid sulfate soil risk areas within the study area

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16.2.4 Catchments and watercourses

The project would be constructed within the Cooks River catchment. The Cooks River catchment forms part of the greater Botany Bay Catchment (SMCMA, 2011) and is fed by nine tributaries:

- Greenacre Creek
- Cox's Creek
- Cup and Saucer Creek
- Fresh Water Creek
- Bardwell Creek
- Wolli Creek
- Muddy Creek
- Shea's Creek / Alexandra Canal
- Eastern Channel.

Of these nine tributaries, Wolli Creek, Shea's Creek / Alexandra Canal and the Eastern Channel are located within the surface water study area and are relevant to the project.

The following field inspections were undertaken:

- 16 April 2015, inspection of geomorphology and waterways
- 17 April 2015, inspection of geomorphology and waterways as well as existing water quality improvement devices
- 23 April 2015, inspection of drainage infrastructure and assessment of waterway capacity following heavy rainfall.

The catchments of these tributaries, and that of the Cooks River, are described below.

Cooks River catchment

The Cooks River catchment measures around 10,000 hectares. The landscape within the catchment has been highly urbanised, with a history of intensive land use ranging from residential to heavy industry.

Residential land use is the predominant zoning within the catchment, covering around 58 per cent of the catchment. Open space represents the smallest land use within the catchment, covering around 11 per cent of the catchment. The catchment has no significant rural lands, eight per cent park land and a small area of bushland surrounding Wolli Creek. Industrial zoned land is concentrated in the Port Botany area, along Alexandra Canal and the southern portion of the Strathfield Council area.

The heavily urbanised nature of the catchment is a likely influencer on the Cooks River catchment being regarded as one of the most polluted catchments in Australia, and the majority of watercourses within the Cooks River catchment are anthropogenically modified channels.

The Cooks River flows for around 23 kilometres from Graf Park in Bankstown into Botany Bay at Kyeemagh (CRA, 2013). The Cooks River is almost uniformly 50 metres wide upstream of Cahill Park, Tempe where it widens to roughly 150 metres until its trained mouth.

The Cooks River is semi-tidal due to its connection with Botany Bay at Mascot. The tidal limit of the Cooks River is estimated to be adjacent to Sando Reserve, Croydon Park (Manly Hydraulics Laboratory, 2005). This is roughly 7.5 kilometres upstream of the confluence of the Eastern Channel, deemed to be the upstream extent of the potential influence of the project.

The Cooks River is highly modified and lined with steel sheet pilings, concrete walls or stone block revetments and with some rehabilitated natural sections. As a result of the channelization and lining works, this lower section of the Cooks River is not susceptible to erosion or mass movement, providing river flows are contained with the channel. During flooding events, there is potential for erosion of the floodplain and slopes adjacent to the Cooks River.

Wolli Creek sub-catchment

The Wolli Creek sub-catchment measures around 2100 hectares. The catchment extends from Narwee in the west, Wolli Creek to the east, Mortdale to the south and Roselands to the north. The catchment has been significantly altered by urbanisation including general residential, industrial and commercial development, as well as the construction of the M5 East Motorway and the East Hills Railway line. Prominent open space areas within the catchment include the Canterbury Golf Course, the M5 Linear Park (part of the M5 East works) and the Wolli Creek Regional Park.

Wolli Creek is the largest tributary of the Cooks River and measures around 3.5 kilometres long. The creek starts in Beverly Hills and flows through the Wolli Creek Valley in a north-easterly direction until joining the Cooks River near Tempe. The creek is tidal to near Hannam Street, Bardwell Park.

The geomorphology of the watercourse is broadly characterised by:

- The western extent of the project corridor downstream to Bexley Road
- Bexley Road downstream to the Wolli Creek confluence with the Cooks River.

The western extent of the project corridor downstream to Bexley Road Bridge crossing is generally anthropogenically modified with hard engineered lining. This section consists of: open concrete-lined trapezoidal channels; underground concrete channels; piped channels; and rock-lined channels.

The section from Bexley Road to the Cooks River has been modified to accommodate the railway line and urban development. The creek flows into a modified natural channel from Bexley Road with alluvial creek banks and densely vegetated weed species within a confined valley setting before transitioning into a partly confined meandering platform controlled setting.

The watercourse travels through the Wolli Creek Regional Park and is joined by Bardwell Creek on the northern side of the passenger rail line at Bardwell Park. A weir and associated fishway at Turrella Park, near Henderson Street regulates flow before it reaches its confluence with the Cooks River adjacent to Wentworth Park, Wolli Creek

Alexandra Canal sub-catchment

The Alexandra Canal sub-catchment measures around 2300 hectares and is a tidal sub-catchment of the Cooks River. The catchment extends from Tempe in the south west to Moore Park in the north east. The catchment is heavily altered, predominantly covered by commercial, industrial and residential development with a small amount of parkland.

The Alexandra Canal is around 3.9 kilometres long and up to 60 metres wide. It is a constructed canal that was originally a natural watercourse named Sheas Creek, flowing into the Cooks River near the north-western corner of Sydney Airport. Sheas Creek is now a shortened concrete-lined channel upstream of Alexandra Canal. The Alexandra Canal is tidally dominated through its connection to the Cooks River. The tidal influence extends up to Huntley Street, St Peters.

Historically, dredging was regularly untaken to remove sediment build up. The canal bank walls were originally constructed using sandstone blocks, the condition of these walls is highly variable. The bottom of the canal is mainly earth except where Sheas Creek enters the canal near Huntley Street, where a base has been laid in sandstone (Department of Public Works and Services, 2004).

The majority of the canal is devoid of geomorphic units, due to the rock-lined banks and dredged canal base. Due to the accretive nature of the Alexandra Canal in its middle reaches, sediments tend to build up and are not protected from scour events. The canal contains a scour hole at the headwaters of the canal and a number of sediment deposition material (slugs), particularly at the extents of the waning flow energy, channel edges, tidal influence, and in-stream structures. These sediment slugs are remobilised when larger events pass through the system, eventually over time entering the Cooks River. The potential for the mobilisation of contaminated sediments is discussed in **Section 5.5.5** and **Section 9.5** of the Technical working paper: Contamination (**Appendix O**). A further study showed that older sediments in the Alexandra Canal are known to be highly contaminated and these are overlain by more recent less contaminated sediments (UoQ, 2002).

Overall, the past investigations have found the following main sources of pollution in the Alexandra Canal to be:

- Stormwater pollution including runoff from roads, industrial, commercial and residential premises
- Seeps and overflows from the sewer system
- Discharges from industry
- Contaminated land within the catchment combined with porous soils allowing leachate to migrate via stormwater or groundwater into the canal
- Release of chemicals from contaminated sediments in the canal into the water column
- Contaminated groundwater input (DPWS, 2004).

Alexandra Canal was declared a remediation site (number 21008) on 25 August 2000 by the EPA due to contaminated bed sediments. A Remediation Order (number 23004) was subsequently issued by the EPA to Sydney Water on 10 May 2004.

The Remediation Order includes a requirement not allowing ‘any works or activities on the bed sediments of the site that would result in the disturbance, or further disturbance, of the bed sediments’ except as provided by the Remediation Order. The Remediation Order also states that works disturbing the bed sediments require a plan to be submitted to the EPA for approval prior to commencement of the works (refer Section 5.5.5 of **Appendix O**).

Eastern Channel sub-catchment

The Eastern Channel sub-catchment measures around 500 hectares. Within the project corridor the catchment includes the suburbs of Tempe, Sydenham, St Peters and Alexandria. The area is highly urbanised and altered by a relatively even mix of commercial and residential property. The catchment has a very small proportion of open space in the form of recreational parklands.

The Eastern Channel runs along the Sydenham to Tempe railway line. The channel is an open concrete lined channel of varying dimensions and grade (average grade of 0.17 per cent) which carries stormwater. The main open section is around 2.3 kilometres near Murray Street, Marrickville to its confluence with the Cooks River adjacent to Tempe Station. Part of the channel is tidal due to its connectivity with Cooks River.

16.2.5 Catchment land use

The geomorphology and water quality of the watercourses in the surface water study area is closely linked to the land use in each of the catchments. A summary of land uses for each catchment is provided in **Table 16-3**.

Table 16-3 Land use within the Cooks River catchment and sub-catchments within the surface water study area

Land use	Entire Cooks River catchment	Alexandra Canal sub-catchment	Wolli Creek sub-catchment	Eastern Channel sub-catchment
Commercial	3343 ha (31%)	1409 ha (63%)	327 ha (16%)	218 ha (45%)
Residential	6389 ha (58%)	609 ha (27%)	1513 ha (72%)	242 ha (49%)
Open space	1169 ha (11%)	2478 ha (10%)	255 ha (12%)	30 ha (6%)
Total catchment	10881 ha	2230 ha	2094 ha	488 ha

Source: Earth Tech, 2007

16.2.6 Geomorphology

A number of concrete lined and unlined watercourses convey stormwater to the Cooks River. The network of open and partially open channels within the surface water study area, and their geomorphological characteristics, is shown in **Table 16-4**.

Table 16-4 Surface water study area - Riverstyles categorisation

Geomorphic Categorisation	Length within study area (metres)	% of study area
Concrete channel	10230	50
Partly confined channel - Meandering, platform controlled, discontinuous floodplain	2690	13
Occasional pockets - Confined channel with alternating discontinuous floodplain pockets	270	1
Piped channel	220	1
Rock-lined channel	3700	18
Shaped channel	1540	8
Underground concrete channel	1880	9

Source: Earth Tech, 2007

The geomorphological characteristics of the watercourses within the surface water study area are primarily categorised as having no potential for lateral or vertical adjustment (concrete channel, piped channel, rock-lined channel, shaped channel and underground concrete channel). The geomorphic characteristics of the watercourses reflect their urban and anthropogenic nature.

Conversely, slopes in parts of the surface water study area are greater than 10 per cent grade. This combined with an R factor (rainfall erosivity) of 3000-3500 for this area of Sydney presents as a high erosion and mass movement hazard. Soil landscapes with erosion / mass movement potential are identified in **Table 16-2.**

16.2.7 Water quality

The Cooks River catchment is one of the most polluted urban catchments in Australia and its surface water quality is considered to be poor. Water quality of the catchment has been historically affected by stormwater pollution, industrial and domestic wastewater discharge, rubbish dumping and modification of the waterway, and is therefore representative of the water quality to be expected in a highly urbanised catchment.

The Alexandra Canal in particular is a heavily polluted waterway (refer **Table 16-7**). The results of this sampling indicated that metal concentrations in the upper reaches of Alexandra Canal were below the ANZECC Water Quality Guidelines (ANZECC, 2000) for cadmium, chromium, Lead, nickel, and mercury and Ammonia. Copper concentrations were greater than the 95 per cent, though below the 80 per cent protection level at two sites. Zinc concentrations were greater than the 95 per cent trigger value at all test locations, and greater than the 80 per cent protection level at other two test sites.

The following studies concluded that water quality at a number of locations in Wolli Creek, Cooks River and Alexandra Canal is generally poor with frequent occurrences of test results outside the ANZECC Water Quality Guidelines (ANZECC, 2000):

- The City of Rockdale Water Quality Monitoring Study (Equatica, 2014) included four monitoring sites along Wolli Creek. A summary of the parameters analysed during the study is shown in **Table 16-5**
- The 2011 Annual Water Quality Study by the Cooks River Valley Association (2010/2011) reported on a range of water quality parameters measured by Streamwatch at locations in the Cooks River catchment. This sampling gives an indication of water quality in the Cooks River upstream of the project (refer **Figure 16-2**). The results of their reporting are summarised in **Table 16-6**
- In 2012, Sydney Water undertook a Review of Environmental Factors for the Alexandra Canal (6a Huntley Street, Stormwater Renewal Program). The study included water quality testing at four locations in the upper 350 metres of Alexandra Canal. A summary of the parameters analysed during the study in relation to the ANZECC Water Quality Guidelines (ANZECC, 2000) for marine water quality is shown in **Table 16-8**.

A compilation of the water quality data collection points used in these studies is shown in **Figure 16-2**. For detailed information regarding the findings of these studies refer to Section 4.6 of the Technical working paper: Surface water (**Appendix N**).

Where historical data was not available from these existing sources, results from the project specific water quality monitoring program were used to supplement the data set. This included water quality monitoring within the Eastern Channel, the results of which are shown in **Table 16-10**. Water quality monitoring data from the project-specific water quality monitoring program within the Cooks River and Alexandra Canal are presented in **Table 16-7** and **Table 16-9**.

Table 16-5 Water quality in Rockdale LGA - City of Rockdale Water Quality Monitoring Study

Parameter	Wolli Creek Bonalbo St, Kingsgrove (WC1) (Lowland Freshwater River)	Slade Rd, Bardwell Valley (WC2) (Lowland Freshwater River)	Henderson St, Turrella (WC3) (Estuary/ Marine)	Levey St, Wolli Creek (LS1) (Estuary/Marine)	ANZECC (2000) default trigger values*	
	Median				**Lowland rivers**	**Estuaries**
Dissolved oxygen (% Sat)	135.5	75.5	53	17.5	85-110	80-110
Temp (ºC)	21.4	18.8	19.45	21.5	-	-
pH	7.205	6.865	6.65	6.965	6.5-8.0	7.0-8.5
Turbidity (NTU)	8.05	6.7	5.55	110	6-50	0.5-10
Total suspended solids (TSS) mg/L	13	16.5	11	51		
EC (mS/cm)	1340	725	n/a	n/a	125-2200	N/A
NOx (µg/L)	190	420	785	165	40	15
TKN (µg/L)	700	750	1000	1200		
TP (µg/L)	60	70	55	125	50	30
BOD (mg/L)	2.8	4.3	2.95	6.9		
Chl - a (ug/L)	< 0.2	< 0.2	< 0.2	< 0.2	5	4
ANZECC (2000) trigger value for protection of 80% of marine species					**Freshwater**	**Marine Water**
As (µg/L)	2	1	1.5	2	140[#]	ID
Cd (µg/L)	<0.1	<0.1	<0.1	<0.1	0.8	36
Cr (µg/L)	<1	<1	<1	<1	40[#]	85[#]
Cu (µg/L)	5.5	3.5	2	2.5	2.5	8
Pb (µg/L)	1.5	1	2	<1	9.4	12
Ni (µg/L)	1	1	1	2	17	560[3]
Zn (µg/L)	15	23.5	33	51	31	43
Water quality guidelines for recreational waters						
Enterococci (MPN/100 mL)	170	470	114	390	35[1]	230[2]

Source: Equatica, 2014

* ANZECC (2000) default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values for toxicants are for 80 per cent protection of marine species.

1 = Maximum for any one sample for primary contact associated with recreational purposes. 2 = Maximum for any one sample for secondary contact associated with recreational purposes.

3 = Figure may not protect key test species from acute toxicity (and chronic).

ID = Insufficient data. DO = dissolved oxygen, TSS = Total Suspended Solids, EC = Electrical conductivity, NOx = Nitrate + Nitrite, TKN = Total Kjeldahl Nitrogen, TP = Total Phosphorus, FRP = Filterable Reactive Phosphorus, BOD = Biological Oxygen Demand, Chl-a = Chlorophyll a, As = Arsenic, Cd = Cadmium, Cr = Chromium, Cu = Copper, Pb = Lead, Ni = Nickel, Zn = Zinc.

[#] For further indication on how these values were derived, refer to Table 12 of **Appendix N**.

Table 16-6 Water quality in the Cooks River

Parameter	Cooks River				ANZECC (2000) default trigger values*
	Younger Ave, Earlwood (CR1)	Wardell Rd, Marrickville (CR2)	Bruce St, Marrickville (CR3)	Richardsons Cr Marrickville (CR4)	
	Median				
DO %	40	32	55	56	80-110
Temp (ºC)	19	19	20	21	-
pH	8.5	8	8.5	8	7.0-8.5
TURB (NTU)	18	10	15	15	0.5-10
FRP (µg P-1)	180	160	130	140	30
E.coli	2500	2000	400	<100	1000*

Source: Cooks River Valley Association, 2010/2011
*ANZECC (2000) default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems (estuaries)
DO = dissolved oxygen, TURB = Turbidity, FRP = Filterable Reactive Phosphorus, EC = Electrical conductivity.

Table 16-7 Water quality in the Cooks River

Parameter	Site 3 – Cooks River – Levey Street, Wolli Creek		Site 4 – Cooks River – Riverine Park, Arncliffe		ANZECC (2000) default trigger values*
	Range	Median	Range	Median	Estuaries
NOx (µg/L)	130-290	155	90-870	125	15
TN (µg/L)	500-1300	800	300-1400	700	300
TP (µg/L)	60-90	75	40-140	70	30
Parameter	**ANZECC (2000) trigger value for protection of 80% of marine species for marine water**				
As (µg/L)	10-28	10	1-10	10	ID
Cd (µg/L)	1-5.5	1	0.1-1	1	36
Cr (µg/L)	10-22	10	1-10	10	85#
Cu (µg/L)	10-107	10	7-10	10	8
Pb (µg/L)	10-36	10	4-10	10	12
Ni (µg/L)	10-16	10	1-10	10	560[3]
Zn (µg/L)	50-120	50	21-52	50	43
Mn (µg/L)	10-49	19.5	10-49	11.5	N/A
Fe (µg/L)	440-470	500	240-640	500	N/A

Source: AECOM, 2015
* ANZECC (2000) default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values for toxicants are for 80 per cent protection of marine species
3 = Figure may not protect key test species from acute toxicity (and chronic)
ID = Insufficient data. NOx = Nitrate + Nitrite, TN = Total Nitrogen, TP = Total Phosphorus, As = Arsenic, Cd = Cadmium, Cr = Chromium, Cu = Copper, Pb = Lead, Ni = Nickel, Zn = Zinc, Mn=Manganese, Fe = Iron.
# For further indication on how this value was derived, refer to Table 14 of **Appendix N**.

Table 16-8 Water sampling results in upper Alexandra Canal

Parameter	Alexandra Canal Site AC1	Site AC2	Site AC3	Site AC4	ANZECC (2000) default trigger values*
As (µg L-1)	3	3	2	2	ID
Cd (µg L-1)	0.2	0.1	<0.1	<0.1	36
Cr (µg L-1)	<1	<1	<1	<1	85
Cu (µg L-1)	1	3	3	<1	8
Pb (µg L-1)	<1	<1	<1	<1	12
Ni (µg L-1)	28	<1	<1	1	560
Zn (µg L-1)	36	43	50	68	43
Hg (µg L-1)	<0.1	<0.1	<0.1	0.2	1.4
Ammonia as N (µg/L)	540	470	410	-	1700

Source: GHD, 2012

* ANZECC (2000) default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values for toxicants are for 80 per cent protection of marine species.

ID = Insufficient data. As = Arsenic, Cd = Cadmium, Cr = Chromium, Cu = Copper, Pb = Lead, Ni = Nickel, Zn = Zinc, Hg = Mercury.

Table 16-9 Water quality in Alexandra Canal

Parameter	Site 1- Alexandra Canal- Via Alexandra Cycleway, near Coward St		ANZECC (2000) default trigger values*
	Range	Median	Estuaries
Dissolved oxygen (% Sat)	34-53	45.5	80-110
Temp (ºC)	9.5-19.8	14.6	-
pH	7.27-7.92	7.41	7.0-8.5
Turbidity (NTU)	2.3-256	9.6	0.5-10
EC (µS/cm)	11483-39060	24714	N/A
NOx (µg/L)	270-4710	1285	15
TN (µg/L).	900-5400	2600	300
TP (µg/L)	10-110	55	30

* ANZECC (2000) default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values for toxicants are for 80% protection of marine species.

DO = dissolved oxygen, EC = Electrical conductivity, NOx = Nitrate + Nitrite, TN = Total Nitrogen, TP = Total Phosphorus

Table 16-10 Water quality in the Eastern Channel

Parameter	Site 10- Eastern Channel- Murray St, Marrickville		ANZECC (2000) default trigger values*
	Range	Median	Estuaries
Dissolved oxygen (% Sat)	63-133	75	80-110
Temp (ºC)	13.5-19	16.7	-
pH	8-8.8	8.3	7.0-8.5
Turbidity (NTU)	20-249	93.5	0.5-10
EC (µS/cm)	291-765	529	N/A
NOx (µg/L)	150-1580	1070	15
TN (µg/L)	1200-3200	2100	300
TP (µg/L)	30-140	80	30
	ANZECC (2000) trigger value for protection of 80% of marine species in marine water		
As (µg/L)	1-5	3	ID
Cd (µg/L)	0.1-1	<0.1	36
Cr (µg/L)	0.001-0.002	0.0015	85[#]
Cu (µg/L)	5-20	14	8
Pb (µg/L)	2-13	7.5	12
Ni (µg/L)	2-4	2.5	560[3]
Zn (µg/L)	30-61	42.5	43
Mn (µg/L)	53-64	56	N/A
Fe (µg/L)	600-1950	630	N/A

Source: AECOM, 2015
* ANZECC (2000) default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values for toxicants are for 80% protection of marine species.
3 = Figure may not protect key test species from acute toxicity (and chronic).
ID = Insufficient data. DO = dissolved oxygen, EC = Electrical conductivity, NOx = Nitrate + Nitrite, TN = Total Nitrogen, TP = Total Phosphorus, As = Arsenic, Cd = Cadmium, Cr = Chromium, Cu = Copper, Pb = Lead, Ni = Nickel, Zn = Zinc, Mn=Manganese, Fe = Iron.

The Sydney Water Environmental Indicators Compliance Report Volume 3 (Woodlots, 2004) provided a comparison between Wolli Creek, Alexandra Canal and Cooks River, classifying them as highly disturbed systems in relation to the ANZECC Water Quality Guidelines (ANZECC, 2000).

Results indicated poor water quality overall with a number of parameters failing to comply with respective guidelines. The study indicated that:

- Faecal coliforms including Escherichia coli and enterococci failed to meet guidelines at all watercourses during wet-weather flows
- Phosphorus and nitrogen failed to meet guidelines at all watercourses during both wet and dry weather flows
- Chlorophyll failed to meet guidelines during dry weather flows, but was not detectable during wet weather flows
- Dissolved oxygen fell within the guideline range except at Wolli Creek during both wet and dry weather flows and at Cooks River during dry weather flows
- pH levels were recorded at acceptable levels across all tests.

The City of Rockdale Water Quality Monitoring Study concluded that water quality at a number of locations at Cooks River is poor with frequent exceedances of Water Quality Guidelines (ANZECC, 2000). Further, sediment sampling between 2008 and 2011 by local councils and the University of New South Wales showed that highly contaminated river sediments were present. Surface sediments were less contaminated than at depth. It was cited that heavy metal mobilisation would be associated with remediation activities (RCC, 2011).

The City of Rockdale Water Quality Monitoring Study sampled four locations along the Wolli Creek. Findings concluded that pH and turbidity was generally acceptable with elevated levels of nutrients, Copper and Zinc. Faecal coliforms (enterococci) exceeded the guidelines for secondary recreational contact.

The Review of Environmental Factors for the Alexandra Canal (Stormwater Renewal Program) (GHD, 2012) concluded that metal concentration in upper reaches of Alexandra Canal were below the ANZECC guidelines. Zinc and copper were found in parts to exceed respective guideline values. Alexandra Canal is a heavily polluted waterway with older sediments known to be highly contaminated, and overlain by more recent less contaminated sediments (University of Queensland (UoQ), 2002).

16.2.8 Sensitive receiving environments

A sensitive receiving environment is defined as one that has a high conservation or community value, or one that supports ecosystems or humans uses of water that are particularly sensitive to pollution of degradation of water quality.

Sensitive receiving environments include:

- Nationally Important Wetlands and State Environmental Planning Policy No 14 (SEPP 14) wetlands (actual or potential groundwater dependent ecosystems)
- National parks, marine parks, nature reserves and State conservation areas
- Threatened ecological communities associated with aquatic ecosystems
- Known and potential habitats for threatened fish
- Key fish habitats as identified by the NSW Department of Primary Industries (DPI)
- Recreational swimming areas
- Areas that contribute to drinking water catchments
- Areas that are available or used for aquaculture and commercial fishing
- Green and Golden Bell Frog RTA Ponds at Arncliffe (refer Table 18 of the Technical working paper: Surface water (**Appendix N**)).

Changes to water quality may have the potential to impact a number of sensitive receiving environments, including:

- Wolli Creek
- Botany Bay
- Towra Point Wetlands
- Saltmarsh and other wetlands around Sydney Airport
- Seagrass in Botany Bay.

Potential impacts on groundwater dependent ecosystems and other sites of ecological significance area provided in **Sections 19.2.5** and **19.4.5** (Groundwater) and **Sections 21.2.7** and **21.3.1** (Biodiversity).

16.3 Assessment of potential impacts

16.3.1 Construction

Soils

Removal of vegetation and soil exposure during construction may weaken surface soil structure. This could lead to erosion (i.e. mobilisation and deposition of sediments), sedimentation and mass movement within and around watercourses and slopes in the surface water study area, particularly during periods of high wind or rainfall.

Sediments can fill and smoother in-stream geomorphic units and habitat features such as pools and riffles. Furthermore, sediments can accumulate at in-stream barriers and constrictions, which may result in localised flooding and / or channel avulsion (a new altered flow path around an in-stream barrier).

Erosion and sediment loads would gradually diminish after construction as the disturbed areas are stabilised and the vegetation starts to establish and hold the soils in place.

During construction and operation, the key objective is to minimise erosion of areas disturbed by earthworks and to contain any sediments on-site before they enter the riparian zone at Wolli Creek, or other watercourse / drainage system.

There is a risk that any runoff within the Alexandria Landfill site would be contaminated leachate. Therefore, any runoff from the Alexandria Landfill would be directed to a leachate treatment plant and discharged to sewer under a trade waste agreement with Sydney Water. Further details about water management within the Alexandria Landfill site during construction are provided in **Section 17.3.4** (Contamination).

Acid sulfate soils

Most of the study area has a low probability of acid sulfate soils occurrence, except land adjacent to watercourses that have the presence of alluvial deposits. These areas have a high probability of being potential acid sulfate soils, including Cooks River, Alexandra Canal and Muddy Creek (refer **Figure 16-5**). Where acid sulfate soils are encountered during excavation, potential impacts may include:

- Weakening of concrete and steel infrastructure, resulting in increased maintenance and replacement costs
- Damage to aquatic environments (surface water and groundwater) due to the liberation of acids generated from oxidised acid sulfate soils
- Mobilisation of aluminium, iron and manganese from soils as a result of increased acidity from disturbance of acid sulfate soils.

In relation to excavation, the alignment of tunnels around land adjacent to watercourses is deep below the ground surface, within Hawkesbury Sandstone. Alluvial deposits are unlikely to be encountered at this depth and in this geology.

There is a high potential for acid sulfate soils at the Arncliffe construction compound (C7), as well as in sediments in the Alexandra Canal. Further contamination investigation would be conducted in areas with medium or high acid sulfate soils potential during the detailed design stage as part of early works.

Acid sulfate soils could be excavated during earth moving works and/or acidic groundwater could be pumped during construction dewatering. **Section 17.3.2** outlines the potential for contamination in the project area to come into contact with human or environmental receivers through source-pathway-receiver link during construction works. Where acid sulfate soils are disturbed and not managed appropriately, the potential affects to human health may include:

- Exposure to contaminated water, eg during recreational activities
- Ingestion of contaminated water or animal / plant products with an uptake of contaminated water
- Increase in acidic dust causing eye, nose and throat irritation
- Increase in presence of acid-tolerant mosquitos and mosquito-borne diseases.

If and where acid sulfate soils are disturbed, the potential impacts are considered manageable. The material would be stored temporarily in a bunded area, treated and disposed of off-site at a licensed facility. Management of acid sulfate soils would be in accordance with the Guideline for the Management of Acid Sulfate Materials (RTA, 2005c).

The Construction Environment Management Plan and Acid Sulfate Soil Management Plan would also outline the measures and monitoring required where potential acid sulfate soils are expected. The plan would also outline the type of treatment required for acid sulfate soils, bunding and requirement for treatment ponds.

Water uses and balance

Section 6.10.2 provides estimates for the volumes and potential supplies of water for each site, based on the construction program and the anticipated demand and supply sources at varying times during construction.

Preference would be given to the use of non-potable water sources during construction over potable sources where appropriate. The volume of water required would depend on a number of factors including rainfall, wind direction and intensity, soil type, area of ground disturbance at any one time, and the storage space required to collect runoff water for reuse purposes.

Water treatment plants

During construction, tunnelling works would result in significant volumes of groundwater ingress requiring treatment. Other sources of wastewater during construction would include water used in dust suppression, wash down runoff, and sewage / grey water from construction compound sites. Water captured from both surface flows and groundwater ingress during construction works would be collected in sumps and pumped to holding tanks, from where it would be pumped to one of the temporary construction water treatment plants at the following locations:

- Kingsgrove North construction compound (C1)
- Commercial Road construction compound (C3)
- Bexley Road South construction compound (C5)
- Arncliffe construction compound (C7)
- Canal Road construction compound (C8).

The water treatment plants would treat tunnel groundwater, including runoff and inflows during construction. They would be capable of treating the maximum required discharge rates and to meet the minimum water treatment requirements during construction.

Each treatment plant would comprise a series of modular water-tight tanks with automated probes and dosing units designed to test and treat the water to the required standard. Based on the existing groundwater quality (refer to **Section 16.2.7**), water treatment would typically involve:

- Flocculation to remove total suspended solids
- Reverse osmosis to reduce salinity and dissolved solids
- Correction of pH level through the addition of lime or acid
- Treatment of elevated levels of iron and manganese
- Treatment of salinity and other contaminants such as ammonia.

The treatment train adopted for each plant would vary depending on the origin of water being treated at each plant.

The estimated discharge rates from temporary water treatment plants are identified in **Table 16-11**. Temporary water treatment plants and discharge locations are shown in **Figure 16-6** and **Figure 16-7.**

Table 16-11 Expected water treatment plant rates of discharge

Location	Receiving Watercourse	Average discharge flow L/s (ML/d)*
Kingsgrove North construction compound (C1)	Wolli Creek	2.8 (0.09)
Commercial Road construction compound (C2)	Wolli Creek	2.8 (0.24)
Bexley construction compounds (C4-C6)	Wolli Creek	7.6 (0.66)
Arncliffe construction compound (C7)	Cooks River	11.6 (1.00)
Canal Road construction compound (C8)	Alexandra Canal	7.2 (0.62)

*subject to confirmation during detailed design

Water from the temporary water treatment plants may be used for dust suppression where reasonable and feasible to do so. Excess of water treatment discharge would drain to the existing stormwater drainage systems, eventually discharging into the Cooks River via its tributaries including Wolli Creek. Temporary water treatment plants would therefore be designed to discharge at a minimum standard so as to meet the Water Quality Reference Criteria (refer to Appendix A of the Technical working paper: Surface water (**Appendix N**)). Provided these criteria are met, there would be a low risk of adverse impacts from water treatment plant discharge on the quality of the receiving environment.

As outlined in **Section 16.2.7**, the receiving environments for water treatment plant discharge are highly disturbed ecosystems, which cannot feasibly be returned to a 'slightly to moderately disturbed' condition (ANZECC Water Quality Guidelines, 2000). This is due to the historical catchment land use change from a natural catchment to a highly urbanised one, as well as past engineering works which removed natural ecosystems by replacing natural watercourses with straightened, concrete lined channels.

Based on the design of the project, it is anticipated that water treatment plant discharge would be of a better quality than the current water quality of the receiving environments. The quality and outflow velocities of water treatment plant discharge would be in accordance with the project's Water Quality Reference Criteria (refer to Appendix A of the Technical working paper: Surface water (**Appendix N**)) and the project's Environment Protection Licence.

The proposed water treatment plant at the Canal Road construction compound (C8) would be subject to measures to minimise the disturbance of bed sediments within the Alexandra Canal. Approval from Sydney Water and the NSW EPA would be sought on this matter as per the requirements of the Remediation Order 23004 (refer **Section 17.4**).

Provided these criteria are met, there would be a low risk of adverse impacts of water treatment plant discharges on the water quality of the receiving environment, including the sensitive receiving environments outlined in **Section 16.2.8**.

During landfill closure activities, there is also the potential for overland surface flows to become contaminated through exposure to waste and other contaminants in the absence of appropriate environmental controls. As such, mitigation measures would be required to isolate and capture runoff from these areas and direct these flows to the existing leachate treatment plant.

The Remediation Order 23004 is in place over the Alexandra Canal due to contamination of bed sediments with chlorinated hydrocarbons including organochlorine pesticides, polychlorinated biphenyls and metals in such a way as to present a significant risk of harm to human health and the environment. **Section 17.3.2** outlines the potential for existing contamination in the project area to come into contact with human or environmental receivers through source-pathway-receiver link during construction works. However, construction works would be undertaken in accordance with the requirements of the *Contaminated Land Management Act*, as well as the *Work Health and Safety Regulation 2011*. Following these regulatory requirements, including relevant exposure standards would effectively break any potential for source-pathway-receiver linkages to be completed, and for health impacts to result (refer **Section 17.4**).

Figure 16-6 Location of construction water treatment plants and discharge locations - Kingsgrove and Bexley Road construction compounds

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Figure 16-7 Location of water treatment plants and discharge locations - Arncliffe and St Peters interchange

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Watercourses and geomorphology

During construction the following activities would have the potential to impact upon the geomorphic condition of watercourses:

- Direct construction activity within or adjacent to the watercourse and / or Wolli Creek riparian zone
- Concentrated discharge from temporary water treatment plants
- Concentrated drainage during upgrade of existing infrastructure
- Sediment deposition in receiving waterways caused by wind or runoff from construction activities
- Increased impermeable areas and / or altered flow paths that may result in increased over bank flows entering the waterway causing erosion
- Tunnelling activities causing bedrock fracturing and /or subsidence / mass movement with the watercourse bed.

A number of construction activities would occur near watercourses, namely Cooks River, Wolli Creek, Alexandra Canal and the Eastern Channel. Watercourse crossings would be designed and constructed in accordance with the Guideline for Controlled Activities on Waterfront Land (DPI, 2012a). A summary of the construction impacts are identified in **Table 16-12**.

For details regarding existing and proposed drainage infrastructure, refer to **Chapter 18** (Flooding and drainage).

Table 16-12 Potential construction impacts on geomorphology

Construction activity	Impacts
Wolli Creek	
Construction activities associated with the western surface works have the potential to impact the geomorphology in Wolli Creek as a result of: • Exposing and weakening terrestrial surface soils, allowing them to be mobilised and deposited into the Creek during wind or rainfall • Clearing a small portion of grassed / vegetated parkland, particularly where this land lies on steep grades (eg Bexley Road South construction compound just upstream of Bexley Road) with the potential for scour and bank failure during flood events • Upgrades to existing drainage and construction of new outlets with the potential for localised impacts such as weakened bed and bank soil structure, localised erosion and sediment mobilisation • Temporary waste water treatment plant discharges into the concrete lined reach of the Creek, which could nevertheless be transported to the natural reaches downstream of Bexley Road • Two discharge from the temporary water treatment plants of up to around 2.8 litres per second at Kingsgrove, with an additional discharge of around 7.6 litres per second at Bexley Road. A total of around 13.2 litres per second would therefore enter Wolli Creek during construction.	Discharge to Wolli Creek would be to the concrete lined section upstream of Bexley Road. Between Bexley Road and the fish weir at Turrella – the discharge would contribute up to 13.1 litres per second to a highly altered reach of creek, affected by both upstream lining and downstream hydraulic controls. This small amount of discharge would not have the potential to impact what was the natural flow variability in Wolli Creek. When compared to the one year ARI flow of 58.9 cubic metres per second at Bexley Road, this discharge from the water treatment plant would contribute an increase of 0.02 per cent. This is a relatively insignificant increase in flow that would likely have minimal impact on stream levels and velocities in the creek. As a result, it is not expected to impact the geomorphology of the Creek. Notwithstanding, erosion and sedimentation controls would be in place to control water quality impacts and slow surface water runoff prior to it leaving the construction compound. This would further reduce the impact on watercourses. Drainage and discharge outlet infrastructure during construction would also include energy dissipation and erosion scour protection as appropriate.

Construction activity	Impacts
Alexandra Canal	
Construction of the St Peters interchange and local roads upgrades has the potential to impact the geomorphology in Alexandra Canal as a result of: • Discharge from the temporary water treatment plant of up to around 7.2 litres per second at the Ricketty Street bridge construction works at Campbell Road and Gardeners Road, although no piers would be installed within the Canal • Upgrades to existing drainage outlets and construction of a new outlet adjacent to Campbell Street (a culvert alongside the Burrows Road bridge). These have the potential to cause localised impacts such as weakened bed soil structure, localised erosion and sediment mobilisation.	When compared to the one year annual recurrence interval (ARI) flow of 83.9 cubic metres per second at its confluence with the Cooks River, discharge from the water treatment plant would contribute an increase of 0.02 per cent. This is a relatively insignificant increase in flow that would likely have minimal impact on levels and velocities in the canal. As a result, it is not expected to impact the geomorphology of the Canal. Alexandra Canal is tidal at the location of drainage outlets, with two tidal cycles daily producing relatively small velocities. High energy flows as a result of rainfall events have the potential to create high velocities in the Canal. Peak velocities and the size of sediments likely to be mobilised by various flow scenarios are shown in Section 7.3.3 of the Technical working paper: Surface water (**Appendix N**). New discharges have the potential to cause both a change in direction and velocity of flows in the Canal. Based on grain size distribution, the majority of sediment would likely experience minor mobilisation even under tidal conditions and various flood events would have the potential to uncover a greater volume of sediment. The canal floor is said to be in a state of dynamic equilibrium meaning mobilised sediments would not travel far and the system would tend to return to its preceding state. However there is some potential for impacts associated with sediment disturbance, due to: • Uncertainty regarding sediment distribution in the Canal, including contamination therein • Minimal understanding of three dimensional flow mechanisms within the Canal • Potential increase in point velocities from scouring These impacts would be manageable for the following reasons: • The minor extent of works resulting in new discharge structures within the canal (one culvert, one pipe) • The Alexandra Canal's tendency (based on previous numerical modelling and anecdotal evidence) to return to equilibrium, and accrete sediment in its middle reaches • Modelling would be undertaken prior to design of the outlets to determine velocities. Design would include energy dissipaters where appropriate, and/or sufficient scour protection to minimise the potential for contaminated sediments to be mobilised. Further details on the likelihood of sediments being contaminated are included in Technical working paper: Contamination (**Appendix O**). The potential impacts relating to scour would need to be mitigated as per mitigation measures in **Section 16.4**. These matters are dealt with further in

Construction activity	Impacts
	Section 5.5.5 and Section 9.5 of the Technical working paper: Contamination (**Appendix O**).
Eastern Channel	
Minor construction works at Camdenville Park have the potential to impact the Eastern Channel as a result of uncontrolled surface runoff from construction areas. A small extent of land clearing would create the potential for materials to be transported into the existing stormwater detention basin in Camdenville Park, though not at the location of the Eastern Channel itself. No discharges would be made to the Eastern Channel during construction.	No discharges would be made to the Eastern Channel during construction of the project. Regardless the concrete lined trapezoidal nature of the channel means the potential for geomorphic impact is minimal from any water treatment plant discharges to the head of the channel. Notwithstanding, erosion and sedimentation controls would be in place to control water quality impacts.
Cooks River	
Construction activities associated with the Arncliffe surface works and construction compound have the potential to impact the geomorphology in the Cooks River as a result of: • Stockpiling of soil • Temporary waste water treatment plants discharging up to around 20 litres per second (during peak discharge at any point in time) into the Cooks River adjacent to Kogarah Golf Course. Note that the average daily discharge is predicted to be 11.6 litres per second (refer **Table 16-11**) • The Cooks River receiving flows discharged into Wolli Creek and Alexandra Canal.	When compared to the one year ARI flow of 357.3 cubic metres per second the discharge from this temporary water treatment plant would be a very small (less than 0.01 per cent) increase at its discharge to Botany Bay. At this location the river is almost fully tidal due to its close proximity to Botany Bay. This small inflow would therefore not impact the geomorphology of the Cooks River. At the outlet location, scour resulting from the discharges related to construction activities has the potential to locally impact the floodplain, bank and bed morphology. Erosion and sedimentation controls would be in place to control water quality impacts and slow surface water runoff prior to it leaving the construction compound. This would further reduce the potential impact on watercourses. Drainage and discharge outlet infrastructure during construction would also include energy dissipation and erosion scour protection as appropriate.

Erosion

A preliminary erosion and sedimentation assessment was undertaken for the project in accordance with the Erosion and Sedimentation Risk Assessment Procedure (RTA, 2004) – Appendix 1a &1b for Concept Designs. The assessment identified the project works to be high risk to erosion and mass movement due to slopes in parts of the surface water study area being greater than ten per cent grade. This combined with an R factor (rainfall erosivity) of between 3000 and 3500 for this area of Sydney presents as a high erosion hazard.

A soil conservation specialist would therefore be engaged before and during construction to assist in the design of controls, carry out site inspections and develop progressive erosion and sediment control plans, in accordance with the Erosion and Sedimentation Management Procedure (RTA, 2008c). An Erosion and Sedimentation Management Plan would also be prepared as outlined in Erosion and Sedimentation Risk Assessment Procedure (RTA, 2004).

Water quality

The assessment of the potential impacts from water treatment plant discharge is based on a comparison of discharge quality with relevant environmental water quality criteria, including the ANZECC Water Quality Guidelines (ANZECC, 2000) for highly disturbed systems. Provided these criteria are met, there would be a low risk of water treatment plant discharge causing adverse impacts on the water quality of the receiving environment, particularly given the relatively poor quality of the existing waterways (refer to **Section 16.2.7**). The water treatment plant would be designed to meet the discharge water quality criteria outlined in the Water Quality Reference Criteria (refer to Appendix A of the Technical working paper: Surface water (**Appendix N**)).

During construction the following activities would have the potential to impact upon surface water quality:

- Earthworks and exposed soil, followed by wind or rain has the potential to mobilise sediments that could be discharged to local watercourses
- Accidental leaks or spills of chemicals, fuels and oils from construction plant or construction materials during the construction phase
- Construction activities within the Alexandra Canal (ie stormwater infrastructure and discharge points), as well as construction activities adjacent to the canal could introduce foreign contaminants such as oil or greases, and disturb contaminated sediments, potentially having an adverse impact on water quality
- The project would increase the impervious surfaces in the road corridor. Consequently, pollutant loads building up on the road surfaces would increase, and greater loads of pollutants may be washed off and discharged to receiving environments
- Discharge of inadequately treated water from the temporary water treatment plants.

The specific risk level associated with each construction compound would be subject to site specific factors including:

- Extent of soil disturbance and susceptibility of the soil to erosion and mass movement
- Proximity to local watercourses and drains
- Stockpiling activities and locations
- Potential for dust generation
- Land rehabilitation on completion of construction.

These surface water quality impacts due to soil erosion would be effectively managed through the application of the proposed mitigation and management measures as detailed in **Section 16.4**. Additional measures for managing surface water quality include:

- The management of dust is discussed in **Section 10.5.1** (Air quality)
- The management of dangerous goods and hazardous substances is discussed in **Section 26.1.1** and **Section 26.1.2** (Hazards and risk)

- The management of waste (**Section 24.1.1** and **Section 24.1.2** (Construction resource use and waste minimisation))
- Appropriate management of runoff and temporary water treatment plants (as detailed earlier in this section).

Wolli Creek

The extent of works located within the Wolli Creek catchment includes the western surface works, the Kingsgrove surface works and Bexley Road surface works, and includes construction compounds. A summary of potential impacts to surface water quality within the Wolli Creek catchment is as follows:

- Stockpiling of spoil and construction materials could present a risk to water quality. However, this would predominantly occur within the stockpile sheds. The sheds would minimise the potential for transport of spoil sediments by both wind and rain
- Runoff from these construction compounds would drain to the concrete lined tributary of Wolli Creek and the main arm of Wolli Creek. Runoff could impact these environments by delivering sediments and pollutants to Wolli Creek. Mitigation measures would be required to reduce the potential for environmental impacts arising during construction. Provided that appropriate controls are implemented during construction, short term impacts are expected to be manageable and expected to have no material impact on receiving water quality
- During construction, an existing water quality wetland would be removed due to the construction of a replacement wet basin. The basin currently treats pavement runoff from a catchment of 2.21 hectares of the existing M5 East Motorway. The time between removal and construction opens the potential for a reduction in the water quality treatment provided for the M5 East Motorway pavement drainage discharge, if not treated by some other means, such as the construction water treatment plants.

Cooks River

The Arncliffe surface works would include the establishment and use of the Arncliffe construction compound (C7). Runoff from these construction compounds would drain to the Cooks River, which is a heavily polluted waterway with poor water quality and contaminated sediments (refer to Section 4.6 of the Technical working paper: Surface water (**Appendix N**)). The location of this compound is very close to the mouth of the Cooks River and Botany Bay. Botany Bay and its estuaries are associated with significant biodiversity and other environmental values as well as significant community and social values.

Runoff from construction areas could impact this environment by delivering sediments and pollutants to the river. Spoil and other construction materials would also be stockpiled at the site. As discussed earlier, there is also a high risk of acid sulfate soils. Unmitigated runoff from the project during the construction phase would place increasing pressure on the already-stressed Cooks River, and could endanger the ecological health of Botany Bay. Mitigation measures would be required to reduce the potential for environmental impacts arising during construction.

Provided that appropriate controls are implemented during construction, short term impacts are expected to be manageable and expected to have no material impact on receiving water quality.

Alexandra Canal

Construction of the project would involve works within the Alexandra Canal catchment. These activities have the potential to impact surface water in the surface water study area. A summary of potential impacts to surface water quality within the Alexandra Canal catchment are as follows:

- Stockpiling of spoil and construction materials could present a risk to water quality. In some instances, stockpiling would be within sheds. Mitigation and management measures would be implemented to manage risks to water quality
- Runoff from these construction compounds would drain to Alexandra Canal. Runoff from construction areas could impact these environments by delivering sediments and pollutants to the canal. Alexandra Canal is a heavily polluted waterway with poor water quality and contaminated sediments. There is also a high risk of acid sulfate soil at the canal. Unmitigated

runoff from the project during the construction phase would place increasing pressure on this already stressed environment

- Mitigation measures (as described in **Section 16.4**) would be required to reduce the potential for environmental impacts arising during construction. Provided that appropriate controls are implemented during construction, short term impacts are expected to be manageable and expected to have no material impact on receiving water quality
- Construction of the two bridges over Alexandra Canal would not involve installation of any piers within the canal. However, works would occur in close proximity to the canal. Runoff from these activities would be managed to minimise potential impacts to water quality within the canal.

Provided that appropriate controls are implemented during construction, short term impacts are expected to be manageable and expected to have no material impact on receiving water quality.

Eastern Channel

Construction activities in the Eastern Channel catchment would occur as a result of upgrades to road and drainage structures and works at the existing water quality basin in Camdenville.

Runoff from construction areas could impact the receiving environment by delivering sediments and pollutants to the channel. Water quality within the Eastern Channel is not yet known, but due to its direct connection to the Cooks River, and proximity with similar land use to Alexandra Canal, it is expected that the water quality would be similar to these other watercourses, characterised by high turbidity, high nutrients, pathogens and toxicants (refer Section 4.6 of the Technical working paper: Surface water (**Appendix N**)). The Eastern Channel, being concrete-lined, has little habitat value but is an efficient conveyance for water that would impact upon the ecosystem health of the Cooks River. Therefore, unmitigated runoff from the project during the construction phase would place increasing pressure on the already stressed environment of the Cooks River and would undermine attempts by the surrounding community and stakeholders to improve the ecosystem health.

Provided that appropriate controls are implemented during construction, short term impacts are expected to be manageable and expected to have no material impact on receiving water quality.

Water quality monitoring

Water quality monitoring commenced in June 2015. Monitoring would continue until either 12 months of data is collected or until the commencement of construction (whichever is sooner) to represent pre-construction conditions for the project. Monitoring would continue during construction of the project. This would include monitoring at upstream (control) and downstream measurement locations. Samples would be taken twice a month, once in dry and once in wet conditions where possible. Parameters to be tested for and locations of monitoring sites are shown in Appendix B of the Technical working paper: Surface water (**Appendix N**). Water quality monitoring locations have been suitably established so that the place and methodology of capture is consistent both pre-construction and during construction. The data obtained during this program would be used to ascertain any potential water quality impacts of the construction of the project, as opposed to placing reliance on the previously obtained water quality monitoring data outlined in **Section 16.2.7**, for which sampling locations and methodologies would have varied.

Riparian ecosystems

The construction impacts of the project on riparian ecosystems are set out in more detail within **Section 21.3.2**, and are summarised as follows:

- Aquatic habitats may be impacted by:
  - Groundwater discharge
  - Weed invasion
  - Polluted surface water runoff
  - Erosion, sedimentation and increases in turbidity

- While impacts to aquatic fauna in the upper reaches of watercourses which traverse the biodiversity study area are unlikely, given the already degraded condition of these environments and the lack of available habitat, higher quality environments downstream could be affected during construction by:
  - Increased surface water volumes and velocities, which may contribute to bank erosions and sedimentation
  - Transport of weeds and nutrients, which may increase the potential for algal blooms to occur.

It is noted that impacts to aquatic habitat may also reduce the availability or desirability of habitat for macroinvertebrates.

Overall, impacts to aquatic habitats during construction would be avoided by reducing the speed of discharge flows into watercourses, removing sediment and nutrients prior to the discharge of water into watercourses and stabilising banks, where necessary (refer **Section 16.4** and **Section 21.4**). The impacts to riparian vegetation are therefore considered to be negligible.

Green and Golden Bell Frog Habitat

One sensitive environment in proximity to construction is the breeding ponds for Green and Golden Bell Frog near Marsh Street, Arncliffe. The species also uses parts of the golf course for foraging habitat. Dust generated by construction activity has the potential to impact the water quality of the RTA ponds and frog habitat on the golf course. The presence of the tunnelling shed in addition to targeted mitigation measures for the species, as detailed in the Biodiversity Assessment Report (**Appendix S**), would minimise these potential impacts. The project is not expected to impact the function or quality of the RTA ponds or surrounding habitat. Environmental management measures to be implemented during construction to minimise impacts to the Green and Golden Bell Frog and their habitat would be contained in a Green and Golden Bell Frog Plan of Management. More information regarding the management of impacts to the Green and Golden Bell Frog during construction of the project is provided in **Section 21.4**.

Cumulative impacts

For water quality and geomorphology, the key construction related impacts would be erosion of exposed soil resulting in sedimentation, and water pollution associated with sediment-laden runoff.

Although this might be considered a temporary impact, ongoing re-development within the catchment has the potential to persistently expose receiving environment to these impacts. Such cumulative impacts would be managed through proper implementation of the project’s Construction Environmental Management Plans. There is also the risk that uncontrolled spills during construction works (eg of hydrocarbons, cleaning fluids or other liquids) may be released into the surrounding environment, potentially causing soil and groundwater contamination, as well as adverse water quality impacts. However with the mitigation measures outlined in **Table 16-14**, the risk of this occurring is low.

Further information on the project’s potential cumulative impacts is provided in **Sections 27.4** and **27.5** (Cumulative impacts).

16.3.2 Operation

Water treatment plant

Operation of the project would include collecting, managing and pumping groundwater seepage from the main alignment tunnels to a collection tank for treatment and discharge. An operational water treatment plant would therefore be built at Arncliffe as part of the Arncliffe motorway operations complex (MOC3). This operational water treatment plant would be designed to receive and treat two separate streams:

- Contaminated groundwater from the eastern section of the project
- Non-contaminated groundwater from the western section of the project, stormwater, wash down, fire testing, hydrant and deluge water.

The proposed operational water treatment plant location is shown on **Figure 16-7** and would include:

- A main sump at the tunnel low point, which would have the capacity to store around 50,000 litres in case of a spill within the tunnel, with a separate sump to capture potentially contaminated groundwater from the eastern portion of the project area
- A holding tank at Arncliffe motorway operations complex which would receive water from the tunnel sumps. Water would then be directed to the water treatment plant or removed for alternative disposal, eg in case of a spill
- The water treatment, which would comprise a water treatment plant itself, as well as a wetland system
- In the case of higher flows (eg from washdown or deluge), overflow from the holding tank would be directed to the deluge holding tank. These flows would be discharged to the Cooks River via the existing stormwater drainage network.

Groundwater from the eastern section of the project may have elevated levels of ammonia or other contaminants. Groundwater collected from this portion of the project area would be treated through sedimentation / flocculation to remove iron, suspended solids, hydrocarbons and other settle-able compounds.

Following initial treatment, water would be drained to a wetland to remove nitrogen (organic nitrogen, ammonia, nitrate and nitrite) and then to a polishing tertiary treatment system (ozone and biologically activated carbon or membrane filtration and reverse osmosis) to remove additional heavy metals (if required). The wetland system would have a surface area of around 1000 square metres, with floating treatment media to allow plant growth.

Groundwater from the western section of the project area, which is not expected to have elevated levels of ammonia or contaminants, would be treated to remove suspended solids and iron using the same water treatment process as outline above, without the need to be transferred to a wetland system.

Once the two streams of water have been treated they would be blended downstream of the wetland and would be discharged into the Cooks River. The outfall would consist of a submerged diffuser system such that the effluent stream is dispersed into the Cooks River. The operational water treatment plant would discharge at a predicted maximum rate of around 20.1 litres per second into the Cooks River at the Marsh Street Bridge.

The receiving environments for operational water treatment plant discharge are ‘highly disturbed’ ecosystems, which cannot feasibly be returned to a ‘slightly to moderately disturbed’ condition (ANZECC Water Quality Guidelines – Section 2.2, 2000). In such cases, ANZECC (2000) recommends suitable guidelines for water quality trigger values. The operational water treatment plant would be designed to ensure that discharge water quality would meet the Water Quality Reference Criteria (refer to Appendix A of the Technical working paper: Surface water (**Appendix N**)). Monitoring of the Cooks River would be undertaken in accordance with the water quality program (as provided in Appendix B of **Appendix N**) for 12 months post-construction or as otherwise required by the conditions of approval to ensure discharge is meeting these criteria.

Water extraction and use

Water use for various operational activities such as building use, emergency deluge and cleaning would be sourced from Sydney Water mains. Alternative sources to portable water (such as rainwater and treated wastewater) would be investigated during detailed design.

Opportunities for reuse of treated water generated at the Arncliffe motorway operations complex would be considered during detailed design in preference to discharge to the stormwater system, including irrigation of landscaped areas within the project area, and / or local parks and reserves.

Watercourses and geomorphology

During operation, the project has the potential to impact the geomorphology of receiving watercourses. Impacts on watercourses could result from:

- Discharge of groundwater

- Discharge of drainage at new locations
- Increased discharges at existing locations due to drainage upgrades
- New overland flow paths construction in the floodplain.

The increase of impervious surfaces, drainage discharges from new and upgraded pipes and the operational water treatment plant would result in a relatively insignificant increase in water flow to each of the receiving watercourses (Wolli Creek, Alexandra Canal and Cooks River). Further, the geomorphological characteristics of the watercourses within the study area are primarily categorised as having no potential for lateral or vertical adjustment (concrete channel, piped channel, rock-lined channel, shaped channel and underground concrete channel). Therefore, the relatively insignificant increase in stream levels and velocities would not impact the geomorphology of the watercourses.

Drainage and discharge outlet infrastructure during operation would include energy dissipation and erosion scour protection as appropriate in order to further reduce impacts to geomorphology at the discharge location.

In terms of the Alexandra Canal, two new discharge outlets would convey stormwater into the Canal as follows:

- A 3300 x 2400 millimetre open channel discharging immediately to the south west of Gardeners Road Bridge
- A 525 millimetre reinforced concrete pipe discharging immediately to the south east of Gardeners Road Bridge.

The detail of these outlets, including discharge velocities and scour protection measures, would be confirmed during detailed design.

There is some potential for operational impacts associated with sediment disturbance at the discharge location of these proposed outlets, due to:

- Uncertainty regarding sediment distribution in the Alexandra Canal , including contamination therein
- Minimal understanding of three dimensional flow mechanisms within the Alexandra Canal
- Potential increase in point velocities from scouring.

As outlined in **Table 16-12**, the Alexandra Canal has a tendency to return to equilibrium, and accrete sediment in its middle reaches, meaning these impacts are not likely to occur.

Modelling would also be undertaken prior to stormwater outlet design at the Alexandra Canal to clarify velocities. Outlet designs would include energy dissipaters where appropriate, and/ or sufficient scour protection to minimise the potential for contaminated sediments to mobilise. These matters are dealt with further in Section 5.5.5 and Section 9.5 of the Technical working paper: Contamination (**Appendix O**).

The potential for human health impacts as a result of the operation of the project follows the same logic to that outlined in **Section 17.3.2** in terms of source-pathway-receiver links. Newly constructed stormwater outlets along the banks of the Alexandra Canal could cause localised erosion and scour in the vicinity of the stormwater discharge points, which could potentially mobilise contaminated sediments which may already be present within the canal or contributed as discharge through the stormwater drain.

New stormwater infrastructure discharge points would be constructed in the vicinity of an upstream of Ricketty Street bridge, which is located greater than two kilometres from the junction of Alexandra Canal with the Cooks River. As demonstrated in historic studies undertaken for existing stormwater drains within the Alexandra Canal (refer to Section 2.2.11 of **Appendix O**), it is considered unlikely that sediments mobilised as a result of the impact of new operational infrastructure would extend a significant distance from the stormwater discharge points. As such, the risk of mobilised sediment migrating to the Cooks River as a result of discharge from stormwater infrastructure is considered to be low (refer Section 9.5 of **Appendix O**). In addition, mitigation measures would be installed at the points of discharge to further minimise the potential for sediment disturbance caused by the construction and operation of a new stormwater system (refer **Section 16.4**).

During operation, flooding and drainage impacts could include the following:

- Impacts from the operational water treatment plant
- Localised flooding
- Mainstream flooding.

In terms of managing localised flooding, existing drainage and surface water management infrastructure (identified in **Table 18-2** of **Section 18.2.1**) would continue to manage surface drainage and potential flooding. Additional upgrades would be carried out where parts of the drainage infrastructure would be impacted by the project and / or would require relocation. **Table 18-4** of **Section 18.3.2** provides an overview of the proposed drainage systems as part of the project.

The discharge of treated water during operation would be to the Cooks River. As flow variability in the Cooks River is dominated by tides, the proposed discharges would not impact its natural flow variability.

Water quality

Operation of the project has the potential to cause water quality impacts resulting from the increased impervious surface areas and changes to the total catchment. Surface runoff carries pollutants that have built up on these surfaces. Such runoff would typically contain pollutants such as nutrients, oils, greases, petrochemicals and heavy metals. In a typical year, pollutants are generated from impervious surfaces at a rate of about:

- Total suspended solids - 3130 kilograms per hectare
- Total phosphorus - 5.83 kilograms per hectare
- Total Nitrogen - 25.5 kilograms per hectare.

The above were estimated from MUSIC stormwater quality modelling for a 100 per cent impervious catchment. These additional pollutant loads would be managed through a range of stormwater treatment measures such as gross pollutant traps, constructed wetlands, bioretention systems, water quality basins and proprietary treatment devices. These would be designed with consideration to the pollutant reduction targets of the Botany Bay and Catchment Water Quality Improvement Plan (SMCMA, 2011).

Current provisions are sufficient to meet the treatment targets for most catchments, and stormwater treatment in some catchments exceeds the treatment requirements, such that the project overall would result in less pollutants being delivered to Botany Bay. The final design would be would be confirmed during detailed design.

Wolli Creek

The project would result in new permanent infrastructure, as well as increased pavement area within the Wolli Creek catchment. Paved surfaces within the catchment would increase by roughly seven hectares as a result of the project, increasing the overall imperviousness of the catchment. This would create the potential for higher pollutant loads in the receiving Wolli Creek environment.

Existing stormwater treatment would be upgraded or, where existing stormwater treatment devices are impacted by the project, offset by the installation of new stormwater treatment devices. This would be determined during detailed design with a target of meeting the pollutant load reductions outlined in **Table 16-13**.

Stormwater runoff from new impervious surfaces created by the project would be treated by new stormwater treatment systems with a target of meeting the pollutant load reductions outlined in **Table 16-13**. The design of new treatment systems would be confirmed during detailed design.

The performance of the proposed stormwater treatment systems was modelled. For the Wolli Creek catchment, the model indicated that the proposed systems would meet targets set for total phosphorous and total nitrogen removal. However, the model indicates that removal for total suspended solids would be substantial but that the target would not be met.

The deficit in treatment for total suspended solids would be somewhat compensated for by the high pollutant removals from the Alexandra Canal and Eastern Channel catchments further downstream.

However, it is acknowledged that:

- Sydney Water own and operate a gross pollutant trap in the concrete lined section of Wolli Creek at Kingsgrove. The trap would receive both treated and a relatively small amount of untreated drainage from the project drainage network and would contribute further to total suspended solids reductions in the catchment
- The catchment of the project footprint (around 7.1 hectares) compared to the total Wolli Creek catchment (2,100 hectares) is relatively minor and is unlikely to generate significant impacts to downstream water quality.

Stormwater treatment designs would be defined during detailed design in consultation with the future owners and or operators. Stormwater treatment would be designed in accordance with the recommendations made in **Section 16.4**.

Cooks River

The project would result in a small amount of new permanent infrastructure within the Cooks River catchment, including the operational water treatment plant. The final footprint of these facilities would be roughly 1.7 hectares. The Kogarah Golf Course currently has a very low impervious fraction (assumed zero). The project would include new impervious surfaces of around 1.7 hectares, with an accompanying increase in pollutant loads that would be discharged to the Cooks River (**Table 16-13**).

Although no provision has been made for the treatment of stormwater runoff from the permanent infrastructure located at the Arncliffe motorway operations complex, the modelled increased in pollutants from this site would be offset by the pollutant removal achieved in the Eastern Channel and Alexandra Canal catchments. In those catchments, the pollutant reductions have been modelled as being in excess of the required load reductions, and these more than account for the additional pollutants created by the project at the Arncliffe motorway operations complex (**Table 16-13**). Therefore the project's net environmental impact immediately downstream of the golf course is a substantial reduction in pollutant loads.

Alexandra Canal

The project would result in new permanent infrastructure within the Alexandra Canal catchment, including new roads and bridges. Additional pavement associated with this infrastructure would increase the imperviousness of the pavement drainage catchment area. The future impervious area attributable to the project is estimated to be about 45.74 hectares. This creates the potential for higher pollutant loads to be discharged to the receiving environment of Alexandra Canal.

The Alexandra Canal catchment is made up of multiple sub-catchments. Within some of these sub-catchments there is minimal or no available space in the road reserve for the installation of stormwater treatment devices such as bioretention systems or constructed wetlands. Further, as the project connects directly into the existing stormwater drainage network, there are no treatment opportunities further downstream within these sub-catchments. However, there are opportunities within other sub-catchments that could be used to offset the impacts of the project on the untreatable sub-catchments.

As a result, some of the sub-catchments impacted by the project would not be able to accommodate full stormwater treatment. By reducing pollutant loads in the other sub-catchments, there is the opportunity to offset the treatment deficit from the untreated sub-catchments and provide a net overall environmental benefit. This is because the treatable sub-catchments are larger than the untreatable sub-catchments. Refer to the Technical working paper: Surface water (**Appendix N**) for further details.

Further, the untreatable sub-catchments discharge to Alexandra Canal, which has very little habitat value. As a result, the environmental benefit of treating stormwater that is discharged to this canal is only realised as water is discharged into the Cooks River and the downstream natural environment at

Botany Bay. Consequently, untreated stormwater runoff from small urban catchments is unlikely to impact the habitat value of Alexandra Canal, but if total pollutant loads to Botany Bay can be reduced, this would be of direct benefit to that receiving environment. To determine the likely impact and adequacy of mitigation measures, the pollutant loads from all catchments that discharge to Alexandra Canal have been considered together.

Stormwater treatment devices have been proposed for the Alexandra Canal catchment. Further, provisions would be made, where space is available, for the treating of stormwater runoff from new impervious surfaces created by the project, including the operation of new stormwater treatment systems.

For the Alexandra Canal catchment, the treatment targets for total suspended solids, total phosphorous and total nitrogen would be easily met by the proposed stormwater treatment. The pollutant removal capability of the proposed treatment devices exceeded 100 per cent because these removals would include pollutants from the existing catchment that are over and above the impacts of the project. The designs would be refined during detailed design in consultation with the future owners and or operators, and designed in accordance with the recommendations made in **Section 16.4**.

Eastern Channel

Parts of project (ie some of the local road upgrades) are located in the Eastern Channel catchment. The local road upgrades, specifically the widening of Campbell Street and adjoining streets, would result in additional pavement areas.

These works would result in a relatively large increase in stormwater runoff within the catchment draining to Camdenville Park. It is proposed that the increase in runoff potential be offset through the provision of additional detention storage within and adjacent to Camdenville Park. This would limit increases in peak flow rates discharged to the downstream trunk drainage system. The proposed drainage strategy would be determined during detailed design and would be based on not increasing flows into the Eastern Channel for all events up to and including the 100 year ARI flood (refer Section 7.3.3 of the Technical working paper: Surface water (**Appendix N**)). Matters relating to the disturbance of sediments within Camdenville Park have been further considered in Technical working paper: Contamination (**Appendix O**).

Treatment devices are proposed to reduce pollutant loads in line with the targets in **Table 16-13**. The combined treatment performance of the treatment devices was evaluated by comparing the total pollutant load reduction required, with the reduction achieved. For the Eastern Channel catchment, the treatment targets for total suspended solids, total phosphorous and total nitrogen would be easily met with the proposed provisions. The modelled pollutant removal exceeded 100 per cent because these removals would include pollutants from the existing catchment that are over and above the impacts of the project. The designs would be refined during detailed design in consultation with Marrickville Council, and designed in accordance with the recommendations made in **Section 16.4**.

Table 16-13 Increases in imperviousness and resultant pollutant loads in surface water runoff, and required pollutant load reduction targets*

Criteria	TSS	TP	TN
Wolli Creek – western surface works			
Increase in pollutant loads resulting from the project (kilograms per year)	17,700	31	118
Target pollutant load reduction (SMCMA,2011)	85	60	45
Target pollutant load reduction (kilograms per year)	15,045	18.6	53.1
Kogarah Golf Course			
Increase in pollutant loads resulting from the project (kilograms per year)	4,100	7	27
Target pollutant load reduction (SMCMA,2011)	85	60	45
Target pollutant load reduction (kilograms per year)	3,485	4.2	12.2
Alexandra Canal and Eastern Channel –local road upgrades			
Increase in pollutant loads resulting from the project (kilograms per year)	2,000	4	10
Target pollutant load reduction (per cent) (SMCMA,2011)	85	60	45
Target pollutant load reduction (kilograms per year)	1700	2.4	4.5
Eastern Channel			
Increase in pollutant loads resulting from the project (kilograms per year)	1,000	2	7
Target pollutant load reduction (SMCMA,2011)	85	60	45
Target pollutant load reduction (kilograms per year)	850	1.1	3.2

* Note that these load reductions are indicative and would need to be updated based on the catchment areas used in detailed design.

Discharges from the operational water treatment plant could also impact on the water quality of receiving waterway, depending on the discharge volumes and degree of prior treatment. Appropriate management and treatment of water during operation is discussed above in this **Section 16.3.2** in relation to the operational water treatment plant.

Drainage systems would be designed and implemented to minimise potential impacts on receiving watercourses. Drainage infrastructure is discussed in **Section 18.3.2**.

Water quality monitoring

Operational water quality monitoring would be conducted for 12 months post-construction or as otherwise required by the conditions of approval. This would include upstream (control) and downstream measurement locations. Samples would be taken twice a month, once in dry and once in wet conditions where possible. This would include upstream (control) and downstream measurement locations. Parameters to be tested for and locations of monitoring sites are shown in Appendix B of the Technical working paper: Surface water (**Appendix N**).

Baseline water quality data would not be required for the Eve St Wetlands (separated from the project disturbance footprint by the M5 East and SWOOS) and Green and Golden Bell Frog breeding ponds (fed by Marsh Street stormwater and actively manipulated / managed) as the project would not discharge water to these locations.

Riparian ecosystems

As set out in **Section 21.3.3**, the operation of the project would not result in significant impacts for riparian ecosystems.

With specific reference to the Cooks River, the watercourse itself is currently degraded with limited fish habitat present. As such, the operation of the project is unlikely to have a significant impact on aquatic ecology as a result of the discharge of tunnel groundwater and deluge water.

The potential impacts on aquatic and riparian ecology at Wolli Creek associated with the increased flow in receiving watercourses are described in **Sections 21.3.1** and **21.3.2**. No significant impacts are anticipated for riparian ecosystems, as the project has been designed to avoid impacting such sensitive ecosystems.

Cumulative impacts

The project area is within a continually altering urban environment. Further developments are likely to occur in or around the project area during and after construction of the project.

The project would involve the construction of the St Peters interchange, which would include drainage and pavements associated with future connections road infrastructure. Significant works are currently underway directly to the west of the project as part of the King Georges Road Upgrade which would connect directly to the project.

The cumulative impacts of future infrastructure at this location are considered in Appendix A of the Technical working paper: Surface water (**Appendix N**). In regards to flooding, where other construction activities are not in close proximity to the project, cumulative temporary flood impacts and cumulative operational flooding impacts are not likely. Operational surface water quality would be maintained through the routine application of stormwater treatment devices to new infrastructure and new developments to ensure discharges to the surrounding catchments comply with legislative requirements.

Potential flooding and geomorphological impacts associated with new developments would be mitigated through detailed design so that no unacceptable increases in velocities, discharges, flood levels or flood extents occur. Ongoing maintenance works in the project area have the potential to lead to uncontrolled spills (eg of hydrocarbons, cleaning fluids or other liquids) being released into the surrounding environment, potentially causing soil and groundwater contamination, as well as adverse water quality impacts. However, with the mitigation measures outlined in **Table 16-14**, the risk of this occurring is low.

Due to insufficient information regarding the impacts, design and management of surface water flows and infrastructure associated with other development proposals, cumulative surface water impacts cannot be fully understood at this stage. However, if mitigation requirements are applied consistently to all projects, adverse cumulative surface water impacts are not anticipated. Residual risks to the environment would therefore be low.

Where legislative requirements are applied consistently across the catchment, there is the potential for overall improvement in water quality and / or reduction in flood risk.

16.4 Environmental management measures

Environmental management measures relating to soils and water quality for the construction and operation of the project are provided in **Table 16-14**.

Table 16-14 Environmental management measures – Soils, surface water and flooding

Impact	No.	Environmental management measures	Timing
Construction			
Water quality	SW01	The control and mitigation of potential surface water quality impacts during construction would be defined in a Soil and Water Management Plan prepared as part of the overall Construction Environmental Management Plan.	Pre-construction/ construction
Water quality	SW02	The Soil and Water Management Plan would be developed to incorporate controls and measures in accordance with The Blue Book. The plan would be continually updated to suit the changing needs as the project works progress. The plan would be developed in consultation with the Environment Protection	Pre-construction/ construction

Impact	No.	Environmental management measures	Timing
		Authority and DPI - Water and document the types of measures that would be put in place to minimise the risk of soil erosion or polluted discharges reaching the receiving environments.	
Water quality	SW03	An Erosion and Sedimentation Management Plan would be prepared as outlined in the Erosion and Sedimentation Risk Assessment Procedure (RTA, 2004).	Pre-construction/ construction
Water quality	SW04	The Soil and Water Management Plan would include: • Construction traffic restricted to delineated access tracks, and maintained until construction complete • Appropriate sediment and erosion controls to be implemented prior to soil disturbance • Stormwater management to avoid flow over exposed soils which may result in erosion and impacts to water quality • Stockpiles located outside the 20 year ARI flood extent where feasible. Otherwise, appropriate management control measures such as bunding would be implemented • Staging of surface works to minimise area of exposed surfaces, with re-vegetation and / or stabilisation of disturbed areas to occur as soon as feasible • Site compounds sealed or hard stand to minimise erosion where possible • Wheel wash or rumble grid systems installed at exit points to minimise dirt on roads • A soil conservation specialist would be contracted to supervise construction in high risk areas in accordance with the Erosion and Sedimentation Management Procedure (RTA, 2008c) • All water generated during construction would be captured, tested (and treated if required) prior to reuse or discharge under a site specific arrangement, depending on the quality of water generated. This would target compliance with the Water Quality Reference Criteria. At the St Peters interchange site this would include transfer of some water to the leachate treatment plant. Varying levels of groundwater quality would also require a variation to treatment approaches • Contaminated sediments and potential acid sulfate soils would be segregated and disposed of (with or without prior treatment as appropriate) at a licensed facility or treated onsite • Stockpiles would be located outside of riparian corridors.	Pre-construction/ construction
Water quality	SW05	The water quality and outflow velocities of the water treatment plants at the following compounds would be in accordance with the project's Water Quality	Construction

Impact	No.	Environmental management measures	Timing
		Reference Criteria and the project's Environment Protection Licence: Kingsgrove North construction compound (C1), Commercial Road construction compound (C3), Bexley Road South construction compound (C5), Arncliffe construction compound (C7), Canal Road construction compound (C8).	
Water quality	SW06	The project specific water quality monitoring program would continue to collect to at least 12 months of data or to the commencement of construction (whichever is sooner) to represent pre-construction conditions for the project. Monitoring would continue during construction of the project as identified in Appendix A of the Technical working paper: Surface water (**Appendix N**). The details of this monitoring program would be contained in the Soil and Water Management Plan, and would include the following: • Sampling locations to include upstream (control) and downstream measurement locations • Samples taken twice a month, once in dry conditions and once in wet conditions where possible • In-situ monitoring of: – pH – Reduction Oxidation Potential – Dissolved Oxygen – Temperature – Conductivity – Turbidity – Colour – Odour • Analytical sampling of the following potential constituents of concern: – Total Recoverable Hydrocarbons – Benzene, Toluene, Ethylbenzene, Xylene and Naphthalene – Nutrients including: Total Nitrogen, Total Kjeldahl Nitrogen, Nitrogen Oxide, Nitrite, Nitrate, Total Phosphorous and Reactive Phosphorous – Heavy metals (Arsenic, Cadmium, Copper, Chromium, Lead, Mercury, Nickel, Zinc) – Manganese – Ferrous Iron and Total Iron.	Pre-construction/ construction
Water quality	SW07	Water quality monitoring of the breeding ponds for Green and Golden Bell Frog near Marsh Street, Arncliffe would occur during construction by a suitably qualified scientist as part of the Green and Golden Bell Frog Plan of Management.	Construction
Water reuse	SW08	Opportunities for reuse of treated water generated at the Arncliffe motorway operations complex would be considered during detailed design.	Detailed design
Acid sulfate soils	SW09	An Acid Sulfate Soil Management Plan would be prepared as a sub-plan to the Construction	Pre-construction/

Impact	No.	Environmental management measures	Timing
		Environment Management Plan to outline the requirements for the management of potential acid sulfate soils.	construction
Acid sulfate soils	SW10	Further contamination investigation would be conducted in areas with medium or high acid sulfate soils potential during the detailed design stage as part of early works. Management of acid sulphate soils during the project would be undertaken as per the management measures outlined in **Section 17.4**.	Detailed design / pre-construction
Contamination	SW11	During landfill closure activities, surface water management measures would be implemented in accordance with The Blue Book to isolate and capture potentially contaminated water. Any such water would be transferred to the leachate treatment plant for treatment prior to discharge to sewer under a trade waste agreement with Sydney Water.	Construction
Contaminated runoff and spills	SW12	The following measures would be in place to manage spills of contaminated fluids: • Areas would be allocated for the storage of fuels, chemicals and other hazardous materials • Facilities would be secured and bunded to levels dictated by Environment Protection Authority guidelines • Spills or contaminated runoff would be captured and treated and / or disposed of at a licensed facility • Re-fuelling, wash down and preparation of construction materials would be undertaken in bunded areas to mitigate risks in relation to spills or leaks of fuels / oils or other hazardous onsite construction material • The application of good practice in the storage and handling of dangerous and hazardous goods would provide appropriate practical responses to manage impacts on occupational health and safety and minimise the risk of a spill occurring • Potential discharges from construction sites would be managed through the installation of basins (primarily designed for sediment capture but with capacity to contain the nominated spill volume) constructed in accordance with The Blue Book • Captured contaminants resulting from spills or leaks would be treated and disposed of at a licensed facility • Any soil which has been contaminated with fuel, oils or other chemicals would be disposed as contaminated soil by a waste subcontractor.	Construction
Geomorphology	SW13	Construction work activities within and / or adjacent to waterways would be minimised as much as feasibly possible to minimise disturbance to those waterways and waterfront land.	Construction

Impact	No.	Environmental management measures	Timing
Geomorphology	SW14	Alignment of drainage and discharge outlet infrastructure would direct flows downstream to minimise alterations and erosion of the channel beds and banks.	Detailed design/ construction
Geomorphology	SW15	Drainage and discharge outlet infrastructure would include energy dissipation and erosion scour protection as appropriate.	Detailed design/ construction
Geomorphology	SW16	Disturbed floodplain environments adjacent to watercourses (including waterfront land) and / or along overland drainage lines would be stabilised and vegetation managed in accordance with the *Guidelines for Controlled Activities on Waterfront Land* (DPI, 2012a).	Construction
Operation			
Surface runoff	OpSW01	Suitable stormwater treatment devices would be identified during detailed design, including an operational water treatment plant, with the aim of meeting the targets of the Botany Bay and Catchment Water Quality Improvement Plan (SMCMA, 2011). Where space is available, water quality basins would be installed. In the case where space is unavailable, treatment would include the use of proprietary stormwater treatment devices. The design of treatment trains would be informed by an assessment of the sensitivity of the receiving environments and supported by MUSIC modelling.	Detailed design/ operation
Surface runoff	OpSW02	The treatment capacity lost in decommissioning pond WQP – 3 would be provided by new or upgraded stormwater treatment devices.	Detailed design/ operation
Water quality monitoring	OpSW03	Operational water quality monitoring would be conducted for 12 months post-construction or as otherwise required by the conditions of approval. This would include upstream (control) and downstream monitoring locations. The details of this monitoring program would be contained in the Soil and Water Management Plan, and would include the following: • Sampling locations to include upstream (control) and downstream measurement locations • Samples taken twice a month, once in dry conditions and once in wet conditions where possible • In-situ monitoring of: – pH – Reduction Oxidation Potential – Dissolved Oxygen – Temperature – Conductivity – Turbidity – Colour – Odour • Analytical sampling of the following potential constituents of concern:	Operation

Impact	No.	Environmental management measures	Timing
		– Total Recoverable Hydrocarbons – Benzene, Toluene, Ethylbenzene, Xylene and Naphthalene – Nutrients including: Total Nitrogen, Total Kjeldahl Nitrogen, Nitrogen Oxide, Nitrite, Nitrate, Total Phosphorous and Reactive Phosphorous – Heavy metals (Arsenic, Cadmium, Copper, Chromium, Lead, Mercury, Nickel, Zinc) – Manganese – Ferrous Iron and Total Iron.	
New discharge outlets	OpSW04	New discharge outlets into Alexandra Canal would be designed with sufficient energy dissipation or scour protection to limit the impact on contaminated sediments and reduce the possibilities of contaminated sediments being subject to scour or resuspension.	Detailed design/ operation
Existing drainage outlets	OpSW05	Where existing drainage lines are to be subject to increased inflow, an assessment of their discharge characteristics would be made. If necessary, energy dissipation or scour protection would be added to prevent contaminated sediments from being subject to scour or resuspended. This would be undertaken during detailed design.	Detailed design/ operation
Mitigation for spills	OpSW06	The assessment of risk of spills on the motorway would be undertaken during detailed design. If warranted, spill containment would be provided.	Detailed design/ operation
Operational water treatment plant	OpSW07	The operational water treatment plant would be designed to meet the Water Quality Reference Criteria outlined in Appendix A of the Technical working paper: Surface water (**Appendix N**). Monitoring of the Cooks River would be undertaken during initial operation of the project to ensure discharge meets these criteria.	Detailed design/ operation
Geomorphology	OpSW08	Suitably designed scour and erosion control measures would be included in the detailed design.	Detailed design/ operation
Geomorphology	OpSW09	Drainage and discharge infrastructure where space is available would incorporate measures, as appropriate, to trap and remove sediments in line with the outcomes of the stormwater pollution reduction targets from the Botany Bay and Catchment Water Quality Improvement Plan (SMCMA, 2011). This would reduce the risk of any impacts to the geomorphic condition of receiving waters.	Detailed design/ operation