Redfern Station Upgrade – New Southern Concourse

Technical report 7 - Hydrology, flooding and water quality

Artist's impression of the proposed Redfern Station Upgrade - New Southern Concourse. Indicative only, subject to detailed design.

Transport for NSW | May 2020

Redfern Station Upgrade - New Southern Concourse

Technical report - Flooding, hydrology and water quality

Client: Transport for NSW

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Abbreviations

Abbreviation	Meaning
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ANZECC	Australia New Zealand Environment and Conservation Council
ARI	Average Recurrence Interval
CEMF	Construction Environmental Management Framework
CEMP	Construction Environmental Management Plan
NSW	New South Wales
OEMP	Operational Environmental Management Plan
SEARs	Secretary's environmental assessment requirements
TAP	Transport Access Program
TfNSW	Transport for NSW

Definitions

Term	Meaning
Australian Height Datum (AHD)	The standard reference level used to express the relative height of various features. A height given in metres AHD is the height above mean sea level.
Average Recurrence Interval (ARI)	The likelihood of occurrence, expressed in terms of the long-term average number of years, between flood events as large as, or larger, than the design flood event. For example, floods with a discharge as large as or larger than the 100-year ARI flood will occur on average once every 100 years.
Annual Exceedance Probability (AEP)	The probability or likelihood of an event occurring or being exceeded within any given year.
Blue Book	*Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom, 2004) and *Volumes 2A, 2B, 2C, 2D and 2E* (DECC, 2008).
Concept design	Broadly refers to the process that the Construction Contractor undertakes (should the Proposal proceed) to refine the scoping design to a design suitable to proceed to detailed design (subject to Transport for New South Wales acceptance).
Detailed design	Detailed design broadly refers to the process that the Construction Contractor undertakes (should the Project proceed) to refine the concept design to a design suitable for construction (subject to Transport for New South Wales acceptance).
Feasible	A work practice or mitigation measure is feasible if it can be engineered and is practical to build and/or implement, given Project constraints such as safety, maintenance and reliability requirements.
Flow Width	Flow width represents with width of water flow for a given rainfall event. Flow width limits are applied for the safety of vehicular traffic.
Maximum Depth Velocity	The product of depth of flow and velocity which typically represents a safety criteria for floodway safety.
Proponent	A person or body proposing to carry out an activity under Division 5.1 of the *Environmental Planning and Assessment Act 1979* - in this instance, Transport for New South Wales.
The Project	The construction and operation of the Redfern Station Upgrade – New Southern Concourse.

Executive Summary

Transport for NSW (TfNSW) is the lead agency for the integrated delivery of public transport services across all modes of transport in NSW and is responsible for the delivery of projects within the Transport Access Program (TAP). TAP is a NSW Government initiative to provide a better experience for public transport customers by delivering accessible, modern, secure and integrated transport infrastructure across NSW.

TfNSW is seeking approval to construct and operate an upgrade of Redfern Station (Redfern Station Upgrade – New Southern Concourse) ('the Project') as a component of the TAP. The Project involves the construction of a new pedestrian concourse to the south of the existing Lawson Street concourse providing both lift and stair access to Platforms 1-10. The new pedestrian concourse would provide a new connection across the railway corridor, extending between Little Eveleigh Street and Marian Street in the suburbs of Redfern and Eveleigh and include associated interchange upgrades.

This flooding, hydrology and water quality technical report has been prepared in accordance with the commitments made in Chapter 9 of the Scoping Report (AECOM, 2019) and the Secretary's Environmental Assessment Requirements. These requirements include describing the surface water environment present at the Project area, assessing impacts of the Project on regional flooding, local drainage and surface water quality and identifying mitigation and management measures to address the impacts identified.

The assessment was based on a desktop review of available information including review of existing flood studies, as well as drainage modelling undertaken for the Little Eveleigh Street area.

The Project is located in an environment that is highly urbanised and altered from its natural state, and water quality is typical of that for urban catchments in Sydney. The Project sits on the border of the Blackwattle Bay and Alexandra Canal catchments and flood behaviour is captured by two existing flood studies produced by City of Sydney Council. Under existing conditions, the Project area is subject to localised flooding in areas between the station's tracks and within the proposed location of construction ancillary facility 1, as well as some flow width exceedances along Little Eveleigh Street. Water quality within the receiving waters of Blackwattle Bay and Alexandra Canal are considered to be poor as measured against locally derived environmental and ecological guideline values and Australia New Zealand Environment and Conservation Council Water Quality Guideline levels (Bugnot et al, 2016, Cooks River Alliance 2017, RMS, 2017).

Construction of the Project would result in very little change to imperviousness within the Project area. Potential construction impacts to regional flooding and local drainage can be managed through mitigation and management measures, including locating stockpiles and storage areas outside of the five per cent AEP flood extent and the one per cent AEP flood extent where possible, and controls to cease work in flood prone areas when a severe weather warning is issued.

Construction water quality impacts can be managed through the development and implementation of measures developed in accordance with the principles and requirements in *Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom, 2004) and *Volume 2A* (DECC, 2008) (Blue Book).

The operational footprint of the Project would lie outside mapped flood extents, and involves a minimal change in land use, including impervious areas. As such, negligible impacts to regional flooding are expected during the operational phase of the Project, and no additional mitigation and management measures are necessary. Local drainage impacts would be managed through the upgrade of local drainage systems and removal of an existing localised sag point on Little Eveleigh Street.

Negligible impacts to stormwater runoff quality are expected during operation of the Project, however a treatment device is proposed for roof runoff from the pedestrian concourse, and treatment of the runoff from the new carpark is proposed.

With the recommended mitigation and management measures in place, only minor impacts to flooding, hydrology and water quality are expected as a result of the Project.

1.0 Introduction

1.1 Project overview

Transport for NSW (TfNSW) is the lead agency for the integrated delivery of public transport services across all modes of transport in NSW and is responsible for the delivery of projects within the Transport Access Program (TAP). TAP is a NSW Government initiative to provide a better experience for public transport customers by delivering accessible, modern, secure and integrated transport infrastructure across NSW.

TfNSW is seeking approval to construct and operate an upgrade of Redfern Station (Redfern Station Upgrade – New Southern Concourse) ('the Project') as a component of the TAP. This Project involves the construction of a new pedestrian concourse to the south of the existing Lawson Street concourse providing both lift and stair access to Platforms 1-10. The new pedestrian concourse would provide a new connection across the railway corridor, extending between Little Eveleigh Street and Marian Street in the suburbs of Redfern and Eveleigh and include associated interchange upgrades.

The key features of the Project include:

- a six metre wide concourse between Little Eveleigh Street and Marian Street
- new stair and lift access from the new concourse to Platforms 1 to 10
- an upgraded station entrance at Marian Street including station services and customer amenities
- a new station entrance at Little Eveleigh Street including station services and customer amenities
- formalisation of a shared zone on Little Eveleigh Street, including:
  - safety improvements to vehicle, cyclist and pedestrian interactions
  - improvements to streetscape such as landscaping, lighting, drainage and pavements
  - relocation of approximately 20 parking spaces (including 18 resident/restricted parking spaces, one accessible parking space and one car share scheme parking space)
  - utility adjustments
- upgrade of Marian Street/Cornwallis Street/Rosehill Street area, including:
  - extension of existing shared zone including part of Rosehill Street
  - safety improvements to vehicle, cyclist and pedestrian interactions including footpath widening
  - improvements to streetscape such as lighting, drainage, landscaping and pavements as well as utility adjustments
  - changes to street parking arrangements including removal of approximately 16 parking spaces (including relocation of one car share scheme parking space)
- operation of the Project.

Other components of the Project include:

- relocation of the shuttle bus zone from Little Eveleigh Street to Lawson Street
- kiss and ride on Lawson Street, and associated footpath upgrade
- kiss and ride on Gibbons Street, and associated footpath upgrade
- footpath widening on Ivy Street
- relocation of a building on Platform 1 to accommodate the concourse
- repurposing, relocations and alterations to platform building features and other platform features, including privacy walls, doors, screens and roofing, platform seats and electrical equipment

- addition of platform canopies
- platform resurfacing on all platforms and associated drainage alterations
- installation of station operational components and infrastructure including:
  - wayfinding and signage
  - tactile ground surface indicators (TGSI)
  - rubbish bins
  - CCTV
  - passenger information system (e.g. passenger information display, public address and hearing loops)
  - emergency equipment (e.g. for fire and life safety)
- service relocations and upgrades including:
  - relocation of overhead wiring structures
  - installation of a new rail signal between Platforms 1 and 2.

The Project's context and location is provided in Figure 1, and the Project area and an overview of the key features are shown in Figure 2 and Figure 3.

For further details on the Project, please refer to **Chapter 5** of the Environmental Impact Statement.

The Project is subject to assessment and approval by the Minister for Planning under Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). This technical report provides an assessment of the potential impacts of the Project on known and potential flooding, drainage and water quality impacts and addresses the requirements of the Secretary of the Department of Planning, Industry and Environment (DPIE) (the 'Secretary's Environmental Assessment Requirements' or SEARs, 20 December 2019) (refer Section 1.3).

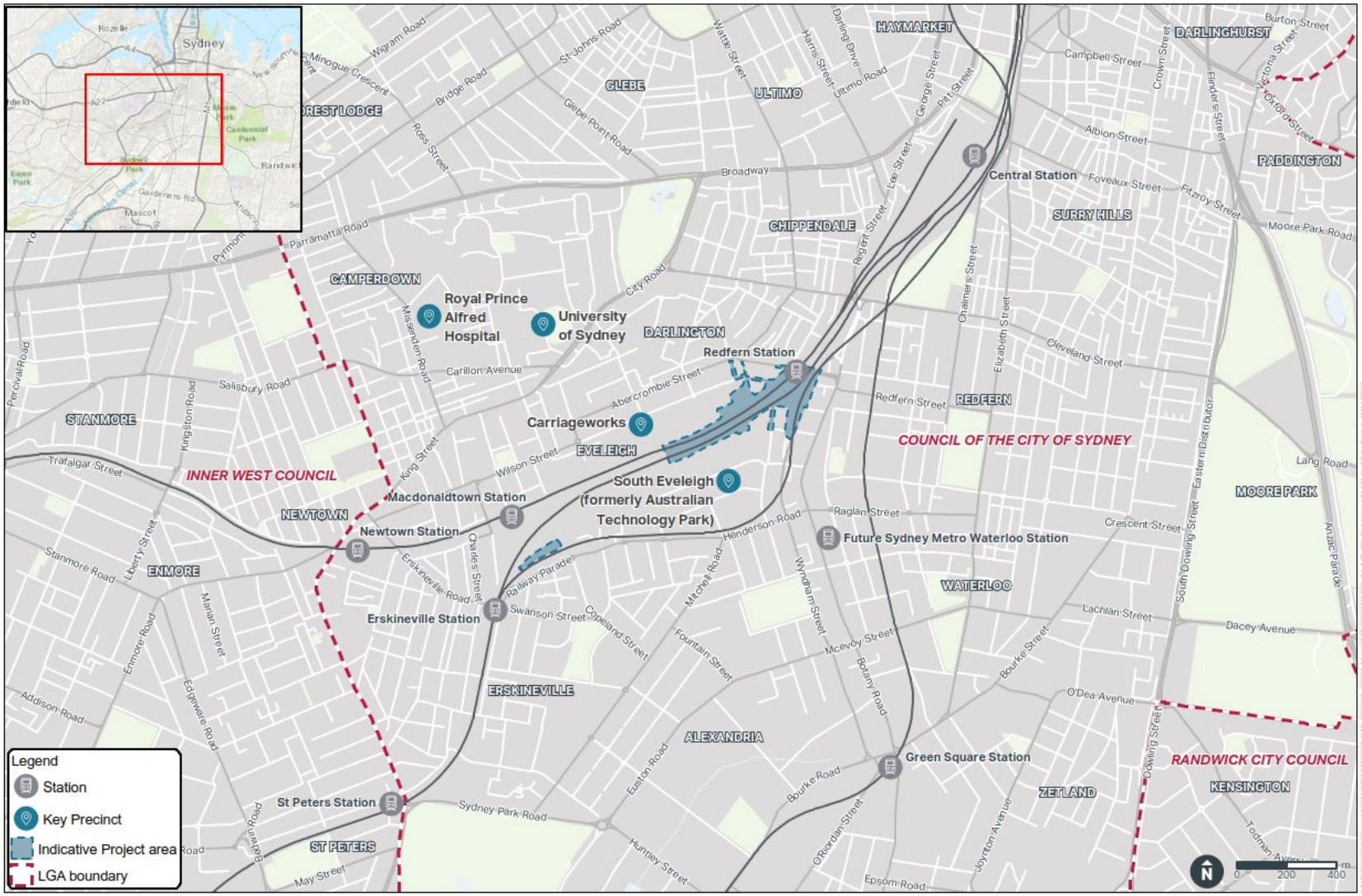

Figure 1 Project overview and location

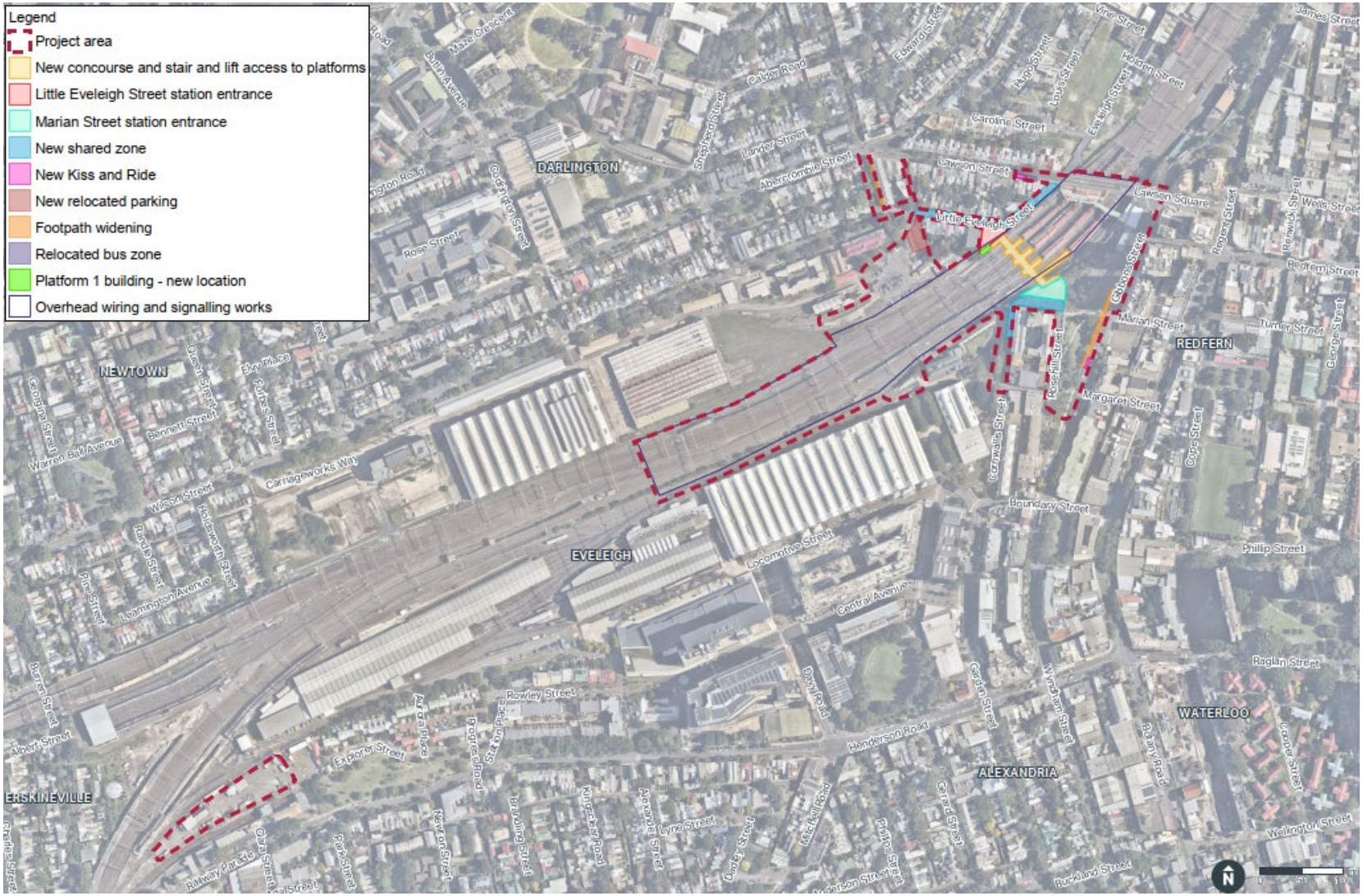

Figure 2 Project area and overview of key features

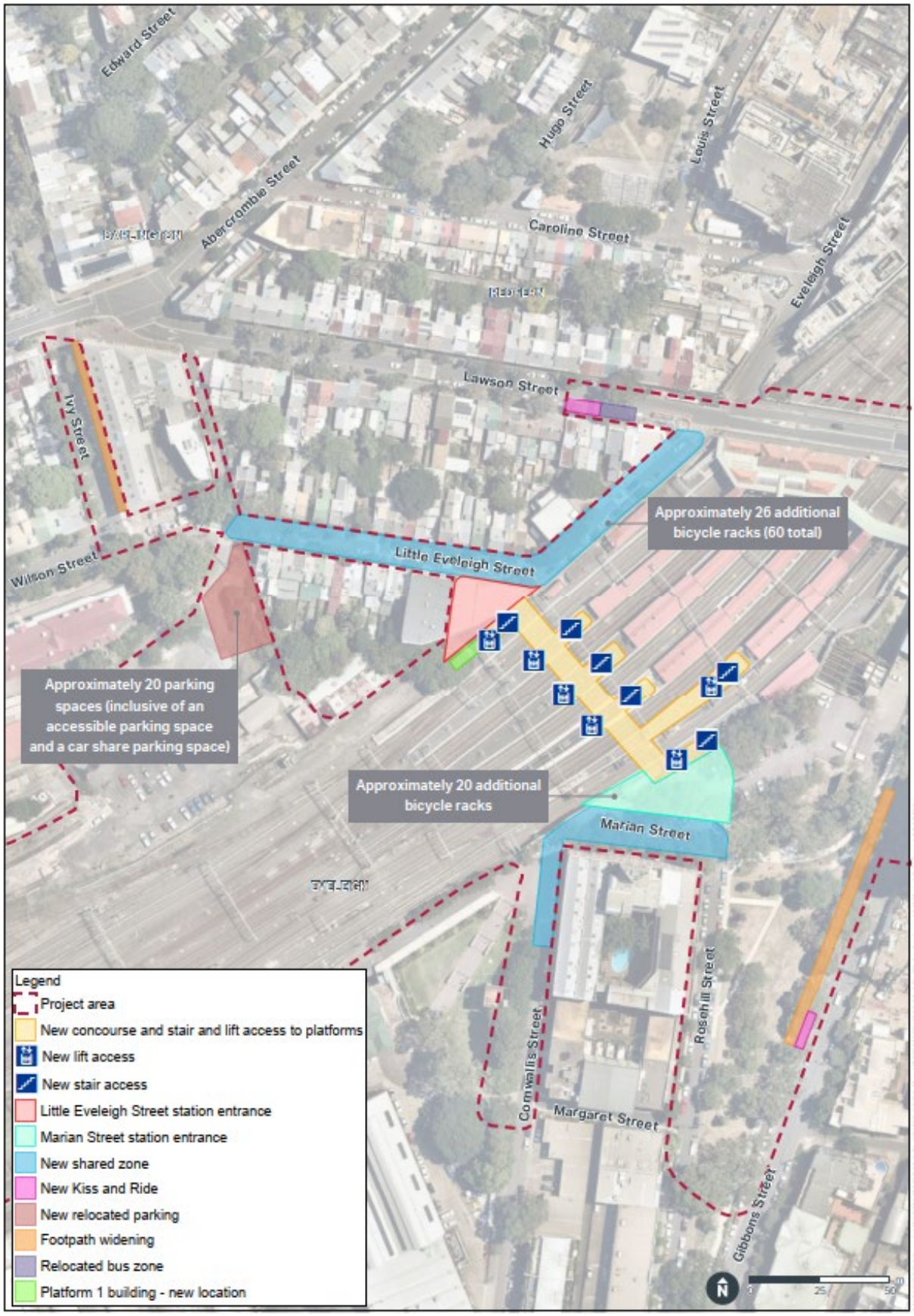

Figure 3 Key features of the Project

1.2 Purpose and scope of this report

This technical report (Flooding, hydrology and water quality impact) is one of a number of technical documents that forms part of the Environmental Impact Statement (EIS). The purpose of this technical report is to identify potential impacts of the Project and to outline mitigation and management measures relating to flooding, hydrology and water quality during detailed design, construction and operation of the Project. This report addresses the relevant SEARs as described in Section 1.3.

1.3 Secretary's environmental assessment requirements

Flooding, hydrology and water quality were not considered key issues in the SEARs, but rather listed under 'other issues'. The SEARs relevant to the Project are shown in Table 1.

Table 1 Secretary's Environmental Assessment Requirements

Secretary's Environmental Assessment Requirements	Where addressed
Other Issues	
(Address) *the following issues in accordance with the commitments made in Chapter 9 of the Scoping Report*: *(c) flooding, hydrology and water quality* The Scoping Report (TfNSW, 2019) makes the following commitments: The EIS will include an assessment of potential impacts to hydrology, flooding and water quality during construction and operation of the Project. The assessment of potential flooding, hydrology and water quality impacts will include:	
• desktop searches and background data review	Section 3.2
• development of a detailed description of the existing hydrological environment including identification of potential receiving waters and flow paths	Section 3.2
• an assessment of the potential impact of the Project on flood behaviour, local hydrologic systems and water quality during construction and operation	Section 4.1.1, Section 4.1.2, and Section 4.1.3
• identification of appropriate mitigation and management measures.	Section 5.3 and Section 5.4

2.0 Assessment methodology

This section outlines the methodology to complete the flooding, hydrology and water quality impact assessment for the Project.

A detailed description of the Project and its associated works are provided in **Chapter 5** of the Environmental Impact Statement.

2.1 Overview

This assessment is a qualitative desktop assessment of flooding, hydrology and surface water quality impacts associated with the Project. The approach adopted in assessing the potential impacts included:

- a desktop review and analysis of existing information to characterise the existing environment, identify surface water receptors, existing flood behaviours and drainage infrastructure, and identify potential issues
- consideration of the location of the Project area in the context of surrounding catchment areas and potential sensitivity and influence on downstream waterways
- identification of key topographical features such as likely overland flow paths and low/sag points around the Project area
- assessment of potential construction and operational impacts relating to flooding, drainage and surface water, including drainage modelling
- identification of appropriate mitigation and management measures to mitigate potential impacts on the environment.

A stormwater drainage assessment has been undertaken by NovoRail Alliance (*Drainage assessment*, refer Appendix A), which informed this assessment. The *Drainage assessment* included consideration of readily available data and information from previous studies on surface water within the area. The key studies included:

- *Blackwattle Bay Catchment Flood Study* (City of Sydney Council 2015, WMAwater)
- *Alexandra Canal Catchment Flood Study* (Cardno, 2014), and *Alexandra Canal Flood Study Model Update* (WMAwater, 2018).

The *Drainage assessment* included results of stormwater drainage modelling undertaken (with DRAINS modelling software) for the Little Eveleigh Street area, as the Project is expected to result in additional flow in this area as a result of the proposed pedestrian concourse. The modelling results were compared against relevant City of Sydney Council standards for drainage design parameters, and are included in this assessment.

Note that increased flooding as a result of climate change has also been assessed for the Project in the climate change assessment in **Chapter 22** of this Environmental Impact Statement (and discussed in Section 18.4.2), which took into account projected climate scenarios for the years 2030 and 2070.

2.2 Legislation and policy

2.2.1 Relevant legislation

The *Water Act 1912* (NSW) and the *Water Management Act 2000* (NSW) are the two key pieces of legislation for the management of water in NSW and contain provisions for the licensing of water access and use. The *Water Act 1912* is being progressively phased out and replaced by the *Water Management Act 2000*, but its provisions remain in force in respect of areas of NSW where water sharing plans under the *Water Management Act 2000* have not yet been made. The objects of the *Water Management Act 2000* are to provide for the sustainable and integrated management of the State's water sources for the benefit of both present and future generations. The principles of the *Water Management Act 2000* relating to drainage and floodplain management include the need to avoid or minimise land degradation.

The Project is defined as State Significant Infrastructure under Section 5.12(2) of the *Environmental Planning and Assessment Act 1979*. Section 5.23 of the *Environmental Planning and Assessment Act 1979* specifies authorisations that are not required for approved State Significant Infrastructure, which includes various approvals under the *Water Management Act 2000*, including a water use approval under Section 89, a water management work approval under Section 90 or activity approvals (other than aquifer interference approvals) under Section 91. Therefore, apart from consideration of a licence for aquifer interference activities, no other approvals under the *Water Management Act 2000* would be required (refer also **Chapter 3** of the Environmental Impact Statement).

The *Protection of the Environment Operations Act 1997* aims to protect, restore and enhance the quality of the environment, having regard to the need to maintain ecologically sustainable development. Section 148 of the Act requires immediate notification of pollution incidents causing or threatening material harm to the environment to the relevant authority.

The *Local Government Act 1993* contains a requirement under clause 68 to gain approval from local council for carrying out stormwater drainage work, except on land within the area of operations of the Sydney Water Board. The Project area is within the Sydney Water Board's area of operations and therefore approval is not required. Notwithstanding, TfNSW would undertake consultation with City of Sydney Council and / or Sydney Water as appropriate prior to connecting to existing stormwater drainage system/s.

2.2.2 Relevant policy and guidelines

Key guidelines referenced in this assessment include:

- *Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom, 2004) and *Volume 2A* (DECC, 2008) (the 'Blue Book')
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000) (the *ANZECC Water Quality Guidelines*)
- *Australian Rainfall and Runoff* (Commonwealth of Australia, 2019)
- *Australian Rainfall and Runoff* (Engineers Australia, 1987)
- *Sydney Streets Technical Specifications* (City of Sydney, 2019).

These guidelines are described further below.

Managing Urban Stormwater: Soils and Construction - Volume 1 and Volume 2A (the Blue Book)

The principles for the management of stormwater are documented in this publication, otherwise known as the Blue Book. The Blue Book and these management principles have been accounted for in the mitigation and management measures developed for the Project.

ANZECC Water Quality Guidelines

In 2000, the former Australian and New Zealand Environment and Conservation Council (ANZECC) released the *ANZECC Water Quality Guidelines* to provide a nationally consistent approach to water quality management based on the principle of ecological sustainable development of water resources. The guidelines contain a set of tools for the assessment and management of water quality across a range of water resource types based on designated environmental values. The *ANZECC Water Quality Guidelines* are ambient water quality guidelines, appropriate for the assessment of the existing water quality of watercourses downstream of the Project.

Australian Rainfall and Runoff

Australian Rainfall and Runoff (Commonwealth of Australia, 2019) is the primary technical publication for hydrological estimates and design considerations. The latest issue was finalised in 2019 and was the result of a number of years' of updates to the previous version of *Australian Rainfall and Runoff* (Engineers Australia, 1987). The technical analysis and development of the original hydrologic and hydraulic models for the Alexandra Canal and Blackwattle Bay flood studies were commenced prior to finalisation of the 2019 version and are therefore largely based on the Engineers Australia 1987 version.

Water Quality Objectives

The NSW Government has developed the *Sydney Harbour and Parramatta River Water Quality Objectives* (NSW Government, 2006) to safeguard the long-term health of waterways through the introduction of wide-ranging reforms. Water quality and river flow objectives are developed to represent the community's environmental values and long-term goals for waterways. The objectives outline the physical and chemical conditions of waterways and their physical flow characteristics:

- aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term
- visual amenity – enhancing the aesthetic qualities of waters such as visual clarity and colour, surface films and debris and nuisance organisms
- primary contact recreation – maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed
- secondary contact recreation – maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed
- aquatic foods (cooked) – enhancing water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.

These objectives guide plans and actions to achieve healthy waters and ensure the maintenance or improvement of water quality. Water Sensitive Urban Design systems are one means for reducing pollutant loads and thereby contributing to the process of working towards the aquatic ecosystem objectives for physical and chemical stressors and toxicants.

Sydney Streets Technical Specification

The *Sydney Streets Technical Specifications* (City of Sydney, 2019) detail the design and construction standards for physical assets in Sydney. Table 2 and Table 3 outline the specifications for overland flow limits and pit blockage design factors as required for any updated drainage systems (City of Sydney, 2019).

Table 2 City of Sydney Council design criteria - 100 year ARI overland flow limits for pedestrian and shared zones

Criteria	Limit
Maximum Depth	50 mm
Maximum flow width	1.5 m
Maximum depth x velocity	0.4 m^2/s

Table 3 City of Sydney Council design criteria - Pit blockage design factors

Pit type	On grade blockage factor	Sag blockage factor
Kerb Inlet <= 1.0 m	50 per cent	70 per cent
Kerb Inlet > 1.0 m	20 per cent	50 per cent
‘V’ grate or grate only	90 per cent	90 per cent
Strip Drain or other	95 per cent	95 per cent

3.0 Existing environment

3.1 Regional drainage catchment and local topography

3.1.1 Regional drainage

The Project area is mostly impervious with limited pervious areas of parks and landscaped areas. It has been highly modified from its natural state by various forms of urban development and transport infrastructure.

The Project sits at the ridge of the Blackwattle Bay and Alexandra Canal catchments, comprising the following land uses:

- The Blackwattle Bay catchment is approximately 315 hectares with extensive urban land use, servicing medium to high density housing with some commercial and industrial developments. The site is serviced by Sydney Water's major trunk drainage system to route flows from the upper regions of the catchment down to Blackwattle Bay. Blackwattle Bay is approximately 1.8 km from the Project area.
- The Alexandra Canal catchment comprises an area of around 2,300 hectares. The catchment is heavily altered, predominantly characterised by commercial, industrial and residential development, with a small amount of parkland such as Sydney Park and Moore Park. Alexandra Canal is approximately 2.1 km from the Project area.

The Blackwattle Bay and Alexandra Canal catchments form the study area for this Project, and are shown in Figure 4.

3.1.2 Local topography

The elevation of Redfern Station is around 25 metres Australian Height Datum (AHD) and is contained within the cutting at the ridge between the Blackwattle Bay and Alexandra Canal catchments. Overall topography within Little Eveleigh Street is relatively flat with an approximate south-north grade of less than one per cent. The Little Eveleigh Street catchment (refer Figure 5) is split by a traffic calming device (raised threshold) in front of properties 135 and 137 Little Eveleigh Street.

East of the raised threshold, towards Redfern Station, the surface slopes at 0.7 per cent with a localised sag depression from 31.5 metres AHD to 30.6 metres AHD over a distance of approximately 138 metres. West of the raised threshold, away from Redfern Station towards Ivy Lane, the surface slopes at 4.1 per cent with a localised sag depression from 31.5 metres AHD to 26.8 metres AHD over a distance of approximately 114 metres.

South of Redfern Station, Marian Street sits at 30 metres AHD, the surface slopes at 2 per cent over a distance of 140 metres down Cornwallis Street and Rosehill Street. Ancillary facility 1 sits at approximately 16 metres AHD, ancillary facility 2 at 25 metres AHD and ancillary facility 3 at 27 metres AHD.

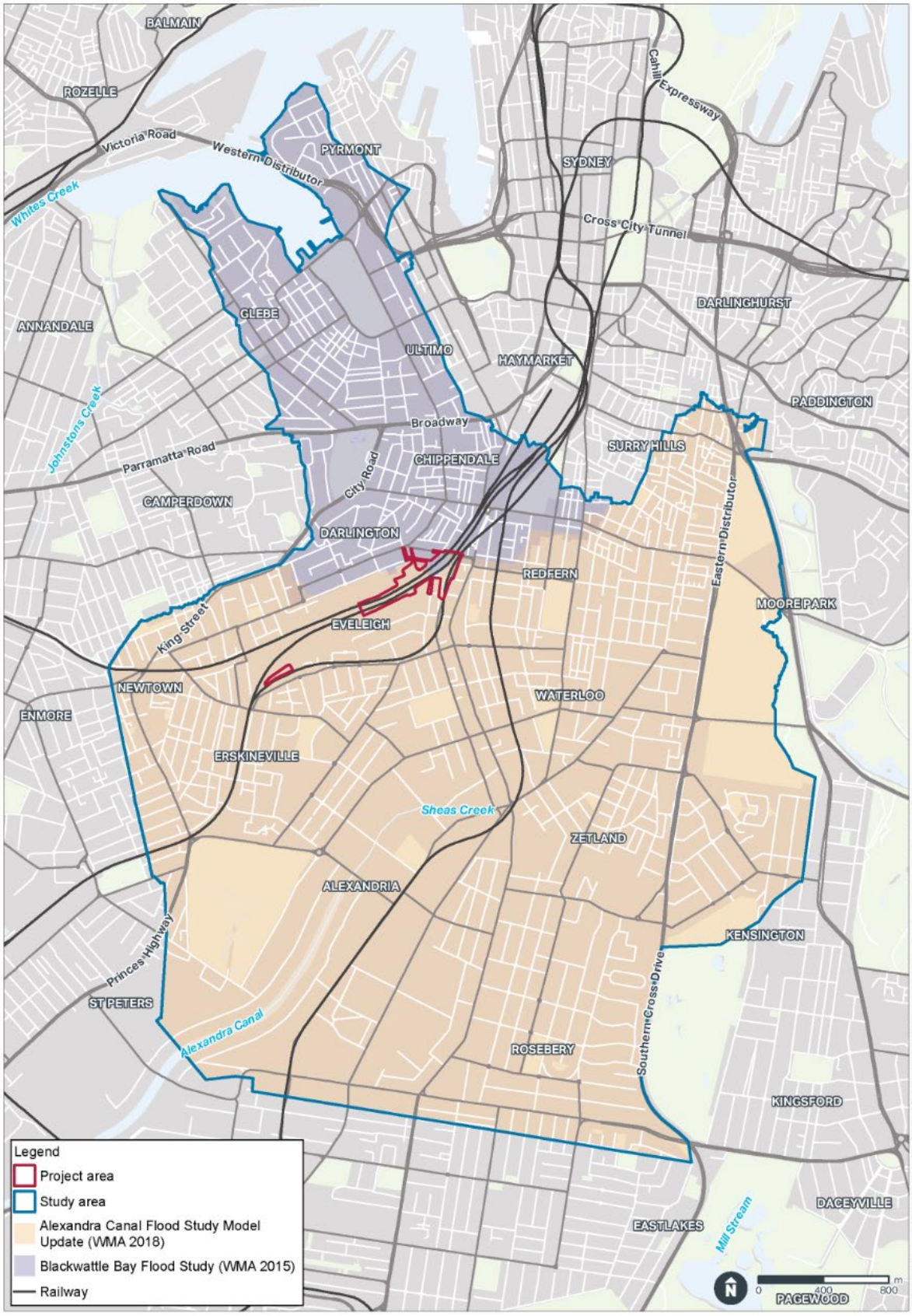

Figure 4 Study area

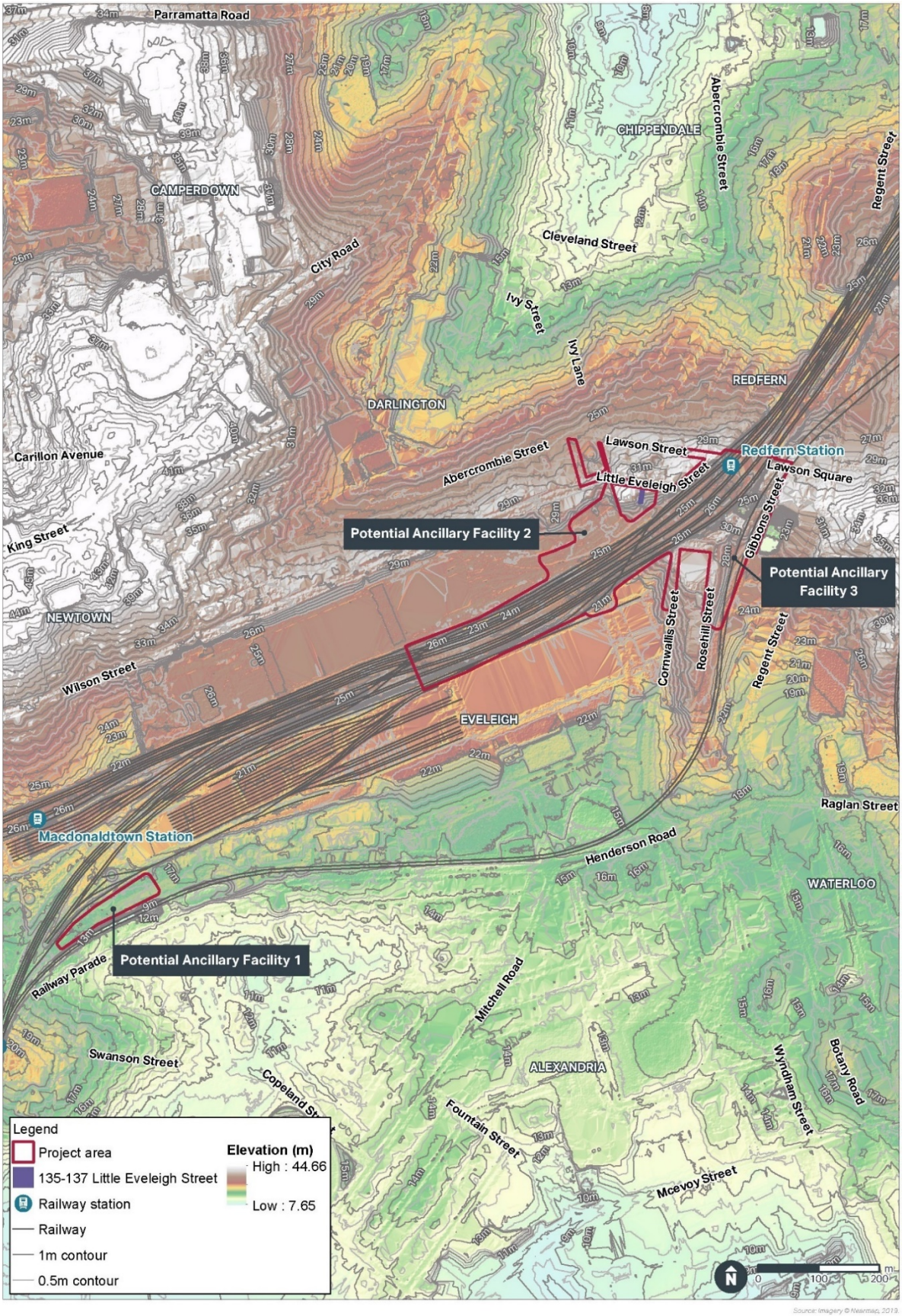

Figure 5 Topography in the vicinity of Redfern Station

3.2 Existing conditions within the Project area

3.2.1 Regional flooding

The Project area sits on the ridge of the Blackwattle Bay and Alexandra Canal catchments, and flood studies for these two major catchments have been prepared for City of Sydney Council: the *Blackwattle Bay Flood Study* (WMAwater, 2015) and *Alexandra Canal Catchment Flood Study* (Cardno, 2014) and *Alexandra Canal Flood Study Model Update* (WMAwater, 2018). The one per cent and five per cent Annual Exceedance Probability (AEP) design flood mapping extracted from the study reports is shown in Figure 6 and Figure 7 respectively.

Redfern Station is located below surrounding surface levels which results in localised ponding during flood events greater than the natural track drainage capacity (i.e. flood water is trapped within the depressed surface levels). This flood behaviour is evident in the *Alexandra Canal Flood Study Model Update* showing ponded flood water between the station platforms (WMAwater, 2018). One per cent AEP flood behaviour relevant to the location of proposed key elements of the Project includes:

- no flooding within the footprint areas of the proposed pedestrian concourse, Little Eveleigh Street and Marian Street station entrance, or new relocated parking area
- no flooding within the footprint areas of Ivy Lane, Ivy Street, Cornwallis Street and Rosehill Street
- some localised ponding is observed across the station area along the train tracks with localised ponding depths of up to 0.2 metres between Platforms 1 and 2 and depths of up to 0.3 metres between Platforms 3 and 4
- ponding of up to 0.5 metres at the proposed ancillary facility 1 north of Railway Parade.

Flooding is also apparent in these same areas under the five per cent AEP flood mapping.

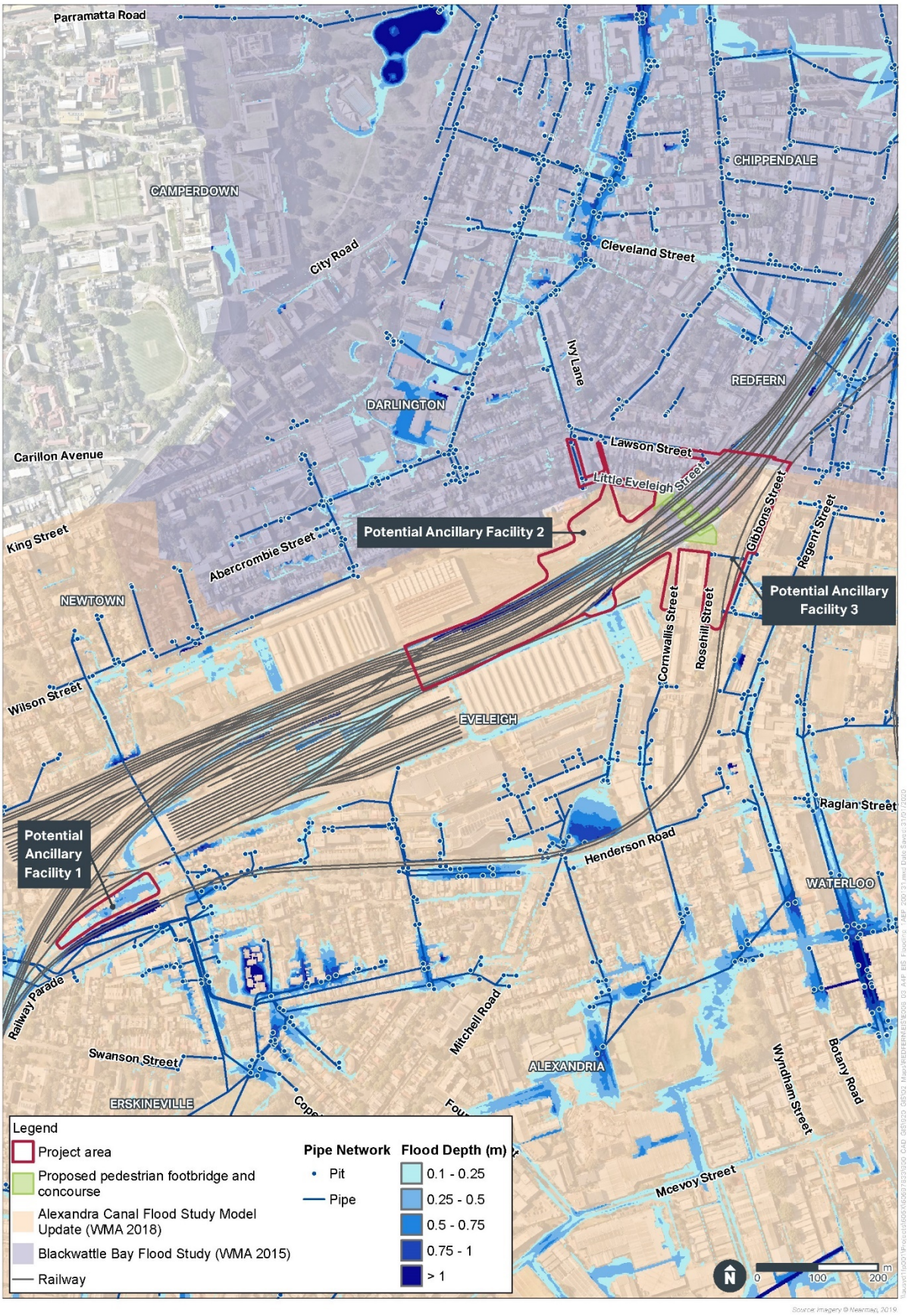

Figure 6 One per cent AEP design flood depths (source: WMAwater, 2015 and WMAwater, 2018)

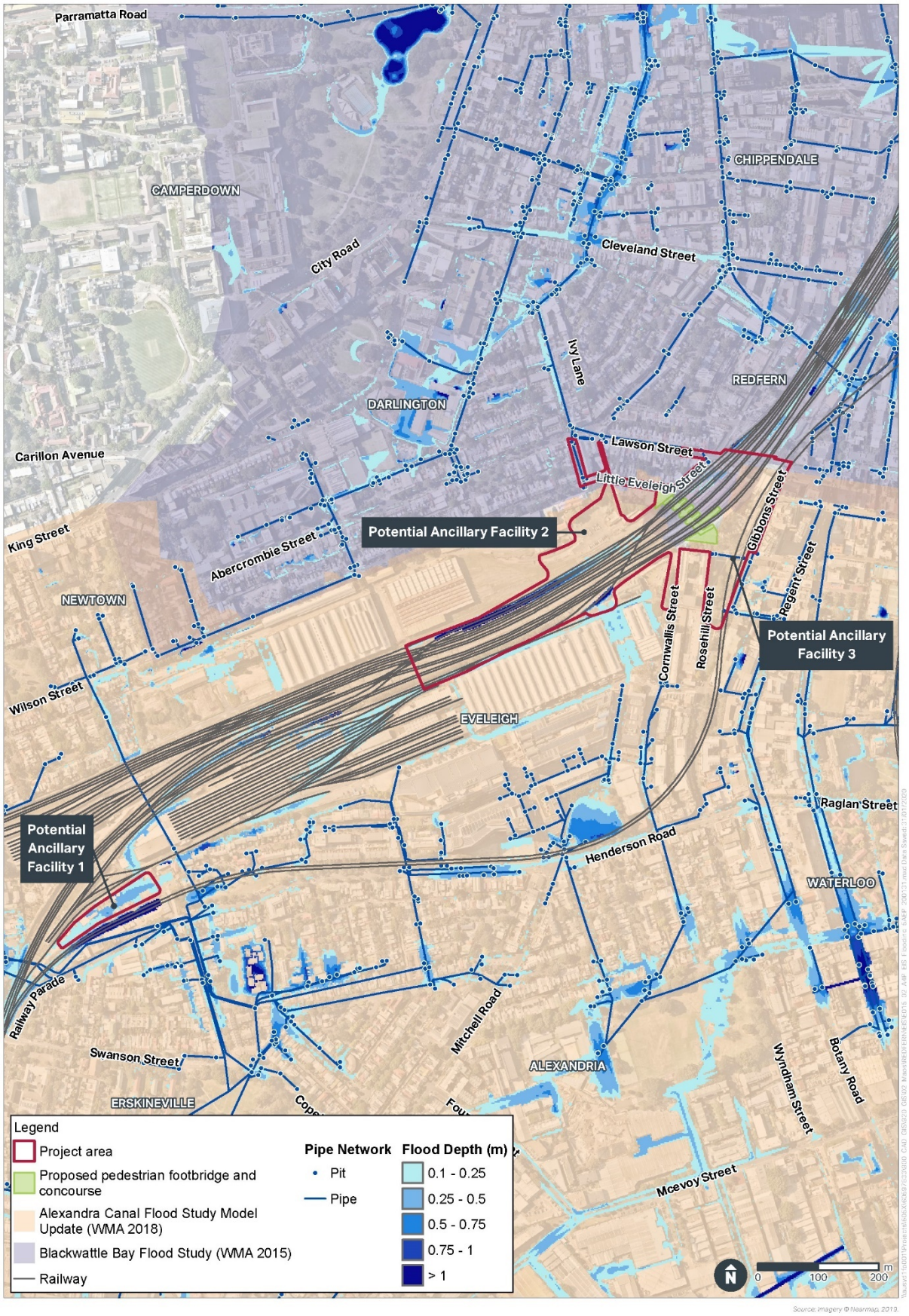

Figure 7 Five per cent AEP design flood depths (source: WMAwater, 2015 and WMAwater, 2018)

3.2.2 Local flooding and drainage

The topography surrounding the station slopes away from the station in all directions, however as noted in Section 3.2.1 the station is located below surrounding surface levels which results in localised ponding during flood events greater than the natural track drainage capacity. There is also a localised sag depression in Little Eveleigh Street which can result in ponding. Other areas prone to flooding have been identified in Section 3.2.1.

Surface water in the Project area is currently conveyed as overland flow and is collected in established stormwater networks by a combination of stormwater infrastructure elements. These include clay, concrete, PVC, and brick pipes and box culverts. Drainage infrastructure within the rail corridor is operated by Sydney Trains. Outside of this area, drainage infrastructure within the Project area is owned and operated by City of Sydney Council and Sydney Water. Drainage systems in the City of Sydney Local Government Area should be designed to accommodate the five per cent AEP, however the *Blackwattle Bay Catchment Flood Study* notes that minor drainage systems within the catchment are exceeded at events as small as the 20 per cent AEP (City of Sydney 2015, WMAwater).

The *Drainage assessment* (NovoRail Alliance, 2019a) included a review of existing local drainage conditions in the Little Eveleigh Street area using DRAINS modelling, as additional flow is expected in this area as a result of the proposed pedestrian concourse. The DRAINS modelling predicted results for maximum pre-development flow rates, depth-velocity product and flow width, which are tabulated in Table 4, with catchments (labelled as Catchment 1 and Catchment 2) (including the proposed pedestrian concourse) shown in Figure 8. Comparison is made against the Council design criteria presented in Table 2 and Table 3, which shows that the maximum depth-velocity product for both catchments is below the Council design criterion of 0.4 m^2/s. The maximum flow width of each catchment however exceeds the Council design criteria (refer Table 4). Upgraded drainage works as part of the Project are expected to rectify current and predicted design exceedances (refer Section 5.4.2).

Table 4 Existing local drainage results - 100 year ARI

	Maximum pre development flow (m^3/s)	Maximum depth x velocity (m^2/s)	Maximum flow width (m)
City of Sydney Design Criteria	N/A	0.4	1.5
Catchment 1	0.29	0.23	3.39[1]
Catchment 2	0.33	0.12	3.79[1]

[1]Greyed cells indicate flow width exceedances. Source: NovoRail Alliance, 2019a.

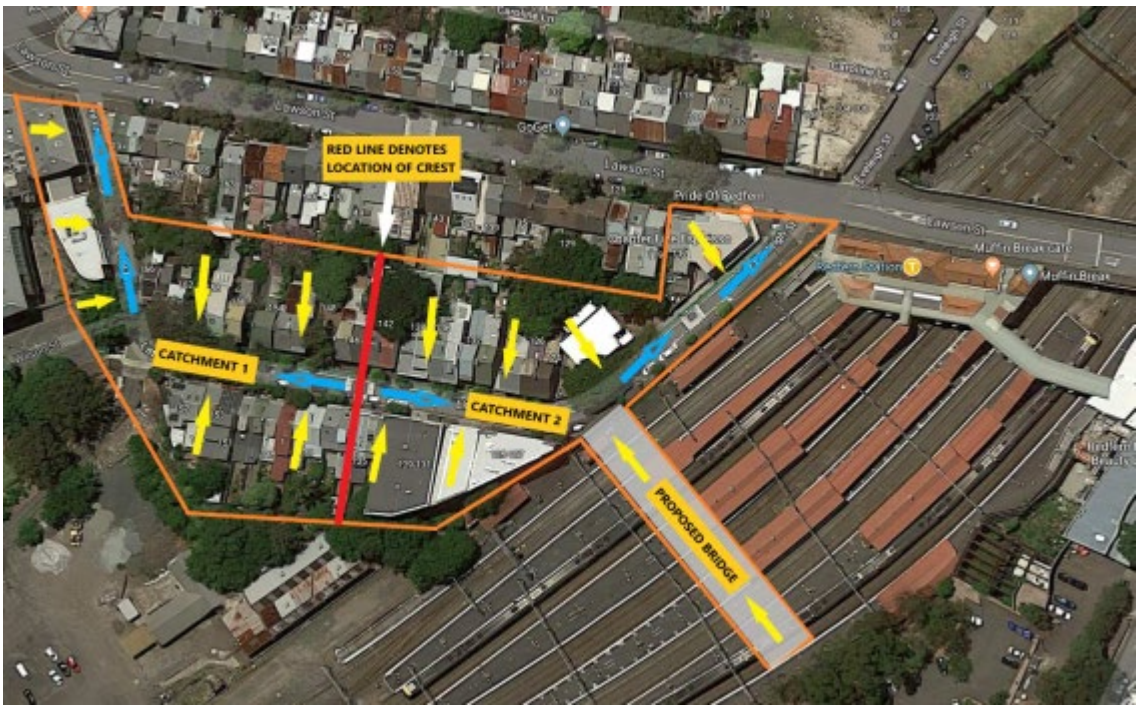

Figure 8 Local catchment areas modelled (Source: NovoRail Alliance, 2019a)

3.2.3 Water quality

Stormwater consists of rainfall runoff and any material (soluble or insoluble) mobilised in its path of flow. Stormwater runoff quality in the Project area could be influenced by surface pollutants typical of urban catchments including:

- oils and hydrocarbons
- heavy metals
- chemicals from spills, localised pesticide application or inappropriate waste disposal
- sediments
- gross pollutants including litter and debris.

With the exception of drainage grills and grates to block gross pollutants such as leaves and branches, and the operation of City of Sydney street sweepers, no existing water quality treatment measures were identified within the Project area by the desktop study.

The Project area drains to Blackwattle Bay and Alexandra Canal which form part of the Sydney Harbour and Cooks River catchments respectively. Receiving water environmental values have been documented in Appendix B. Water quality within the Alexandra Canal is generally considered to be poor and unfit for contact by humans. Non-compliance against locally derived environmental and ecological guideline values for turbidity and chlorophyll-a is frequent as a result of sediment-laden, nutrient enriched urban stormwater entering the waterways causing elevated turbidity and excessive algal growth (Cooks River Alliance, 2017).

Samples collected at Rozelle Bay, directly adjacent to Blackwattle Bay by The University of New South Wales as part of the Bays Precinct transformation as well as a surface water and flooding assessment completed for the WestConnex M4-M5 Link project have shown elevated concentrations of heavy metals (copper, chromium, lead and zinc), nitrogen, phosphorous, nitrate, oxides of nitrogen, ammonia and chlorophyll. On some occasions the pH level was outside guideline levels and the turbidity exceeds *ANZECC Water Quality Guideline* levels (Bugnot et al, 2016; Roads and Maritime Services, 2017).

4.0 Impact assessment

4.1 Construction

4.1.1 Regional flooding

During construction there is the potential for inundation of the Project area in locations close to or within areas prone to flooding. Ancillary facility 1 has been identified as an area prone to regional flooding, with depths of up to 0.5 metres according to the five per cent and one per cent AEP flood mapping (refer Section 3.2.1). Ancillary facility 1 would be primarily used for an administration centre for the Project, comprised of site offices and car parking areas. Similarly areas within the rail corridor on the train tracks have also been identified as being prone to regional flooding, with depths of up to 0.5 metres under the flood mapping (refer Section 3.2.1). There are no proposed construction works within the train tracks themselves, and it is anticipated that a track drainage upgrade being undertaken separately by Sydney Trains at Redfern Station will have been completed prior to operation of the Project.

Flooding within and around both of these areas (within the rail corridor and ancillary facility 1) could present a safety hazard to construction personnel, cause damage or loss of materials and equipment, and could potentially lead to materials being washed offsite and into waterways downstream, resulting in environmental impacts. As ancillary facility 1 is located within the five per cent AEP flood extent, no stockpiles would be located within this area. Where possible, stockpiling within the one per cent flood extent should also be avoided, in order to avoid this risk also.

There is no potential for regional flooding impacts within the remainder of the Project area according to the flood mapping.

Construction works also have the potential to change flood behaviour and impact on the surrounding environment. The construction activities associated with the Project that could result in impacts if not mitigated include:

- utilities adjustments, ancillary facility establishment, and demolition works
- modification or replacement of road surfaces and construction of the new pedestrian concourse
- implementation of environmental management and pollution control facilities for the Project.

Impacts would be adequately managed through the mitigation and management measures identified in Section 5.3.1. Careful planning of the layout of ancillary facility 1, other construction areas, and management and planning of construction activities would be considered during detailed design.

4.1.2 Local flooding and drainage

Construction works required for the Project have the potential to impact local overland flow paths and existing minor drainage paths, by causing a minor redistribution of some surface water flows.

Disruption of existing flow paths, both of existing constructed drainage systems or those of overland flow paths, could occur as a result of:

- disruption of existing drainage networks during upgrade or replacement of drainage pits and pipes
- excavation for foundations, roadworks and the new car park creating localised ponding points which capture stormwater
- establishment of temporary construction ancillary facilities, including storage/stockpiling of materials
- sediment entering existing drainage assets/systems and causing blockages
- overloading the capacity of the local drainage system.

Due to the small size of the Project area in the context of the wider catchment, the redistribution of flows during construction is not expected to significantly affect the performance of downstream drainage infrastructure, however a mitigation measure has been added to maintain stormwater flows during construction so that they do not cause an issue.

The above identified potential impacts are typically faced on most construction projects and would be addressed by adopting standard construction mitigation and management measures (refer Section 5.3.1). Consideration of these impacts would be included during detailed design and construction planning phases.

4.1.3 Water quality

Potential impacts to stormwater runoff during the construction phase could occur as a result of:

- earthworks associated with road pavement resurfacing (at Little Eveleigh Street and Marian Street/Cornwallis Street/Rosehill Street), footpath upgrades (at Gibbons Street and Lawson Street), carpark construction (at Little Eveleigh Street), platform building alterations, demolition works, ancillary facility area establishment, site levelling (including in Gibbons Street Reserve), piling and trenching for electrical cable installation and utility adjustments
- contamination of surface waters due to accidental spillages of fuel, lubricants, effluent and other chemicals and materials used during construction
- dewatering open excavations following periods of rainfall which may contain sediments and other pollutants mobilised by the rainfall.

Where sediments are mobilised from construction areas and allowed to enter the receiving waterways, there is the potential to adversely impact water quality by increasing turbidity, lowering dissolved oxygen levels, increasing nutrients and introducing pollutants.

Impacts to receiving watercourses are considered to be negligible with the implementation of standard mitigation and management measures described in Section 5.4.3.

4.2 Operation

4.2.1 Regional flooding

Existing flood models of the adjoining catchments show that the Project during operation would be located outside of the one per cent and five per cent AEP flood extents. Any increases to surface runoff as a result of a slight increase in imperviousness, for example from the new pedestrian concourse and new carpark on Little Eveleigh Street, would be negligible in the context of regional flooding. The Project is therefore unlikely to result in an impact to regional flooding.

Climate change over time can increase the intensity and frequency of rainfall events and influence flood behaviour. In accordance with the *Floodplain Development Manual - The Management of Flood Liable Land* (DIPNR, 2005), the Alexandra Canal and Blackwattle Bay flood studies (WMAwater, 2015; and WMAwater, 2018) both considered the impacts of climate change on flood behaviour. Climate change modelling investigated the impacts of sea level rise and increases in design rainfall in accordance with guidance provided by *Floodplain Risk Management Guideline - Practical Consideration of Climate Change* (Department of Environment and Climate Change, 2007). An increase in design rainfalls generally result in an increase in flood levels across the catchment areas, predominantly in the main flow paths and lower regions of the catchments. Increases in flood level were a maximum of 0.2 metres for the Blackwattle Bay catchment and 0.3 metres within the Alexandra Canal catchment. Regions located in the steeper areas bordering the catchment boundary are not affected as much by the increases in flood levels as the flatter regions in the centre of the catchment. As such the Project area (which is located near the catchment boundaries) is unlikely to be significantly affected by these predicted flood level increases. The impacts of sea level rise are largely confined to the low lying areas of the catchments and are also unlikely to be of concern to the Project area.

4.2.2 Local flooding and drainage

The Project has the potential to impact local flooding and drainage.

The assessment presented in Appendix A outlined that the distribution of local flows is expected to change as a result of the Project at Little Eveleigh Street, where rainfall that would previously land on the rail tracks is redistributed from the new concourse roof onto the street. The footprint included within the drainage modelling undertaken and the change in flows is provided in Appendix A. It was found that:

- localised flooding between the tracks would be reduced as the concourse would redistribute the water via a pipe network to kerb and gutter at Little Eveleigh Street
- local flooding would be unlikely to impact on pedestrian access points
- impact of the new concourse to the rail corridor is considered negligible.

The existing stormwater arrangements and connections within the Project area, as well as the modelled stormwater conditions without implementation of any mitigation measures were modelled. The results provided show that drainage conditions for the one per cent AEP includes:

- a pre-development total peak flow of 0.61m^3/s and post-development total peak flow of 0.66m^3/s
- a 6.7 percent increase in flow rates which is due to the additional concourse increasing the contributing catchment area and producing an additional 0.04m^3/s
- a maximum flow width of 5.8 metres which would exceed the relevant Council design criteria of 1.5 metres (refer Table 2).

The new carpark proposed on Little Eveleigh Street would also introduce a new impervious area which would capture stormwater and contribute to the increase in flow rates identified above. This carpark area would be connected to the local stormwater drainage network. The drainage network along Little Eveleigh Street would be upgraded as part of the Project (in conjunction with the creation of the shared zone, station entrance and concourse), which would account for the increase in runoff predicted from the carpark and concourse roof described above. The design of the new shared zone would also account for the existing sag depression in Little Eveleigh Street, so that adequate road drainage is achieved. To manage peak flows, water sensitive urban design measures (e.g. detention basin or bioretention basin/s) are also proposed to be installed at or near the Little Eveleigh Street carpark as part of the Project; with these measures in place, the peak stormwater flow for rainfall events of up to a 1.5 year ARI event is not expected to be increased.

Elsewhere in the Project area, the new canopies (for platforms and stairs) introduced by the Project would also capture and distribute additional stormwater runoff to the track drainage system within the rail corridor. This is expected to be adequately managed by the track drainage system (which is also subject to an upgrade by Sydney Trains separately to this Project).

Where works are proposed to the road surfaces (i.e. Marian Street/Cornwallis Street/Rosehill Street, Gibbons Street and Lawson Street) there would be a negligible change in stormwater runoff as there is minimal change in the imperviousness of the catchment and no change in contributing catchments. It is noted that the drainage would also be upgraded in the Marian Street/Cornwallis Street/Rosehill Street area as part of the shared zone extension and works in this area.

As noted in Section 4.2.1, flood behaviour can be influenced by climate change. A *Climate Risk and Adaptations Report* (NovoRail Alliance, 2019b) was prepared for the Project, which recognised the risk of extreme rainfall events having the potential to create flows of water which exceed the capacity of drainage and storm water systems, resulting in localised flooding and spills to natural waterways. This risk would be accounted for in the design of the Project, which would accommodate the one per cent AEP event plus a 10 per cent increase in rainfall intensity to account for climate change. Note that increased flooding as a result of climate change has also been assessed for the Project in the climate change assessment in **Chapter 22** of this Environmental Impact Statement (and discussed in Section 18.4.2), which took into account projected climate scenarios for the years 2030 and 2070.

Overall, where the Project would introduce additional impervious areas, the additional stormwater captured is expected to be adequately managed by existing and upgraded stormwater drainage systems, and in other areas of the Project there are expected to be minimal changes to drainage regimes. Mitigation and management measures are recommended, including incorporation of water sensitive urban design features.

4.2.3 Water quality

Potential impacts to stormwater runoff during the operational phase could occur as a result of changes or additions to the contributing surfaces of the within the Project area to the drainage network.

The design of the Project includes the addition of the roof catchment area for the new concourse, being discharged to kerb and gutter (via pipes) on Little Eveleigh Street. The roof may have higher concentrations of some pollutants (e.g. deposited air emissions/particulates) after a period of no rain and would require mitigation as outlined in Section 5.4.3. Similarly the new platform and stair canopies could also introduce additional pollutants into the track drainage system.

The proposed carpark introduces approximately 20 new car spaces and would increase the impervious area of the Project area, preventing runoff from infiltrating the ground. If stormwater is not infiltrated close to where it falls, there is the potential to collect contaminants and litter from impervious areas before it enters receiving waterways downstream. A stormwater treatment device would be designed and implemented to mitigate against increased pollutants from new impervious surfaces such as the carpark. The type and size of treatment device required (e.g. bioretention basin/s) would be confirmed during detailed design. Mitigation and management measures are proposed to address this risk in Section 5.4.3.

The remaining Project elements would result in minimal changes in land use and imperviousness and would have an negligible impact to water quality.

5.0 Mitigation and management measures

5.1 Overview

This chapter describes the environmental management approach for the Project for landscape and visual amenity during construction and operation. Further details on the environmental management approach for the Project are provided in **Chapter 24** of the Environmental Impact Statement (Environmental management approach and framework).

A Construction Environmental Management Framework (CEMF) (**Appendix D** of the Environmental Impact Statement) describes the approach to environmental management, monitoring and reporting during construction. Specifically, it lists the requirements to be addressed by the construction contractor in developing the Construction Environmental Management Plan (CEMP), sub-plans, and other supporting documentation for each specific environmental aspect.

A Soil and Water Management Plan would be developed for the Project as identified by Section 6.5 (Soil and Water Management) of the CEMF.

The chapter includes a compilation of the performance outcomes as well as mitigation measures, including those that would be included in this plan.

5.2 Performance outcomes

The flooding, hydrology and water quality performance outcomes for the Project are as follows:

- stormwater drainage within the Project area is maintained during construction so as not to cause localised flooding or drainage issues as a result of Project works
- adverse impacts to stormwater quality during construction are avoided
- adverse impacts to stormwater quality during operation are avoided
- adverse impacts to local drainage during operation are avoided.

The Project would be design, constructed an operated to meet these performance outcomes.

5.3 Construction

5.3.1 Flooding and drainage

During the construction phase, works within ancillary facility 1 would occur within the five per cent and one per cent AEP flood extents, as outlined in Section 4.1.1. Construction works also have the potential to change flood behaviour and impact on the surrounding environment, including:

- utilities adjustments, ancillary facility establishment, and demolition works
- modification or replacement of road surfaces and construction of the new pedestrian concourse
- implementation of environmental management and pollution control facilities for the Project.

Careful planning of the layout of ancillary facility 1, other construction areas, and management and planning of construction activities would be considered during detailed design.

Construction works required for the Project also have the potential to impact local overland flow paths and existing minor drainage paths, by causing a minor redistribution of some surface water flows.

Construction phase mitigation and management measures to address these risks would include:

- install temporary drainage or drainage diversions so that stormwater function is not impeded during construction, and construction areas are not significantly impacted in the event of a flood event
- locate stockpiles and storage areas outside of the five per cent AEP flood extent and ideally outside of one per cent AEP flood extent where possible
- cease work in flood prone areas when a severe weather warning is issued and secure work sites

- a Soils and Water Management Sub-Plan would be developed to manage water and soil issues relevant to the construction of the Project. The sub-plan would include detailed water, erosion and sediment control plans based on the final design of each work site and would outline which control measures would be implemented at each location or for specific works.

5.3.2 Water quality

Potential impacts to stormwater runoff during the construction phase could occur as a result of earthworks and other ground disturbing works leading to erosion and sedimentation, contamination of surface waters due to accidental spills, and dewatering open excavations after rainfall.

Impacts on surface water/runoff quality can be mitigated by implementing standard measures to manage and monitor potential surface water quality impacts during construction in accordance with the principles and requirements of the 'Blue Book' and relevant TfNSW guidelines. These measures would be made specific for the final design of the construction areas (to be determined during detailed design), and incorporated into a Soils and Water Management Sub-Plan. This Sub-Plan would be implemented before ground disturbance and updated as construction areas change.

Mitigation and management measures in the Sub-Plan would include (but are not limited to):

- erosion and sediment controls for each work area and each work stage, implemented prior to ground/soil disturbance and updated as work sites change
- stormwater runoff controls to avoid flow over exposed soils which may result in erosion, sedimentation and impacts to water quality
- communication and training (e.g. Project induction, pre-work briefings, tool-box talks) to Project personnel in managing water quality through erosion and sediment control measures.

5.4 Operation

5.4.1 Regional flooding

As the Project at operation lies outside the one per cent and five per cent AEP flood extents, no impacts to regional flooding are expected during the operational phase of the Project and accordingly no mitigation and management measures are recommended.

5.4.2 Local flooding and drainage

As described in Section 4.2.1, the Project has the potential to impact local flooding and drainage. Local drainage and flow rates would be affected by the inclusion of new impervious surfaces, such as the concourse roof and the new carpark area which would both affect drainage at Little Eveleigh Street. The drainage network along Little Eveleigh Street would be upgraded as part of the Project, which would account for the increase in runoff from the carpark and concourse roof. This upgrade would include the following measures (as presented in Appendix A):

- a 300 millimetre wide 'Heel Safe' trench grated drain either side of Little Eveleigh Street connecting to existing downstream stormwater systems
- regrading of the existing sag depression at Little Eveleigh Street.

Implementation of these design measures would eliminate nuisance ponding and issues with flow width conformances, and ensure that applicable Council design criteria is met.

Additional runoff from the proposed carpark can be minimised through the implementation of, stormwater treatment devices measures (e.g. infiltration/filter systems, storage facilities, alternative paving structures, and/or water sensitive urban design measures). The final type and size of these devices would be confirmed during detailed design, and would be designed so that the peak stormwater flow for rainfall events of up to a 1.5 year ARI event is not increased.

The risk from climate change of increased design rainfall events and changes to flood behaviour would also be accounted for in the design of the Project. Drainage upgrades would accommodate the one per cent AEP event plus a 10 per cent increase in rainfall intensity to account for climate change.

5.4.3 Water quality

The roof catchment area for the new concourse is proposed to discharge to kerb and gutter on Little Eveleigh Street. A treatment device is proposed to be installed as part of the concourse roofing system to treat and collect the initial low flow level which may have higher concentrations of air-deposited pollutants.

A stormwater treatment device would be designed and implemented to mitigate against increased pollutants from new impervious surfaces (e.g. the carpark). Water quality modelling would be undertaken during detailed design to confirm the type and size of treatment device required (e.g. bioretention basin/s).

5.5 Mitigation measures

The mitigation measures that would be implemented to address potential impacts relating to flooding, drainage and water quality are listed in Table 5.

Table 5 Mitigation measures

ID	Mitigation measure	Applicable location(s)
Construction		
SW1	Install necessary temporary drainage or drainage diversions so that stormwater function is not impeded during construction.	Project area
SW2	Stockpiles and storage areas would be located outside of the five per cent AEP flood extent and ideally outside of the one per cent AEP flood extent where possible, particularly any loose materials with the potential to wash away.	Ancillary facility 1
SW3	Works would cease in flood prone areas when a severe weather warning is issued for the immediate area, and work sites would be secured accordingly.	Project area
SW4	A Soils and Water Management Sub-Plan would be developed to manage the water and soil issues relevant to the construction of the Project. This sub-plan would be part of the CEMP. The sub-plan would include detailed water, erosion and sediment control plans based on the final design of each work site and would outline which control measures would be implemented at each location or for specific works. These control measures would align with the management approaches outlined in *Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom, 2004), *Managing Urban Stormwater: Soils and Construction Volume 2A* (DECC, 2008) (referred to as the Blue Book), the *Water Discharge and Reuse Guideline (TfNSW, 2015a), Concrete Washout Guideline* (TfNSW, 2015b), *Water Sensitive Urban Design Guideline* (TfNSW, 2017) and *Chemical Storage and Spill Response Guideline* (TfNSW, 2015c).	Project area
SW5	Undertake consultation with City of Sydney Council and/ or Sydney Water (as relevant) prior to connecting to existing stormwater drainage system/s.	Project area

ID	Mitigation measure	Applicable location(s)
Operation		
SW6	Install a 300 millimetre wide 'Heel Safe' trench grated drain either side of Little Eveleigh Street connecting to existing downstream stormwater drainage systems.	Little Eveleigh Street
SW7	Regrade the local sag depression at Little Eveleigh Street.	Little Eveleigh Street
SW8	A treatment device would be installed to treat the first flush of rainfall from the concourse.	New concourse
SW9	Stormwater treatment device/s / water sensitive urban design feature/s would be installed in or near the new carpark at Little Eveleigh Street (which may include a vegetated bioretention basin or similar).	At or near proposed carpark, Little Eveleigh Street

6.0 Conclusion

A flooding, hydrology and water quality assessment was carried out for the Project.

The assessment drew on a desktop review of available drainage, flooding and water quality information. The Project is located in a highly urbanised environment that is altered from its natural state and water quality is typical of that for urban catchments in Sydney.

Under existing conditions, the Project area is subject to flooding between the station's tracks and within the proposed location of construction ancillary facility 1, as well as some exceedances in flow widths along Little Eveleigh Street (which is expected to receive additional flow from the proposed concourse roof). Water quality within the receiving waters of Blackwattle Bay and Alexandra Canal are considered to be poor.

Key construction stage impacts include:

- the potential for increased sediments being discharged to downstream waterway systems as a result of construction activities
- flooding and overland flow issues caused by the presence of construction worksites and compounds on flood liable land.

Construction impacts would be managed through the implementation of measures in accordance with the Blue Book. Additionally, detailed planning and management of construction sites is recommended to avoid impacting overland flow paths without appropriate mitigation.

In the operational stage, drainage measures incorporated into the design are predicted to provide effective mitigation of local flood impacts. Water quality impacts would be managed through a treatment system proposed for roof runoff and stormwater quality treatment devices for the proposed carpark.

7.0 References

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WMAwater, 2018, *Alexandra Canal Flood Study Model Update*

Appendix A

Drainage assessment

1 BACKGROUND

The site is located south of Lawson Street between the intersection of Lawson Street/Gibbons Street and Lawson Street/Little Eveleigh Street, Refer to **Figure 1** for site plan view.

The primary works are proposed to take place within Redfern Train Station and surrounding streets. The proposed works consist of a new pedestrian footway bridge/concourse extending from the eastern side to the western side of the station across all overground platforms. This pedestrian bridge crossing will connect Marian Street with Little Eveleigh Street allowing pedestrian to access platforms from either side.

Additional civil works would also be taking place on Little Eveleigh Street as a part of the overall project works, namely road resurfacing work, redesignation of the street as a shared zone and addressing existing drainage, flooding and stormwater surface runoff issues.

The Novo Rail Alliance has been engaged by Transport for New South Wales (TfNSW) to carry the project design and construction through the TfNSW and Sydney Trains approval process and ultimately construct the works. The works are also subject to planning approval and as part of both the planning approval and design process, a Stormwater Drainage Impact assessment outlining flood issues is required. This memorandum acts as this document.

The intent of this memorandum can be summarised as the production of a flow rate comparison between the pre-development and post development site and an assessment of surface water quality management issues by addressing any water quality comparison between pre-and post-development and the application of water quality treatment procedures if required.

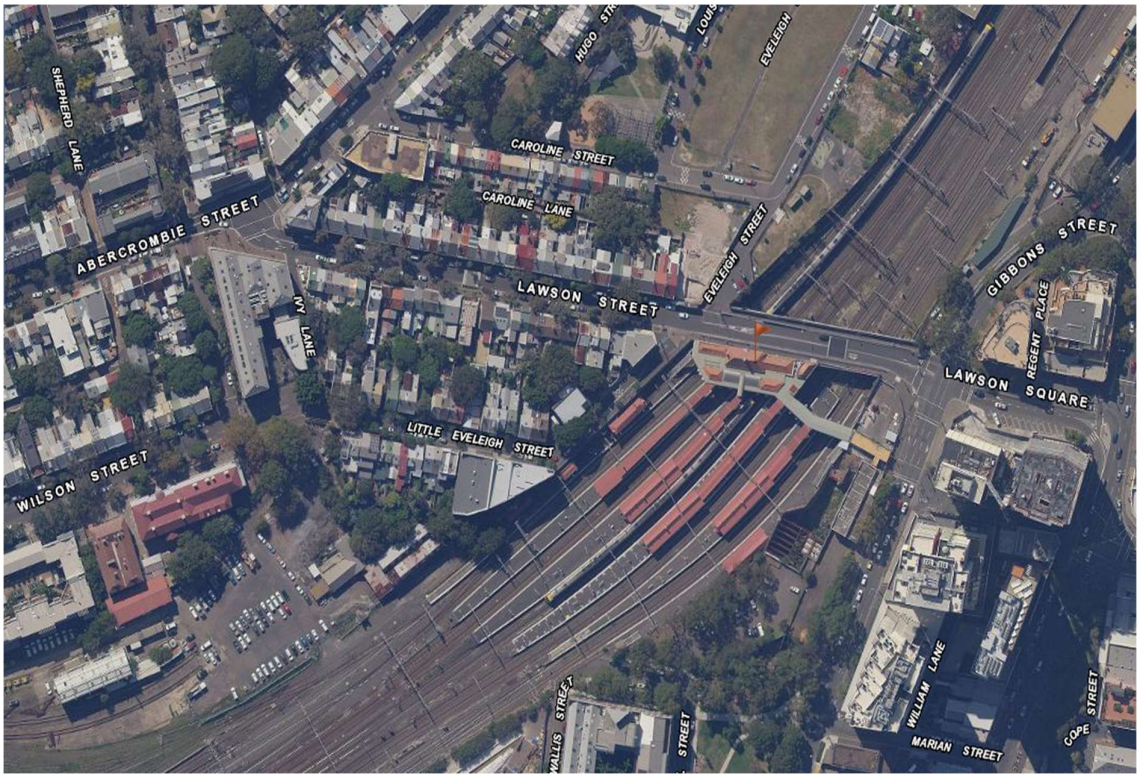


Figure 1– Aerial photography image of site location

2 Design Input

2.1 Available Data

The following data was used for this study:

- Alexandra Canal Floodplain Risk Management Study and Plan by Cardno (2014) for City of Sydney;
- Blackwattle Bay Catchment Floodplain Risk Management Plan by WMA (2015) Water for City of Sydney;
- Accessible topographic information (LiDAR data) sourced from Land and Property Information (2013)
- AR&R 2016 (Annual Rainfall & Runoff)
- BOM 2016 – Bureau of Meteorology – Design Rainfall Data System (2016)
- City of Sydney – Development Control Plan 2012, A4 Stormwater Drainage,
- AS/NZS 3500.3:2018 Plumbing and Drainage, Part 3: Stormwater Drainage
- Detailed Site Survey (DSS) from Aurecon (July, 2019)

2.2 City of Sydney Design Criteria

From City of Sydney's design criteria for overland flow along a shared zone, the following requirements must be met:

Table 2-1 100yr ARI Overland Flow Limits for Pedestrian and Shared Zones

100yr ARI Overland Flow Limits for Pedestrian and Shared Zones	
Criteria	Limit
Maximum Depth	50mm
Maximum flow width	1.5m
Maximum depth x velocity	$0.4m^2/s$

Table 2-2 Pit Design Blockage Factors

Pit Type	**On Grade Blockage Factor**	**Sag Blockage Factor**
Kerb Inlet <= 1.0m	50%	70%
Kerb Inlet >1.0m	20%	50%
V grate or Grate Only	90%	90%
Strip Drain or Other	95%	95%

2.3 Assumptions:

- Assumed that the existing surrounding stormwater network has a usable condition and capacity for reconfiguration of Little Eveleigh Street.

- Localised sag depression exists along Little Eveleigh Street, and that localised regrading is achievable within the roadway constraints.
- No shallow utilities exist within the proposed stormwater drainage network.
- The existing raised threshold remains for Little Eveleigh Street.
- The information provided in the flood studies are accurate

2.4 Requested Design information

Transport NSW have engaged AECOM to prepare an Environmental Impact Statement (EIS). For the development of an EIS statement, the following information is required:

- Flow rates for the existing site conditions
- Flow rates for the proposed site conditions
- Impact of the proposed works downstream (scour/inundation) via providing a range of events (PMF, ARI 100 and other representative events)
- Flood impacts
- Catchments flow into the existing drainage network
- The level of imperviousness of the surfaces in these catchments
- Any water quality treatments the design may require

3 Hydrology and Flood Assessment

A desktop assessment of the potential flood risk to the proposed works area was prepared based on reports obtained from Sydney City Council's database. These reports are based on a flood study prepared for:

- Alexandra Canal Catchment (**Alexandra Canal Flood Study**) prepared by Cardno
- Blackwattle Bay Catchment (**Blackwattle Bay Catchment Flood Study**) prepared by WMA water

The flood risk was identified for the 1% AEP (Annual Exceedance Probability) and PMF flood events.

The information in Section 2.1 was reviewed to identify flood risk at the regional and local scale, with the findings presented in the following sections. This assessment is limited to available information and does not take into consideration the impact of climate change. A more detailed assessment at the next design stage is recommended to confirm the flood risk and impacts local to the project area.

3.1 Regional flooding

The flood risk was initially reviewed at a regional scale. The Alexandra Canal Floodplain Risk Management Study and Plan (Cardno 2014) does not cover Redfern Station, falling just outside of the study area **Figure 2.**

Figure 2 Alexandra Canal Flood Study Area (Cardno 2014)

The Blackwattle Bay Catchment Floodplain Risk Management Plan (WMA 2015) does cover Redfern train station. The station is situated along the edge of the study area indicating that it is closer to the catchment edge. The 1% AEP design flood mapping extracted from the study report is shown **Figure 3** below.

Some localised ponding is observed across the station area along the train tracks. A closer review of the modelling undertaken as part of the Blackwattle Bay Catchment Floodplain Risk Management Plan (WMA 2015) is recommended at the next design stage to confirm the extent of the localised ponding observed against proposed sensitive infrastructure.

Figure 3 Blackwattle Bay 1% AEP design flood extend mapping (WMA 2015, *no better quality imagery is available*)

3.2 Local flooding

The flood risk was also reviewed from a local perspective using LiDAR data captured in 2013. This data was used to identify key topographical features such as likely overland flow paths and sag points around the project area.

The following observations were made based on the local topography shown in the Figure 4 below.

a) The station is not located across an overland flow path.
b) Local topography is shown to slope away from the station.
c) The station is located in a cutting.

The station is located below surrounding surface levels which could potentially result in localised ponding during flood events greater than the track drainage capacity. This flood behaviour is exhibited in the regional flood assessment showing ponded flood water between the station platforms.

The topography surrounding the station slopes away from the station. This indicates that local overland flooding would unlikely impact on pedestrian access points or on vulnerable infrastructure. A closer review of the local flood and drainage risk against proposed finished levels of sensitive infrastructure is recommended in the next design stage.

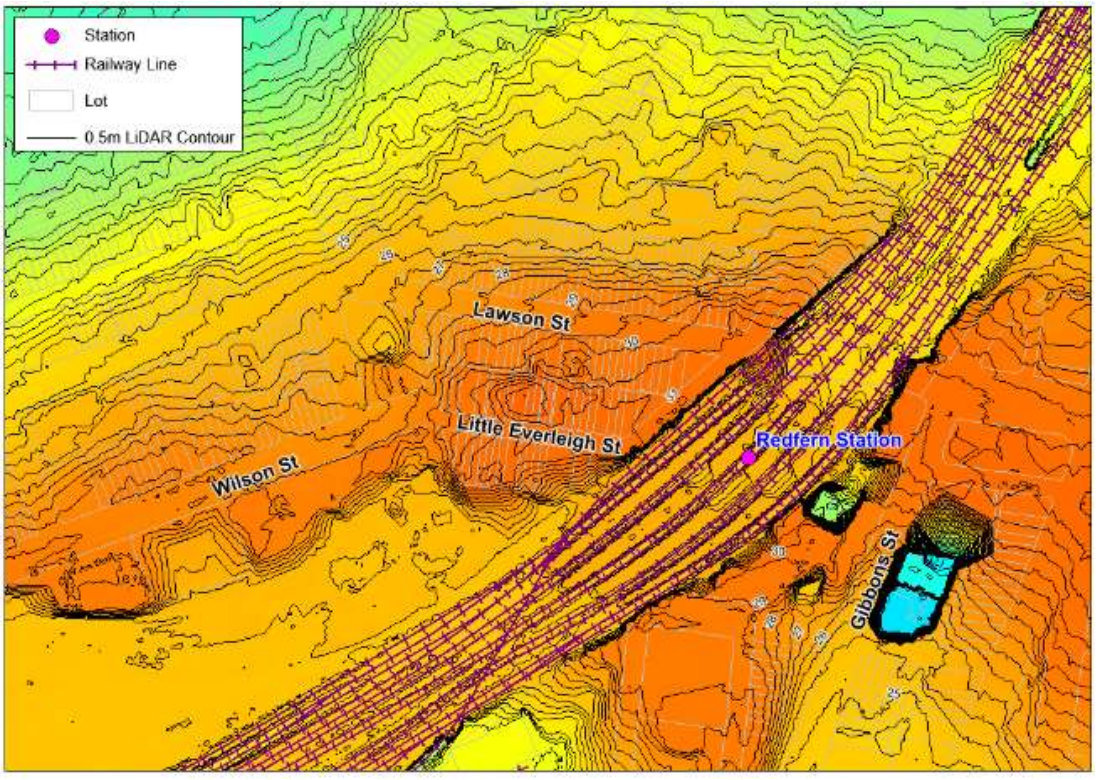


Figure 4 Topographical map of Redfern Station locality

3.3 Little Eveleigh Street

3.3.1 Catchment Delineation

Overall topography within the Little Eveleigh Street is relatively flat with an approximate South North grade of less than 1%. A minor rise appears to be present towards the centroid of Little Eveleigh Street particularly in front of properties 135 & 137 Little Eveleigh Street at the location of a traffic calming device, a raised threshold, refer to **Figure 1** & **Figure 5**.

Right of the raised threshold, towards Redfern Station, the surface slopes at 0.7% with a depression from RL 31.522 to RL 30.61 over 138.1 meters (approximately). Left of the raised threshold, away from Redfern Station towards Ivy Lane, the surface slopes at 4.1% with a depression from RL 31.522 to RL 26.824 over 114.1 meters (approximately).

To assist further with flooding data, a Stormwater run-off assessment was conducted using DRAINS modelling. The focus in this modelling was on the pre and post development flow rates and any adverse effects the post development proposal might cause.

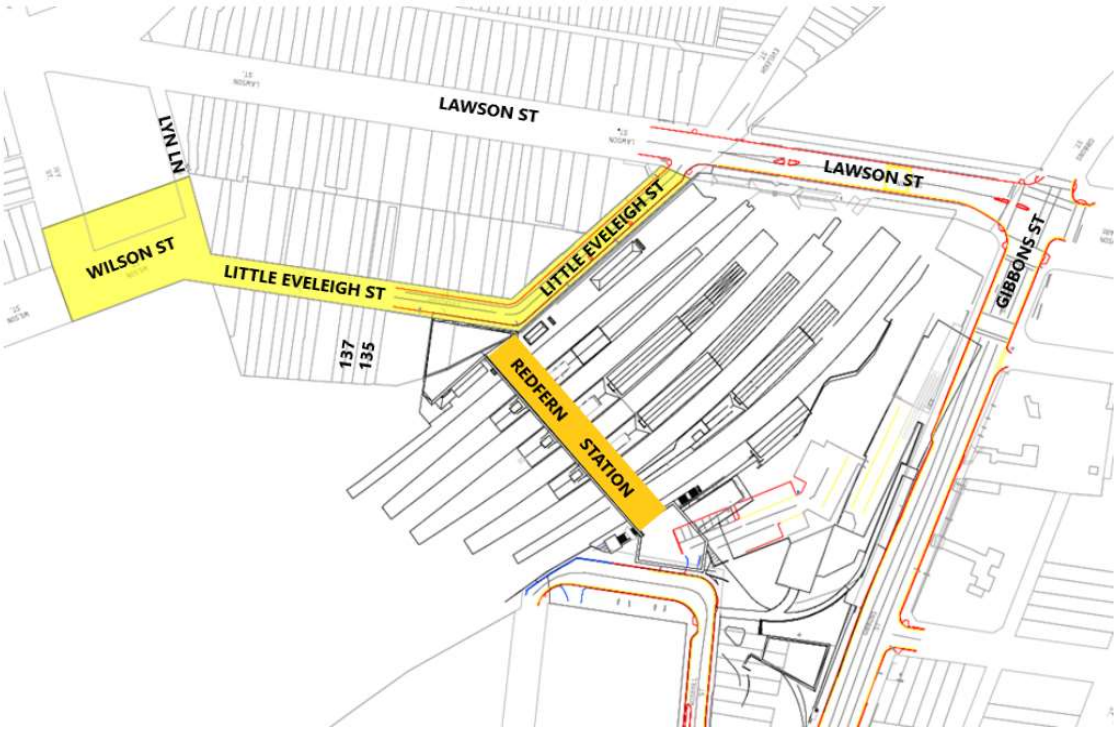


Figure 5 Location of proposed works.

3.3.2 Pre-& Post development Flow Assessment

Drains modelling assessment was conducted illustrating the difference in flow rates between the existing site conditions and the proposed.
Total site area assessed is 8762m2 extending for the full length of Little Eveleigh street.
Approximately 90% of this area is impervious divided upon roads, pavements and roof area.
The remaining 10% consist of pervious surface mainly grass within residential properties.

This catchment area has been divided by a crest created by a raised threshold on Little Eveleigh Street in front of properties 135 & 137, creating opposite directional flow. One section of the road directs Stormwater runoff to the intersection of Lawson street and Eveleigh Street and the other section directs Stormwater runoff to the intersection of Lawson Street and Abercrombie Street, refer to **Figure 5**.

For the proposed development's DRAINS model, no major changes have been considered in comparison to the pre-development. An additional catchment area of 700sqm has been added for the pedestrian footway bridge discharging into a 5m3 storage tank with an overflow discharging to the kerb and gutter at Little Eveleigh Street. The existing drainage has been redesigned adopting a 50% blockage factor through all existing pits, in accordance with Sydney City Council regulations, refer to **Table 2-1**.

By adopting a blockage factor of **0.5 (50%),** the excess flow has been directed to overland flow paths, in this case Little Eveleigh Street.

The additional impervious area introduced to the railway will not add to the adversity of the existing ponding created by severe storms. On the contrary, it will reduce the amount of ponding by rainwater being collected in gutters and directed onto little Eveleigh Street away from the ponding area via a rainwater tank system.

Pre and post development flow rates have been tabulated below:

Table 3-1 Flow Rate Comparison – Pre-& Post Development

Name	**Max Pre Development Flow Q (cu.m/s)**	**Max Post Development Flow Q (cu.m/s)**
CATCHMENT 1	0.288	0.288
CATCHMENT 2	0.326	0.370
TOTAL Q (cu.m/s)	**0.614**	**0.658**

Flow rates for pre and post development are shown in **Table 3-1.** The total flow rate for the pre-development site is ***0.614 cu.m/s*** and the total for the post development is ***0.658 cu.m/s.*** The 6.7% increase in flow rates is due to the additional pedestrian footway bridge which contributed to an additional ***0.044 cu.m/s.***
For the post development catchment, it has been assumed that the pedestrian footway bridge is entirely discharging onto Little Eveleigh Street. Refer to **Figure 5 & Figure 6.**

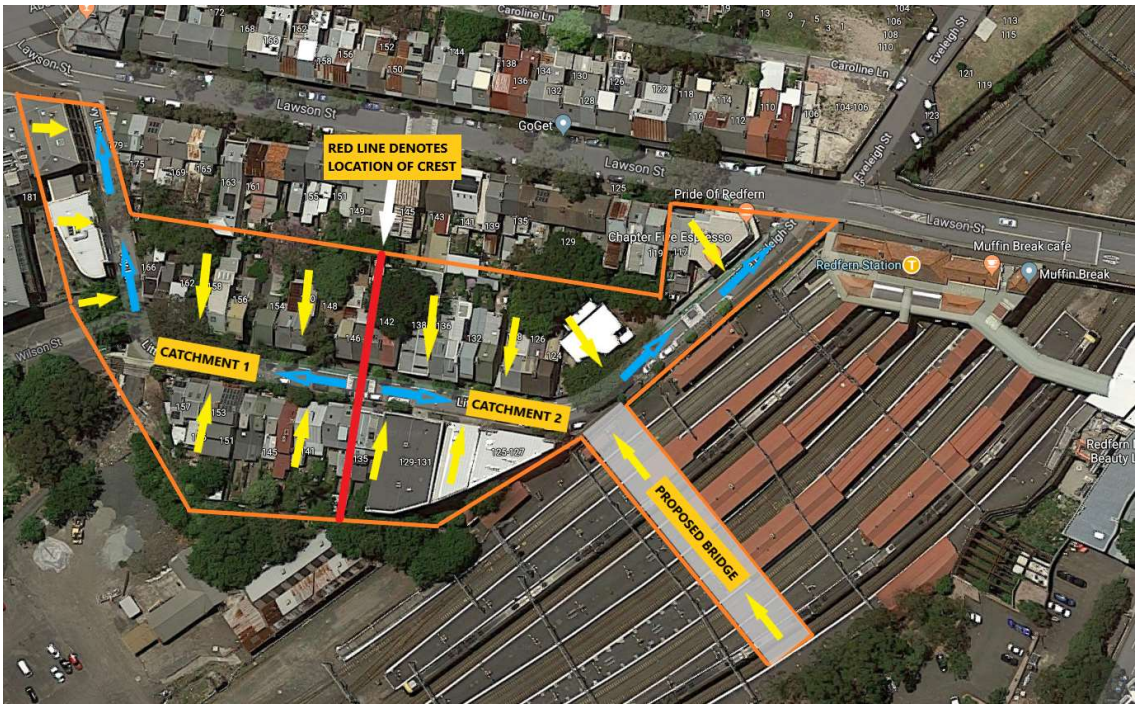


Figure 6 – Catchment area

Figure 6 above, present the DRAINS modelling catchment study area (8762sqm). The orange line denotes the catchment perimeter, the red line denotes the crest that divides the catchment area in two and the shown arrows denote the path of overland flow.
Maximum *depth x velocity* and maximum flow width for pre and post development have been tabulated below.

Table 3-2 – Max (DxV) and Max flow width

100 YR ARI	Maximum DxV (m^2 /s)	Max Flow width (m)
Catchment 1 - Pre	0.23	3.39
Catchment 1 - Post	0.23	3.31
Catchment 2 - Pre	0.12	3.79
Catchment 2 - Post	0.12	5.77

Comparing the results in **Table 3-2** with council requirements **Table 2-1,** the maximum *depth x velocity* for both catchments are below 0.4m^2/s as per council standards. On the contrary, the maximum flow width exceeds 1.5m, the allocated requirement for maximum flow width in council's standards.

3.4 Little Eveleigh Street Local Drainage Network Proposal

To restrict the flow width to 1.5m as stated in council's standards, the following solution has been proposed, **Figure 7:**

- 300mm WIDE 'HEEL SAFE' TRENCH GRATES,

- Either side of Little Eveleigh Street to have trench grates with 'heel safe' covers, conveyance as indicated on the attached indicative typical trench grate detail, (note: **modified SM kerb, NOT the specified kerb detail**),
- Minimum of 0.5% grade for the trench pit run,
- Total length of trench grating for Little Eveleigh Street: Approx. 455m total

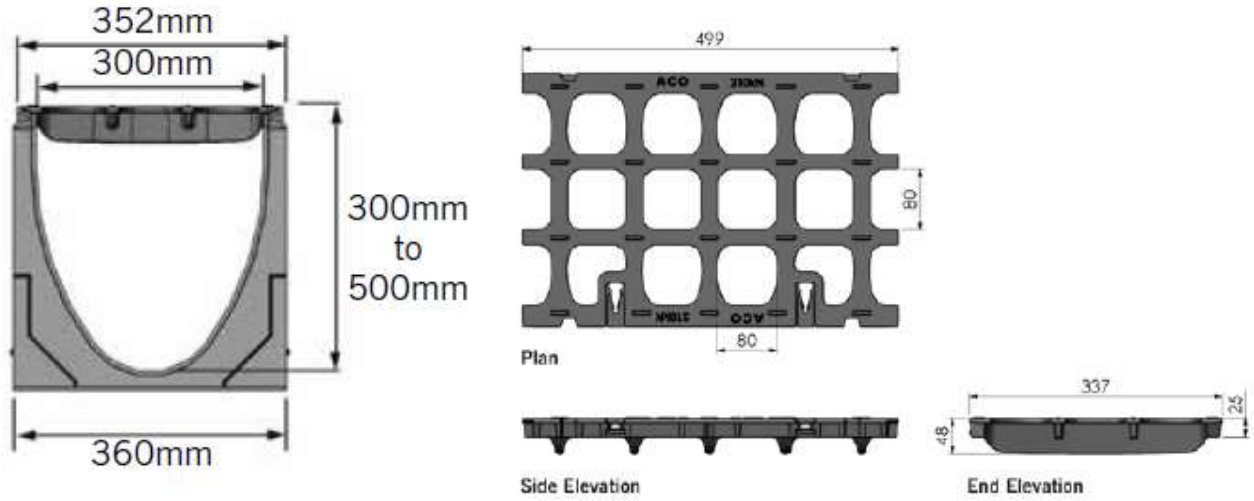


Figure 7: Indicative typical trench grate detail

- Stormwater Conveyance System
  - Capture of surface flows from little Eveleigh street by trench grates will be carried through underground stormwater network/s, either RCP or FRC, or other approved equivalent pipe material,
  - For crossing Little Eveleigh Street at the South Eastern side of Regent Plaza, it is proposed to install a buried drainage pipe crossing to convey trench grate catchment to Ivy Lane,
  - Total length of pipe network required for Little Eveleigh Street: Approx. 25m total.
- Utilization of Existing Stormwater Connection Discharge Points
  - Existing local stormwater networks are currently conveying little Eveleigh street to the greater local council drainage network at the points indicated on the attached indicative stormwater network plan, it is proposed to utilize the existing stormwater drainage network to continue to convey the flows from little Eveleigh street.

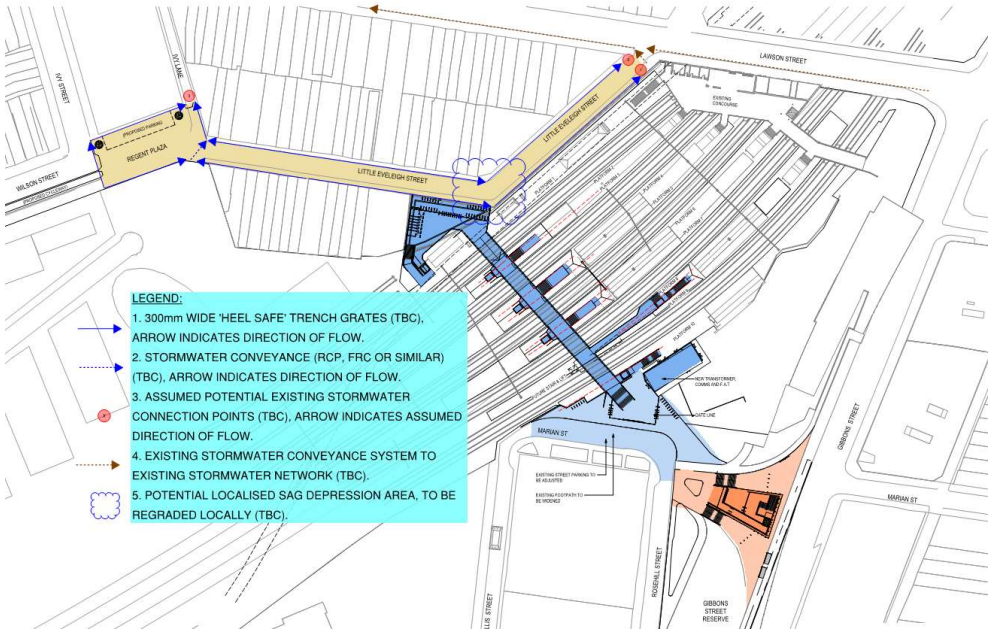


Figure 8 - Indicative stormwater network plan

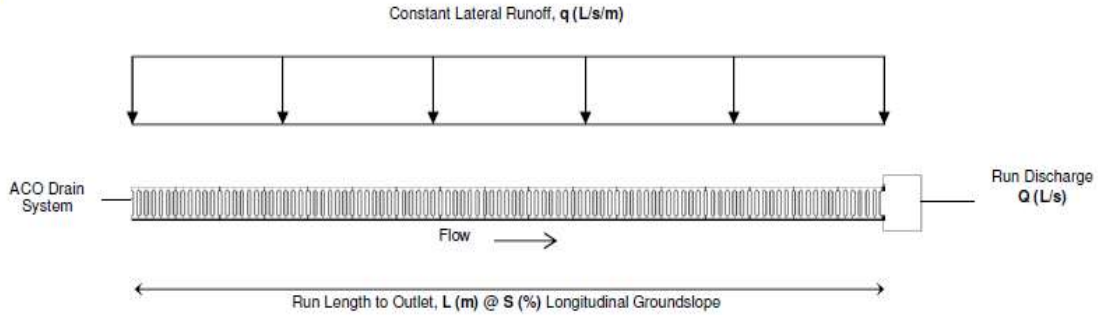
- Regrading Potential Local Sag Depression

    - There is a localised sag depression storage area along Little Eveleigh Street, it's proposed to regrade this area locally to remove the sag depression to mitigate nuisance ponding and issues with flow depth conformances. A road design will be completed aiming to introduce a new grade to the road surface eliminating the existing sag point and any water ponding, refer to **Figure 8**.
    - Moreover, further to the proposed surface regrade of Little Eveleigh Street as a solution to the existing flooding issue, a proposition has been made of introducing grated trench drains for the entire length of the affected site, refer to **Figure 7 & Figure 8** for further details.
    - Analysis were conducted on the proposed 300 x 300 trench drain with Heel Safe Anti-Slip grate. The proposed grate was sufficient enough to withstand the capacity of a 1%AEP with a maximum ponding width of 1.09m, refer to Figure 11, for further details.

Project Name: Nova Rail, Redfern Station

Design File No.: NSW/19/132 Rev. 2

Data & Results Table and Runoff Scenario



Channel Data:

Expected Load Class (kN): D (210kN)

Rainfall Data:

Design Storm, ARI (years):	N/A
Rainfall Intensity, I (mm/hr):	N/A
Duration, T_c (min):	N/A

Catchment Data:

Catchment Surface Type:	Asphalt
Catchment Slope (%):	3
Runoff Coefficient, C:	1

Data: Recommendation: Channel Results:

Run Identity	Run Length to Outlet L (m)	Longitudinal Groundslope S (%)	Catchment		Recommended ACO Drain			Internal Width (mm)	Invert Depth (mm)	Constant Lateral Runoff q (L/s/m)	Run Discharge Q (L/s)	Minimum Freeboard (mm)	Drain Capacity Utilised (%)
			Area A (m²)	Flow (L/s)	System	Channels	Grate						
Run 1	140	1	N/A	185	TraffikDrain TD300 Sloped	20m of TD3-1 to TD3-20 sloped channel, 120m of TD3-020 neutral cahnnel	TD300 Iron HiFlo	300	300 - 400	1.321	185	-53	**120**

Notes:

- At 100% Trench Capacity, the channel is running full.
- Hydraulic "HYDRO" Plots have been provided.
- Trench Capacity is defined as the flow rate when liquid at any point along the run reaches the underside of the grate.
- Minimum Freeboard is measured from the underside of the grate to the liquid level.
- TD300 Iron HiFlo grates have a depth of 48mm.

Figure 9 – ACO Trench Drain Details

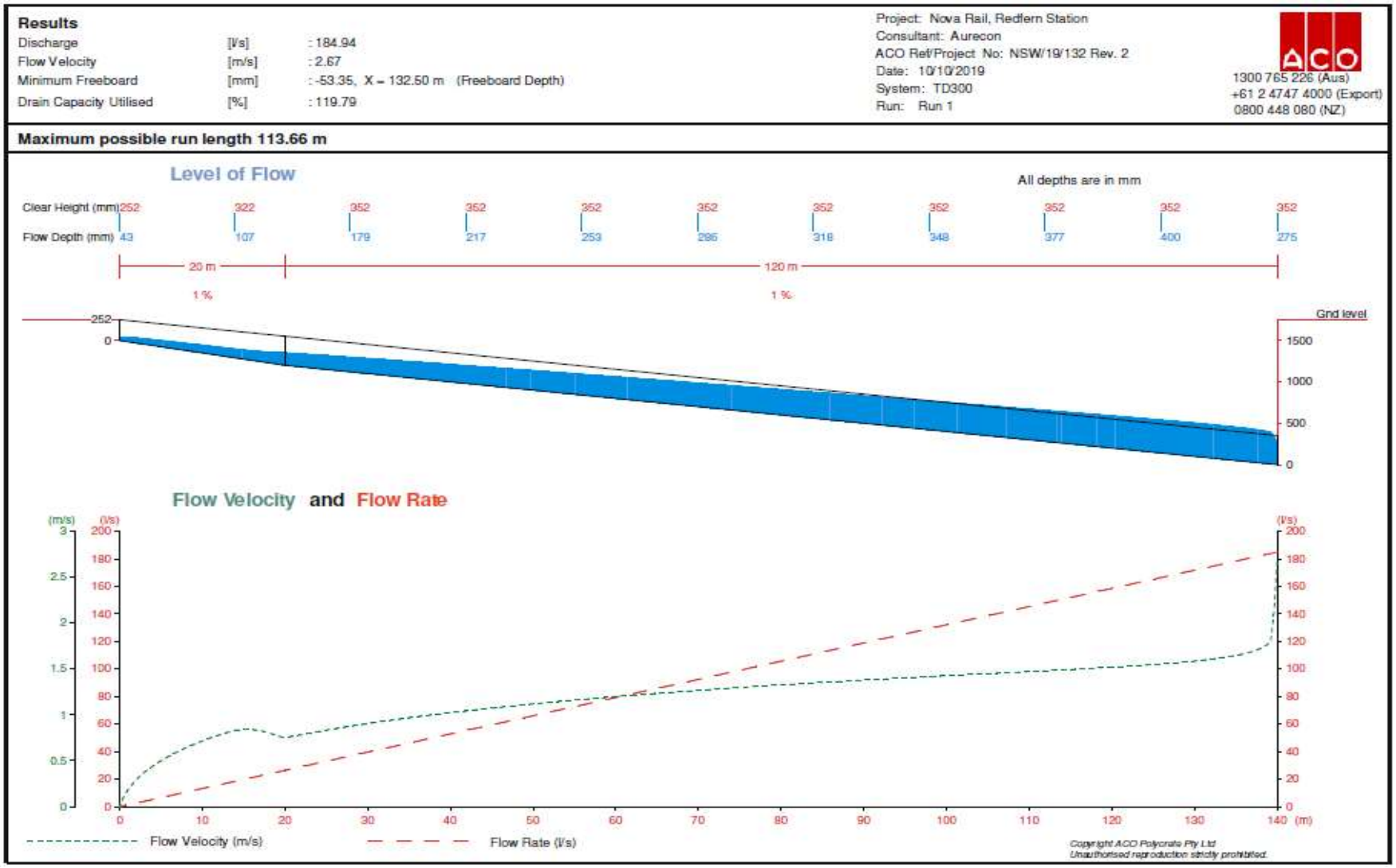


Figure 10 – ACO Trench Drain Long Section

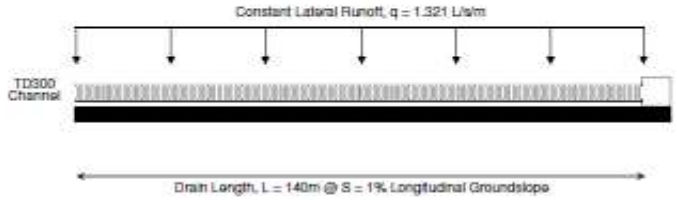
Ponding Analysis

Based on the results from
ACO's 'Hydro' hydraulic design program

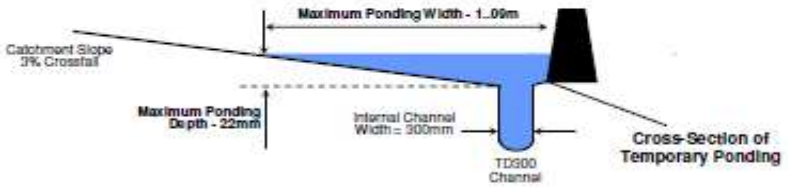
PROJECT: Nova Rail, Redfern Station
Contact: Samir Hakim
Company: Aurecon

Tel. No: 0450 777 787
Fax No: -
email: Samir.Hakim@aurecongroup.com

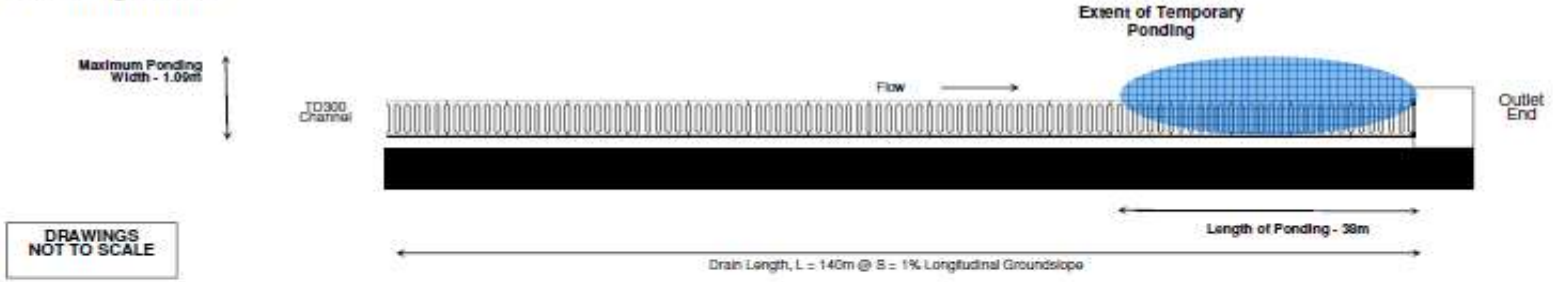
Runoff Scenario



Catchment Geometry (Cross Section)



Ponding Map



General Information

Date: 3009/19 **ACO Contact:** Luke Ricketts **Ref. No:** NSW/19/132 Rev. 2

Note: 1. The hydraulics of the ACO Drain System were calculated based on the assumed Runoff Scenario above.
2. The extent of ponding, depth and width, were determined from the Catchment Geometry (Cross-Section).

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Figure 11- ACO Trench Drain Cross Section

3.5 Surface Water Quality

Due to the constraint of available space and the drainage levels to tie into the existing system, it is impractical to provide water quality control measures to the proposed works. However, the proposed works have minimal increases of impervious areas and therefore there will be little impact to the water quality, compared to the existing condition. Since the roof catchment area of the pedestrian footway bridge is proposed to discharge to kerb and gutter on Little Eveleigh Street, a first flush system would be installed on the roofing system to collect the first flush of rainfall, also known as the initial low flow level which is concentrated in pollutants.

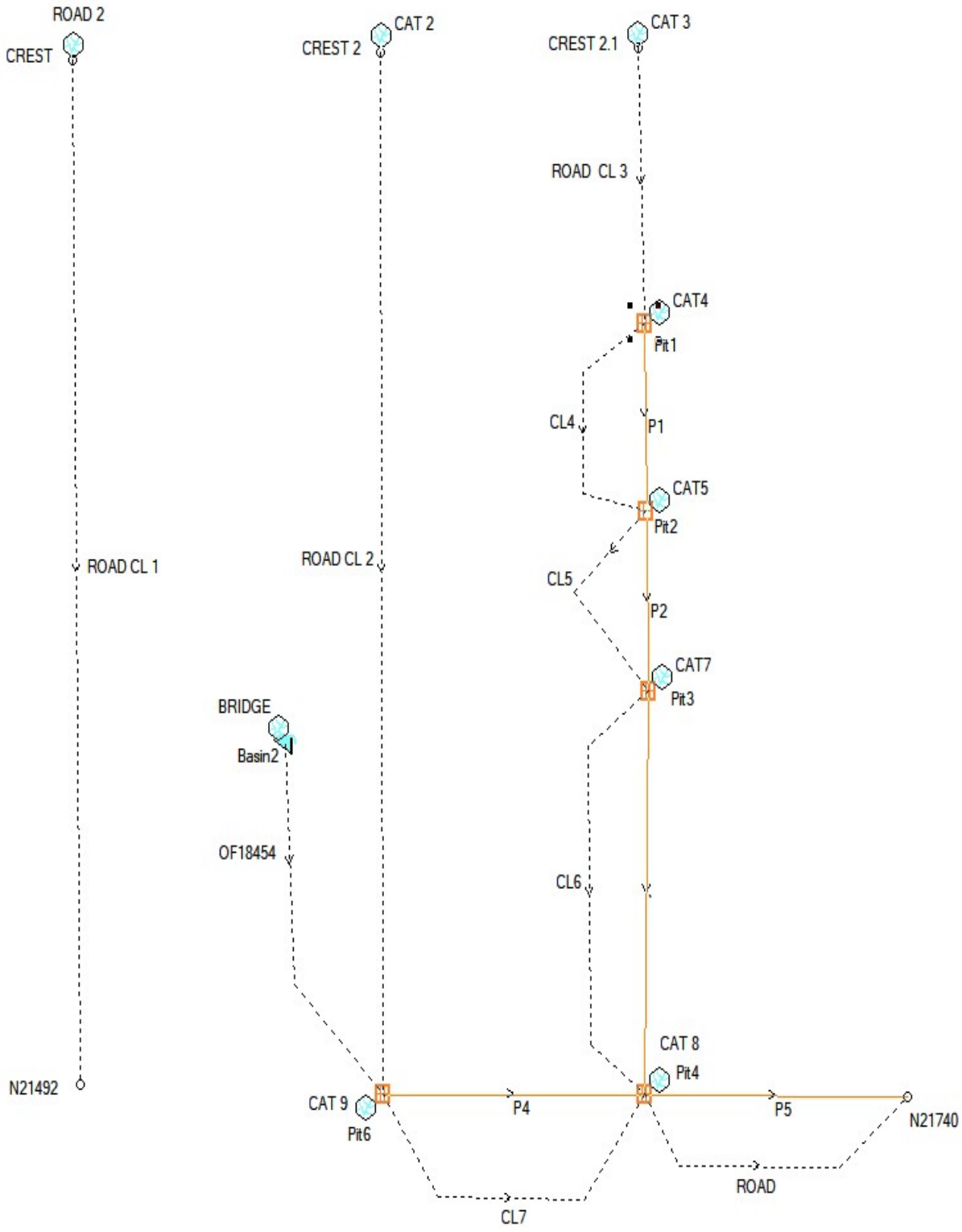
3.6 Rail Track Drainage

Noting that the roof catchment area of the pedestrian footway bridge is proposed to discharge to kerb and gutter on Little Eveleigh Street the only catchment entering the station from the new construction will be the canopies over the new platform stairs, which will discharge onto the platforms below, and in turn into the track drainage.

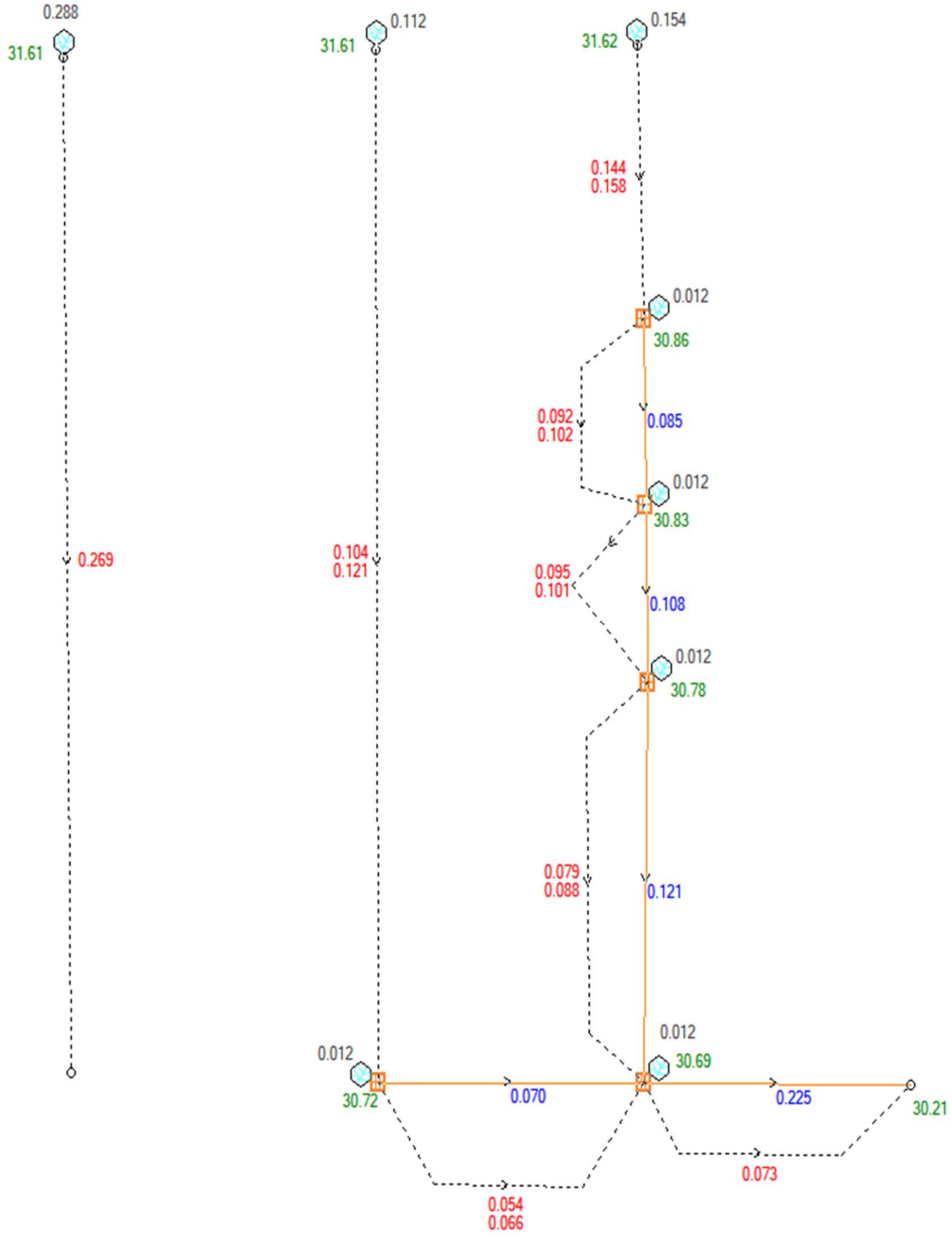
The removal of the concours bridge roof flows from this results in an overall reduction in catchment area contributing to the rail track drainage, and the impact of the canopy drainage connections are therefore considered negligible. The exact configuration of drainage outlets will be developed at the detailed design stage for the works.

Appendix 1 Drains Model Outputs

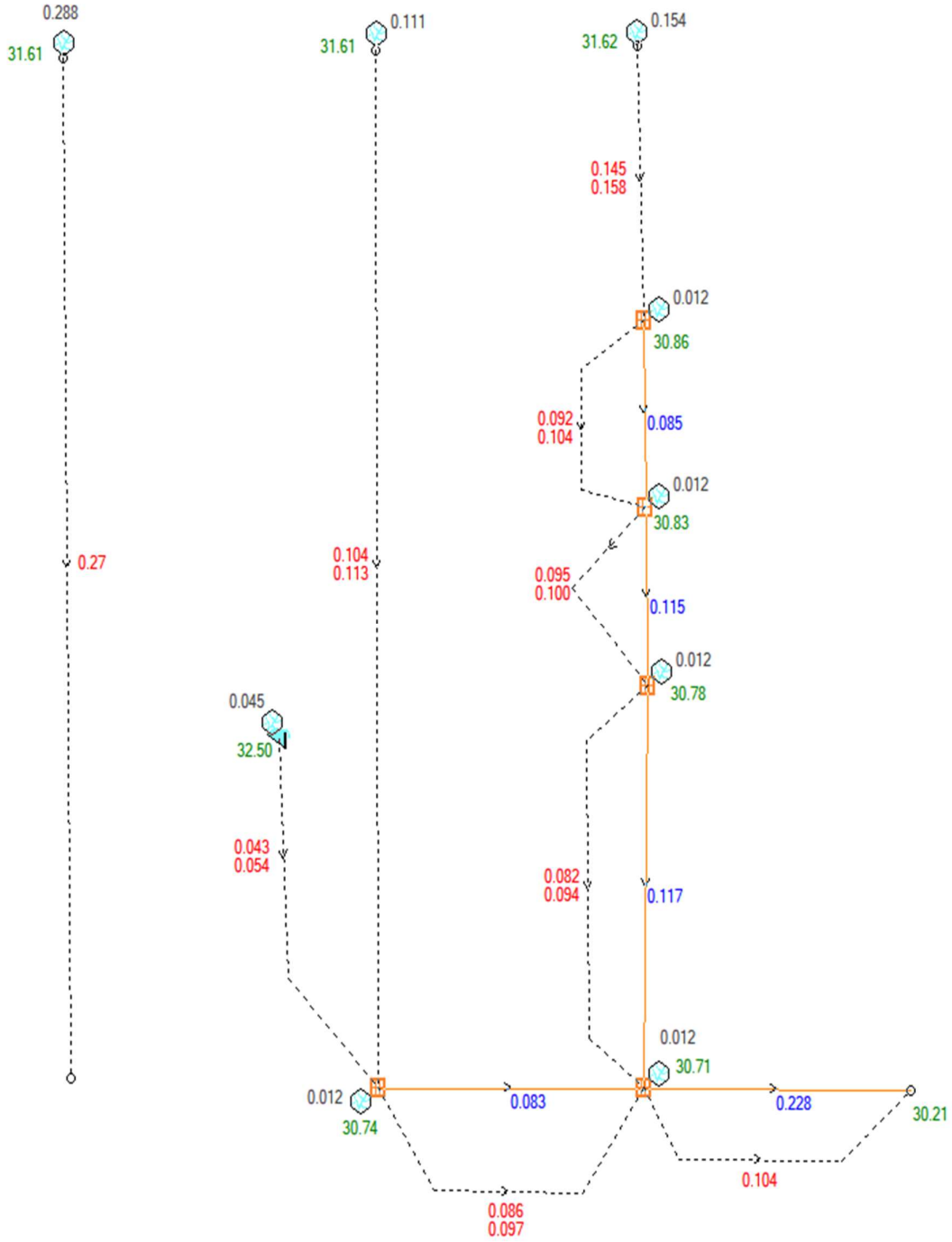
1. DRAINS MODEL LAYOUT FOR POST DEVELOPMENT



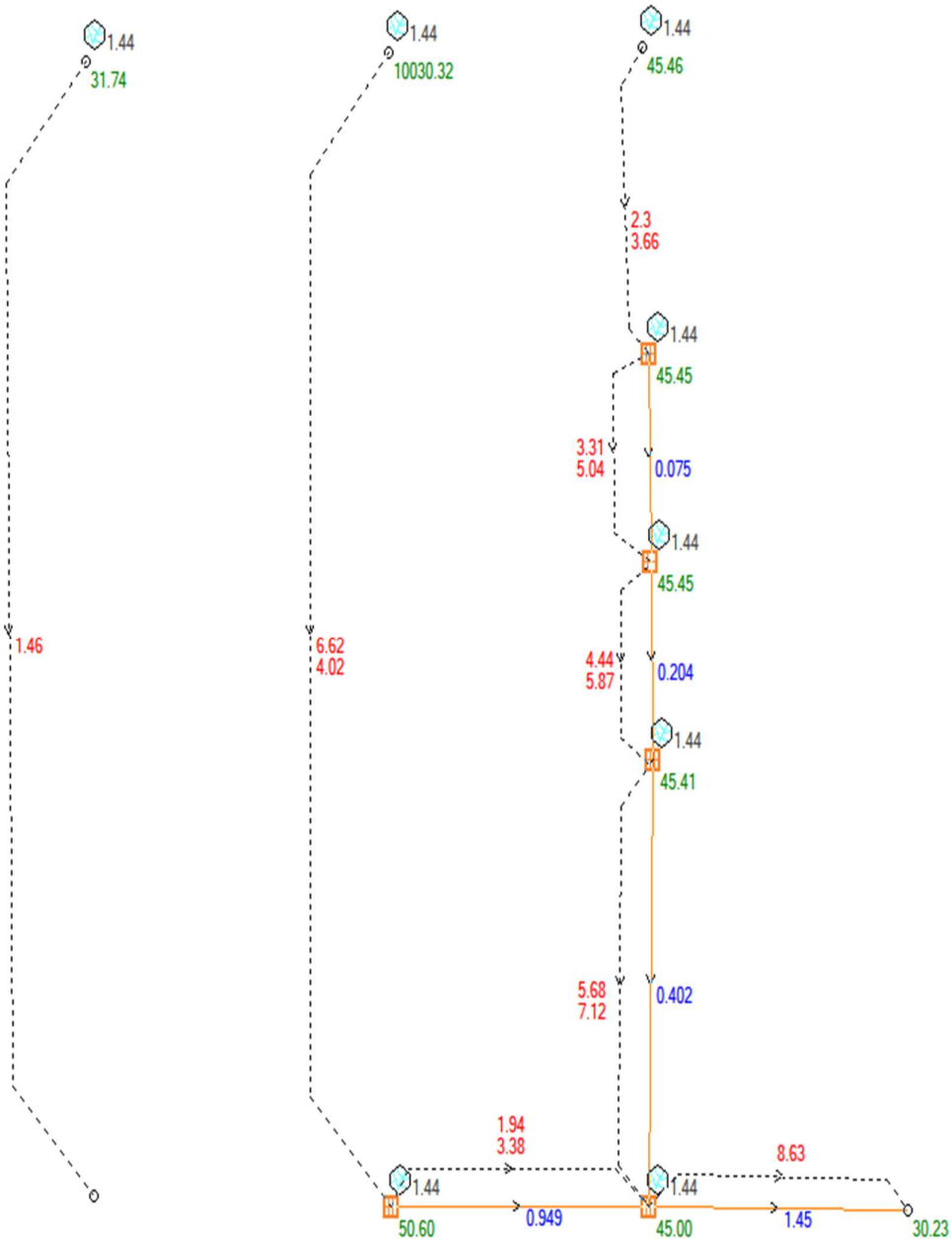
2. DRAINS MODEL 100YR ARI RESULTS FOR PRE-DEVELOPMENT



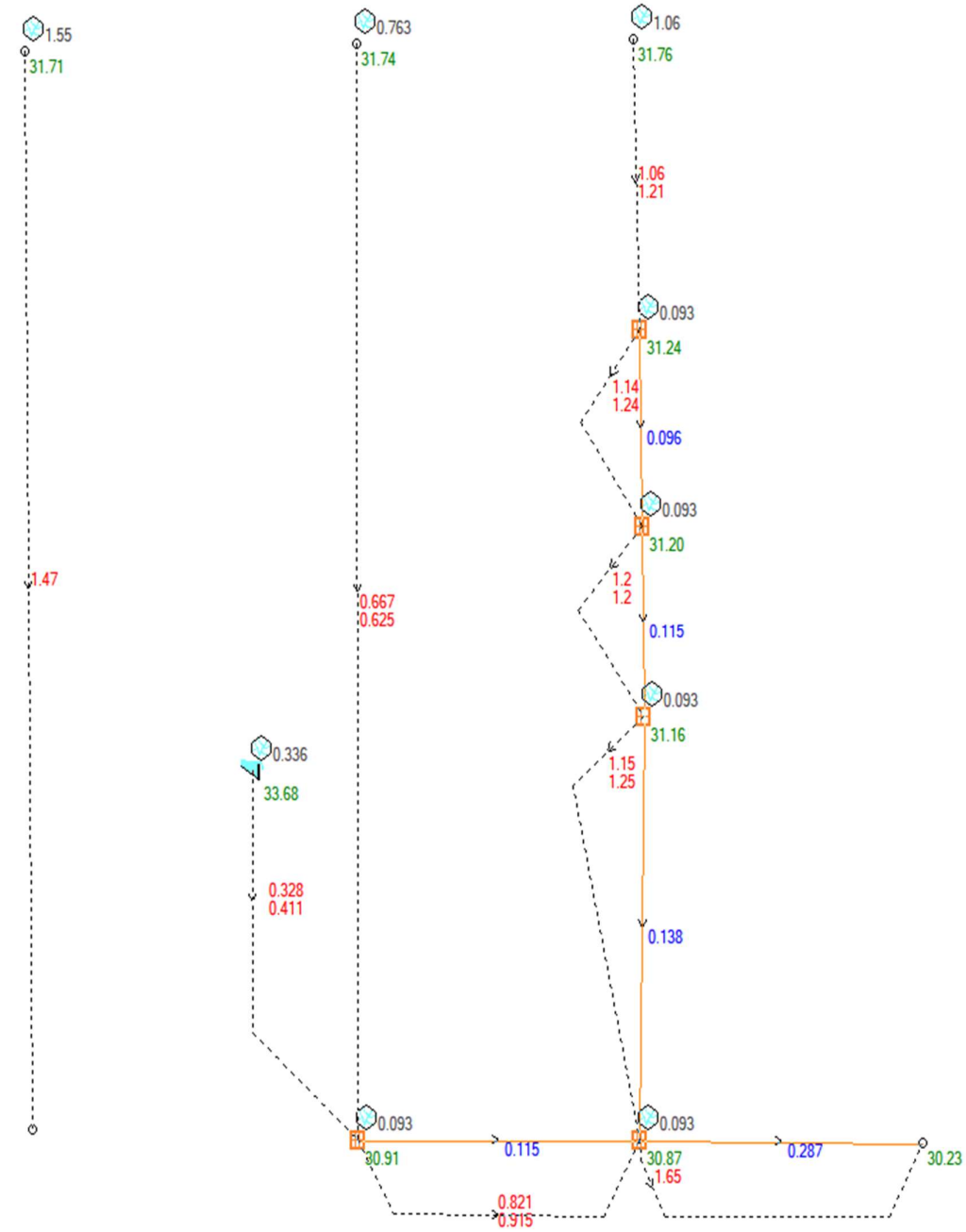
3. DRAINS MODEL 100YR ARI RESULTS FOR POST DEVELOPMENT



4. DRAINS MODEL PMP RESULTS FOR PRE-DEVELOPMENT



5. DRAINS MODEL PMP RESULTS FOR POST DEVELOPMENT


1.55
31.71
1.47
0.763
31.74
0.667
0.625
1.06
31.76
1.06
1.21
0.093
31.24
1.14
1.24
0.096
0.093
31.20
1.2
1.2
0.115
0.093
31.16
1.15
1.25
0.138
0.336
33.68
0.328
0.411
0.093
30.91
0.115
0.093
30.87
1.65
0.287
30.23
0.821
0.915

Appendix B

Water quality monitoring summary

Appendix B Water quality monitoring summary

Table 6 Rozelle Bay surface water quality monitoring summary

Parameter		Guideline criteria	M4 M5 Rozelle Bay monitoring[5] tidal			The Bays monitoring tidal		
	Units	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med[6]
Dissolved Oxygen	mg/L	-	-0.16	66.2	5.6	64	89	85
EC	µS/cm	-	402.9	51100	46630.5	47788	51981	50859
pH		7 – 8.53	5.65	7.96	7.61	7.69	8.14	8.02
Turbidity	NTU	0.5-10	-1.4	15.0	2.35	0.20	3.40	1.40
Total suspended solids	mg/L	-	-	-	-	2.30	11.15	4.40
Arsenic	mg/L	-	-	-	0.005	0.0015	0.0019	0.0018
Cadmium	mg/L	0.0055	-	0.0018	0.0005	-	-	-
Chromium (III+VI)	mg/L	0.0044[7]	-	-	0.005	0.0005	0.0005	0.0005
Copper	mg/L	0.0013	0.002	0.015	0.005	0.0016	0.0052	0.0028
Iron	mg/L	-	0.027	0.67	0.23	0.0025	0.0094	0.0037
Lead	mg/L	0.0044	0.0009	0.015	0.005	0.00004	0.00029	0.00025
Manganese	mg/L	-	0.0068	0.061	0.0059	-	-	-
Mercury	mg/L	0.0004	-	-	0.00005	-	-	-
Nickel	mg/L	0.07	-	-	0.005	0.0017	0.0024	0.0019
Zinc	mg/L	0.015	0.019	0.503	0.0415	0.019	1.559	0.218
Ferrous Iron	mg/L	-	-	0.38	0.07	-	-	-
Silicate	mg/L	-	NS	NS	NS	0.05	1.11	0.27
TRH C10 - C40 (Sum of Total)	mg/L	-	-	-	50	NS	NS	NS
C6 - C 9 Fraction	mg/L	-	-	-	10	NS	NS	NS
C10 - C36 (Sum of Total)	mg/L	-	-	-	25	NS	NS	NS

Parameter		Guideline criteria	M4 M5 Rozelle Bay monitoring[5] tidal			The Bays monitoring tidal		
	Units	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med[6]
Total BTEX (Benzene, Toluene, Ethylbenzene and Xylene)	mg/L	-	-	0.004	0.0005	NS	NS	NS
Phosphorus	mg/L	0.03[3]	0.02	3.76	0.025	0.032	0.046	0.039
Reactive Phosphorus	mg/L	-	-	0.07	0.02	-	-	-
Reactive Orthophosphate			NS	NS	NS	0.013	0.054	0.016
Kjeldahl Nitrogen Total	mg/L	-	0.2	-	0.25	-	-	-
Nitrate	mg/L	0.7	0.01	0.9	0.085	0.01	0.94	0.14
Nitrite	mg/L	-	-	0.02	0.005	0.002	0.007	-
Nitrogen (Total Oxidised)	mg/L	-	0.01	0.92	0.085	-	-	-
Oxides of Nitrogen	mg/L		NS	NS	NS	0.008	0.951	0.140
Ammonia			NS	NS	NS	0.013	0.114	0.042
Nitrogen (Total)	mg/L	0.3[3]	0.3	1.3	0.25	0.256	1.430	0.416
Enteroccoci	CFU/100mL		NS	NS	NS	0	1300	28
Chlorophylla	mg/L	0.003	NS	NS	NS	0.0007	0.0085	0.0032

Notes:

[2] ANZECC (2000) *'marine'* default trigger values for 95% level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[5] M4-M5 sampling conducted by AECOM in 2016 between July 2016 and December 2016, based on 9 samples collected from monitoring point SW1 (Roads and Maritime Services, 2017)

[6] Where the median values is less than the limit of reporting, the median was assumed to be half of the value of the limit of reporting

[7] Based on Chromium (Cr VI)

5.2 = Exceedance of guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Source: Roads and Maritime Services, 2017

Table 7 Alexandra Canal and Sheas Creek surface water quality monitoring summary

Parameter		Guideline criteria		New M5 Alexandra Canal monitoring[5] tidal			M4 M5 Sheas Creek monitoring[6] tidal		
	Units	ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med
Dissolved Oxygen (Field) (Filtered)	mg/L	-	-	2.4	6.75	4.59	5.59	65.18	8.99
Electrical Conductivity (Field)	µS/cm	125 – 2000[4]	-	11483	44865	28091.5	111.2	4830	447
pH (Field)		6.5 – 8.0[4]	7 – 8.5[3]	7.27	7.97	7.46	5.78	9.79	7.78
Turbidity (Field)	NTU	6-50	0.5-10	0	256	6.3	4.6	46.5	10.25
Arsenic	mg/L	0.013[7]	-	0.001	0.003	0.005	<0.001	0.057	0.002
Cadmium	mg/L	0.002	0.0055	-	-	-	<0.0001	0.0014	0.00005
Chromium (III+VI)	mg/L	0.001[8]	0.0044[8]	-	-	-	<0.001	0.143	0.001
Copper	mg/L	0.0014	0.0013	0.003	0.054	0.005	0.008	0.493	0.015
Iron	mg/L	-	-	-	1.38	0.265	0.34	107	0.746
Lead	mg/L	0.0034	0.0044	0.001	0.03	0.005	<0.001	0.392	0.007
Manganese	mg/L	1.9	-	-	0.059	0.03	0.015	1.78	0.0447
Mercury	mg/L	0.0006	0.0004	-	-	-	<0.00004	<0.0001	0.00005
Nickel	mg/L	0.011	0.07	-	0.002	0.005	<0.001	0.277	0.00185
Zinc	mg/L	0.008	0.015	-	0.097	0.039	0.034	0.684	0.0715
Ferrous Iron	mg/L	-		-	0.26	0.055	<0.05	16.3	0.12
TRH C10 - C40 (Sum of Total)	mg/L	-	-	-	-	-	<100	100	50
C6 - C 10	mg/L	-	-	-	-	-	<20	<20	10
C10 - C36 (Sum of Total)	mg/L	-	-	NS	NS	NS	<50	<50	25
Total BTEX	mg/L	-	-	-	-	-	<0.001	<0.001	0.0005
Phosphorus	mg/L	0.05[4]	0.03[3]	0.04	0.19	0.065	<0.01	4.02	0.165
Reactive Phosphorus	mg/L	-	-	-	0.04	0.01	<0.01	0.57	0.055
Kjeldahl Nitrogen Total	mg/L	-	-	-	1.3	0.65	0.2	7.4	1.4

Parameter		Guideline criteria		New M5 Alexandra Canal monitoring[5] tidal			M4 M5 Sheas Creek monitoring[6] tidal		
	Units	ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med
Nitrate	mg/L	0.7	-	0.08	4.69	0.25	0.33	3.17	2.06
Nitrite	mg/L	-	-	0.01	0.03	0.02	0.03	0.2	0.85
Nitrogen (Total Oxidised)	mg/L	-	-	0.09	4.71	0.27	0.39	0.2	0.085
Nitrogen (Total)	mg/L	0.5[4]	0.3[3]	-	5.4	1.0	0.7	8.8	3.8

Notes:

[1] ANZECC (2000) *'freshwater'* default trigger values for 95% level of species protection

[2] ANZECC (2000) *'marine'* default trigger values for 95% level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] ANZECC (2000) *'lowland rivers'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[5] New M5 sampling conducted by Aecom between June 2015 and November 2015, based on 8 samples collected from monitoring point SW1 (Roads and Maritime Services, 2017)

[6] M4-M5 sampling conducted by Aecom between July 2016 and December 2016, based on 9 samples collected from monitoring point SW10 (Roads and Maritime Services, 2017)

[7] Based on Arsenic (As V)

[8] Based on Chromium (Cr VI)

5.2 = Exceeds one or more relevant guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Source: Roads and Maritime Services, 2017