SR39B STORMWATER AMENITY IMPROVEMENT WORKS-
L03 WINDING CREEK, CARDIFF

JULY 2022

REVIEW OF ENVIRONMENTAL FACTORS

HUNTER WATER

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DOCUMENT CONTROL

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DISCLAIMERS

- This report has relied on information and background searches completed for the CP3559 – SR00039 Stormwater Amenity Improvement Environmental Constraints Memo (Aurecon, 2021a)
- A non-Aboriginal heritage assessment was not completed as part of this MW REF scope of works, informed by Project Execution Plan (PEP) cogeneration with Hunter Water

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TABLE OF TERMS AND DEFINITIONS

Term	Definition
The Proposal	The Proposal is for stormwater amenity improvement works that are to be undertaken along the existing concrete-lined stormwater channel at Winding Creek, Cardiff south of Myall Road. The amenity improvement works involves around 193m of channel naturalisation work. Native species would be planted within the revetment and along the top of the bank.
Proposal site	The Proposal site is the general area which includes the land within which the structural works and all construction compounds would be contained. The boundary of this Proposal site was used to understand the environmental constraints surrounding the Proposal in the broader Cardiff area. Labelled as “Proposal site” in Figure 2-1 Site overview of the proposal.
Structural works	The structural works involve removal of the existing concrete stormwater channel walls, battering the sides of the stormwater channel back to a 1V:2H slope, installation of rock revetment (rip-rap) on the channel sides, and planting. The structural works are described in the design drawings in Appendix A.
Structural works extent	Extent of the structural works within the broader Proposal site. Labelled as “Structural works extent” in Figure 2-1 Site overview of the proposal.
Construction boundary	The area within the broader Proposal site which contains the structural works as well as the broader construction compounds such as site sheds and laydown areas and would be directly impacted by construction Labelled as “Construction boundary” in Figure 2-1 Site overview of the proposal.

1 INTRODUCTION

Hunter Water Corporation (Hunter Water) propose to undertake amenity works including channel naturalisation and planting along the concrete-lined stormwater channel at Winding Creek, Cardiff (referred to as the Proposal).

Hunter Water intends to construct 1,000 m of channel naturalisation works within the Hunter Water network to improve the amenity of concrete lined waterways in response to various stakeholder preferences for naturalisation of Hunter Water's concrete stormwater open channels. Winding Creek, Cardiff is one of several areas which is proposed to have stormwater amenity and channel naturalisation works undertaken.

The Proposal has been assessed in accordance with the environmental impact assessment requirements of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Hunter Water is the proponent and the determining authority for the proposal in accordance with Division 5.1 of the EP&A Act.

The purpose of this minor works REF is to describe the proposed works and assess the potential construction and operation environmental impacts with consideration of the factors listed in clause 171 of the *Environmental Planning and Assessment Regulation 2021*. The REF identifies safeguards to mitigate identified impacts.

2 PROPOSAL DETAILS

2.1 Proposal identification

Proposal name	Stormwater Amenity Improvement – Winding Creek, Cardiff
Reference number	HW2018-1118/8/12.001
Proposal location	The Proposal would be located within Winding Creek to the south of Myall Road, Cardiff. This section of Winding Creek is located within Wilkinson Park. The location of the Proposal is shown in Figure 2-1.
Local Government Area	The Proposal is located in the Lake Macquarie local government area (LGA).
Land zoning	The land zoning for the Proposal site is RE1 Public Recreation.

2.2 Existing environment

The Proposal is located in the suburb of Cardiff within the Lake Macquarie LGA, managed by Lake Macquarie City Council (Council). The Proposal site is located within a recreational park, Wilkinson Park, south of Myall Road (refer to Figure 1).

The Proposal site is characterised by a flat, grassed parkland with a concrete-lined stormwater channel running south then south-east through the Proposal site. The northern extent of the Proposal site is bounded by Myall Road. The Cardiff Bowling Club and Cardiff Oval are situated to the west of the Proposal site, a playground and skate ramp to the east, whilst low-density residential development borders to the north-east and south-east.

No native vegetation communities are mapped within the Proposal site. Existing vegetation consists of dispersed mature native and non-native trees. Winding Creek is not considered a key fish habitat and does not contain any mapped distributions of threatened aquatic species. Overall salinity hazard is predominantly low for the majority of the Proposal site. One heritage item, the Former Colliery Tramway, listed on the State Heritage Inventory is located south of the Proposal site. No Aboriginal sites or places have been recorded in or near the Proposal site.

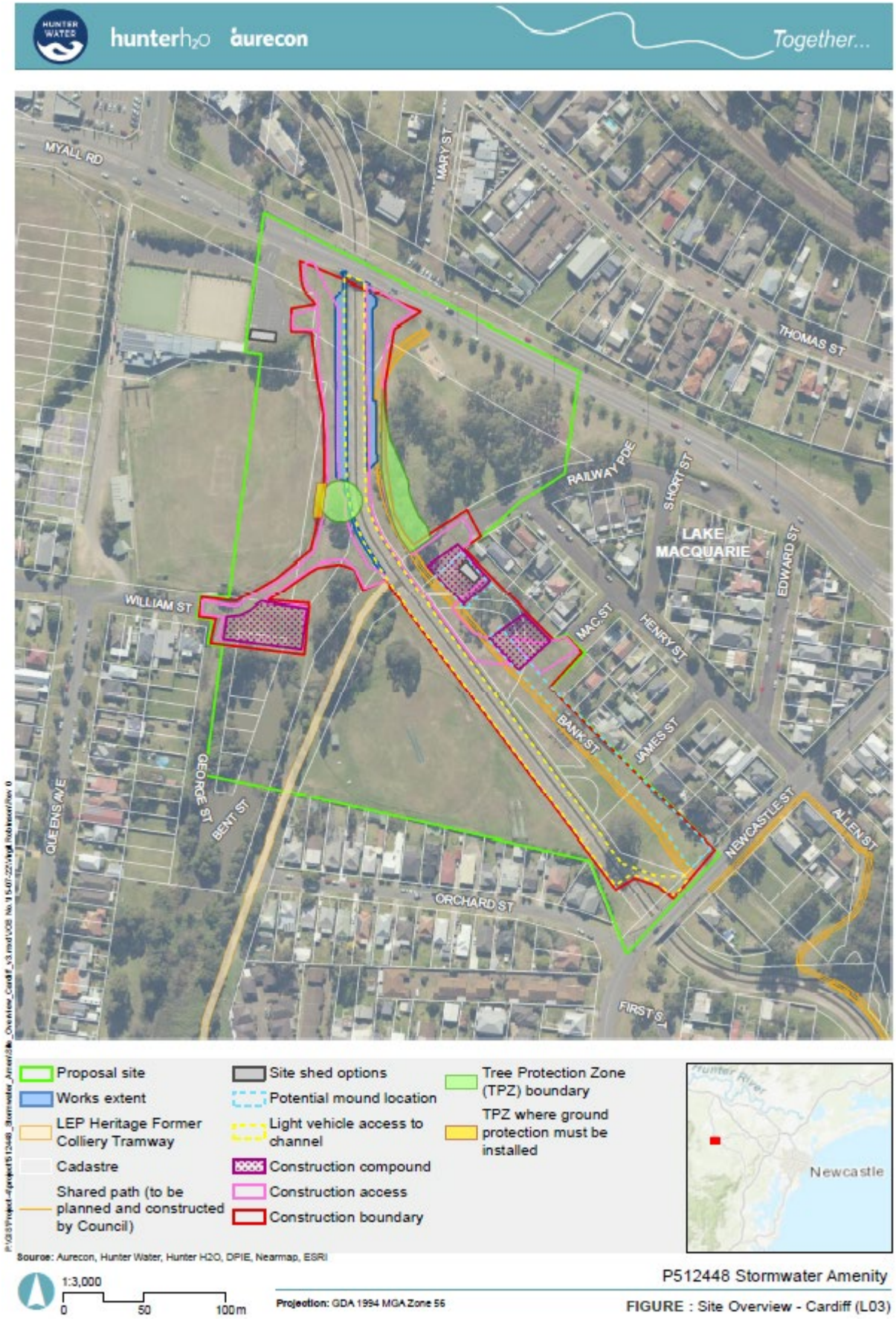

Figure 1 Site overview of the proposal

2.3 Proposal description

<table>
<tr><td>Description of works</td><td>The Proposal would involve about 193m of amenity works (naturalisation of the creek), including around 107m of structural work in the channel planting along the bank of the stormwater channel.
The naturalisation work involves the following:
removing the existing concrete stormwater channel walls
battering the sides of the stormwater channel back to a 1V:2H slope
installing rock revetment (rip-rap) on the channel sides
planting of native species within the revetment and along the top of the bank.
The stormwater channel would remain operational i.e. convey stormwater flows, during construction. Stormwater in the channel would be required to be managed and the works protected during construction. Design drawings are included in Appendix A.</td></tr>
<tr><td>Construction methodology</td><td>Construction works would include:<table><tr><th>Construction activity</th><th>Description</th></tr><tr><td>Site establishment</td><td>placing temporary fencing and signage to designate site access and construction zones
temporarily remove a section of the shared pathway which would be installed by Council prior to construction
setting up security measures
establishing construction compounds including site amenities and site sheds, laydown and stockpiling areas</td></tr><tr><td>Environmental controls</td><td>install temporary flow diversion in channel base e.g. sandbags and/ or barriers on a section by section basis
install temporary erosion and sediment controls
place spill kits</td></tr><tr><td>Investigations</td><td>pre-construction asset inspections</td></tr><tr><td>Materials delivery</td><td>deliver fill materials to laydown areas</td></tr><tr><td>Structural works – Stage 1 (removing concrete channel)</td><td>channel structural works would be completed in sections. This phasing of structural works would ensure protection of the Proposal site during stormwater flow events in the channel
excavator to remove turf and topsoil within Proposal site and move to stockpile
sawcut channel wall and undertake bank works within the Proposal site
excavate channel wall below base of channel (refer detailed design in Appendix A) and temporarily stockpile spoil for disposal</td></tr></table></td></tr>
</table>

		• batter slopes to be shaped at a 1V:2H to facilitate placement of fill and rock revetment (rip-rap) • demolishing existing drainage outlet headwall
	Dewatering	• dewater groundwater or surface water within excavations using portable pumps as required and appropriate disposal
	Waste disposal	• dispose construction waste including spoil to a licensed waste facility
	Structural works – Stage 2 (asset protection/restoration and transition wall works)	• construct transition retaining walls (sandstone blocks) grouted to existing bank wall • reconstruct drainage outlet headwall from sandstone and backfill with stabilised sand • concrete encase sewer on eastern bank if required
	Structural works – Stage 3 (bank protection works)	• place select fill and rock revetment (rip-rap) • place planting material in planting areas • place erosion control matting (thick jute mat) and plant native plants (refer to species list in design drawings, Appendix A) • install permanent fence along edge of works at interface with council shared pathway
	Site restoration •	• reinstate council shared pathway • final landscaping/rehabilitation • remove temporary environmental controls • remove construction compounds such as construction fencing and signage, waste bins and waste materials
Construction compounds	Construction compounds would include: • fencing • site sheds • portable toilets • laydown/stockpile locations • waste facilities.	
Operational requirements	Ongoing management of plant establishment, weed maintenance and inspections of works after significant rainfall events to be undertaken during the two-year contractor maintenance period. During the operational phase, works are to be periodically inspected in accordance with Hunter Water maintenance regime for weeds and any significant defects. Weed management and defect repair to be undertaken as required.	
Equipment and plant	The following indicative plant and equipment would be required: • excavator • concrete saw • portable dewatering pumps • franna/ mobile crane • concrete pump • trucks • wheel loader • hand tools including hammer or core drills	

	• pulveriser (preferred) or hydraulic rock breaker attachment for excavator • small vibratory roller and/ or plate compactor • generator/s • auger • sandstone blocks • rocks and gravels • planting material • geotextile • erosion control matting (thick jute mat)
Land tenure	The majority of the existing stormwater channel in the Proposal site is located within Hunter Water owned land. The northern end of the existing channel in the structural works extent is located within a Council owned land and road reserve (Myall Road). Construction compounds including site sheds and laydown areas and temporary site access would be on Council land. Council have been provided notification of the Proposal and have been engaged in ongoing consultation with Hunter Water (refer to Section 4) Hunter Water has an existing easement for the sewer which is located on Council land, as shown in Figure 2-1. The sewer is alongside the channel which is being extended on the eastern extent of the structural works extent. In this area Hunter Water would require Council's permission to change the easement terms to include the relevant conditions for a stormwater easement.
Commencement and expected duration of construction work	The proposed works are expected to commence in late 2022 and be completed by mid 2024. Once operational, a contractor would be engaged to inspect and maintain the works for 2 years following completion of construction.
Hours of construction work	Working hours would be standard construction hours: • Monday to Friday – 7am to 6pm • Saturday 8am to 1pm • no work on Sundays or public holidays. Emergency out of hours work may be required to protect the structural works during stormwater flow events in the channel. This would be an exceptional event which occurs following significant rainfall. If out-of-hours works are required, approval must be sought from Hunter Water prior, and respective landholders notified as advised by Hunter Water communications and stakeholder team.
Proposal need	Hunter Water owns approximately 97 km of stormwater drainage assets in the Hunter Water region. Approximately 50% are open channels that were constructed during the 1920s and 1940s, with nearly all concrete lined. These drainage assets run next to parks and through major commercial precincts and are visually unappealing. The NSW State Government has developed a 20-year blueprint for the future of the Hunter Region that reflects community and stakeholder aspirations. Its vision is for the Hunter Region to be the leading regional economy with a vibrant new metropolitan city at its heart, acknowledged globally for a number of attributes including its excitement of the inner city, and great lifestyles. A key objective is to enhance amenity for quality of life including creating great public spaces, access and improving pedestrian and cyclist safety. Hunter Water has investigated how they can help deliver on the region's vision. Our Hunter Water's stakeholders and customers have indicated a preference for naturalisation of Hunter Water's concrete stormwater open

	channels, to improve waterway health and improve community amenity. Based on survey results, our customers have also identified a willingness to pay which would be spread across the entire customer base. Hunter Water has obtained approval from the Independent Pricing and Regulatory Tribunal (IPART) to deliver the Stormwater Amenity Improvement Program in the period from 2020-21 to 2023-24. Hunter Water's commitment to IPART includes delivering a minimum length of 1,000m of amenity improvement. This investment is considered 100% discretionary. Hunter Water has worked with local councils to determine priority areas for stormwater amenity improvement works and Winding Creek in Cardiff was identified as a priority.
Proposal objectives	The proposal objectives are: • to improve the amenity of the stormwater system, provide improved community access • increase the value of waterways and encourage more recreational activity by the community. These objectives align with the NSW Government blueprint for the Hunter Region, with its key objective to enhance amenity for quality of life including creating great public spaces, access and improving pedestrian and cyclist safety. The strategic objectives of the proposal include: • protect public safety • minimise negative community impacts • increase contribution to liveability outcomes for the community
Options considered and justification	Due to the modified nature of Winding Creek in Cardiff (concrete-lined channel), the Proposal site is appropriate for channel amenity improvement and naturalisation works. These works would provide residents and users of the park extended views of a more naturalised waterway, which is aligned with stakeholder preferences for naturalisation of Hunter Water's concrete stormwater open channels. Two structural options were considered for the proposal, as well as the 'do nothing' option: • do nothing – does not improve visual amenity • option 1 - replaces almost all the concrete channel walls with rock revetment (rip-rap) on 1(v):2(h) batters and provides the best visual impact (the proposal) • option 2 - replaces the upper sections of concrete channel walls, while retaining the lower portions of concrete walls. this option balances visual impact with construction costs and risks. Option 1 was selected as the preferred option to maximise the extent of concrete to be replaced with more natural materials and maximise the improvements in visual impact. Option 1 to improve stormwater amenity through creek naturalisation works at Winding Creek, Cardiff best fulfills the Proposal's objectives.

3 STATUTORY CONTEXT

3.1 Environmental planning instruments

Lake Macquarie Local Environment Plan 2014

The Proposal is located within the Lake Macquarie Local Government Area (LGA). Local development control and land use zoning within the Lake Macquarie LGA is managed under the Lake Macquarie Local Environmental Plan 2014 (Lake Macquarie LEP). The operation of the Transport and Infrastructure State Environmental Planning Policy 2021 (T&ISEPP) means that the Lake Macquarie LEP does not apply where they impose controls that are inconsistent with the T&ISEPP. However, the LEP is still relevant in identifying land use objectives, potential land use impacts and planning policy conflicts and as such, has still been considered.

The Proposal is located within land zoned as RE1: Public Recreation under the Lake Macquarie LEP. The Proposal is consistent with the objectives of this zone, which are:

- To enable land to be used for public open space or recreational purposes.
- To provide a range of recreational settings and activities and compatible land uses.
- To protect and enhance the natural environment for recreational purposes.
- To facilitate the preservation of the environmental qualities of land.

State Environmental Planning Policy (Transport and Infrastructure) 2021

The T&ISEPP describes certain developments that may be carried out without consent in order to facilitate the delivery of infrastructure in NSW.

Clause 2.136 (1) of T&ISEPP enables development for the purpose of stormwater management systems to be carried out by or on behalf of a public authority without consent on any land. As the proposal would form part of a stormwater management system and Hunter Water is a public authority, it is considered permissible without consent pursuant to the provisions of T&ISEPP and can be assessed under Division 5.1 of the EP&A Act. Development consent from Council is not required.

3.2 Relevant legislation

Environmental Planning & Assessment Act 1979

The *Environment Planning and Assessment Act 1979* (EP&A Act) is the principal legislation for environmental planning and assessment in NSW. The EP&A Act provides for creation and implementation of State Environment Planning Policies (SEPPs) and Local Environment Plans (LEPs), collectively referred to as Environmental Planning Instruments (EPIs).

The description of the proposal and associated environmental impacts has been carried out with consideration of clause 171 of the Environmental Planning and Assessment Regulation 2021 (summarised in Appendix B), the *Biodiversity Conservation Act 2016* (BC Act), the *Fisheries Management Act 1994* (FM Act), and the *Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act). In doing so, the REF helps to fulfill the requirements of Section 5.5 of the EP&A Act that Hunter Water examine and take into account to the fullest extent possible, all matters affecting or likely to affect the environmental by reason of the activity.

Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the NSW Environment Protection Authority (EPA). Part 3.2 of the POEO Act requires an Environment

Protection Licence (EPL) for scheduled development work and the carrying out of scheduled activities. The proposal does not trigger these requirements.

Section 120 of the POEO Act prohibits the pollution of waters. The REF includes measures to address the risk of water pollution, refer to Section 5.2.

Air pollution-related sections 124 to 126 (Chapter 5, Part 5.4., Division 1) of the POEO Act require activities to be conducted in a proper and efficient manner, while section 128 (Chapter 5, Part 5.4., Division 1) of the POEO Act requires that all necessary practicable means be used to prevent or minimise air pollution. Air quality is addressed in Section 5.10.

Pollution of land and waste is covered by Part 5.6 of the POEO Act. The Act defines 'waste' for regulatory purposes and establishes management and licensing requirements for waste. It defines offences relating to waste and sets penalties. The POEO Act also establishes the ability to set various waste management requirements via the Protection of the Environment Operations (Waste) Regulation 2014.

Waste and resource use is addressed in Section 5.11. Contamination is addressed in Section 5.1. Noise is addressed in Section 5.4.

Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) is directed at maintaining a healthy, productive and resilient environment consistent with the principles of ecologically sustainable development (ESD). The BC Act sets out the assessment framework for threatened species and ecological communities.

Certain species of animals or plants are identified as endangered species, populations or communities or vulnerable species under the Act. Areas of land comprising the habitats of listed endangered species may also be declared Areas of Outstanding Biodiversity Value under the Act.

Under Part 7 of the BC Act, an activity that is likely to significantly affect threatened species (which is defined to include ecological communities, or their habitats) requires either:

- A biodiversity development assessment report prepared by an accredited assessor in accordance with the Biodiversity Assessment Method (BAM); or
- A species impact statement and the concurrence of the Environment Agency Head.

Potential impacts on biodiversity as a result of the proposal are considered in Section 5.3. Significant impacts are not expected.

Biosecurity Act 2015

Under the *Biosecurity Act 2015*, which came into effect on 1 July 2017, ‘all plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable’.

A number of weed species may be present within the Proposal site. Management of these weed species during the work would be undertaken in a manner to minimise their further proliferation under the *Biosecurity Act 2015*. The REF includes measures to address weed management, refer to Section 5.3.

National Parks and Wildlife Act 1974

The harming or desecrating of Aboriginal objects or places is an offence under Section 86 of the *National Parks and Wildlife Act 1974* (NPW Act). Under Section 90, an Aboriginal heritage impact permit may be issued in relation to a specified Aboriginal object, Aboriginal place, land, activity or person or specified types or classes of Aboriginal objects, Aboriginal places, land, activities or persons. Further provisions include the protection of Aboriginal objects and places and offences relating to harm or desecration of an Aboriginal object or declared Aboriginal place. Harm includes destroying, defacing damage or moving items or places without consultation.

No Aboriginal objects or places would be impacted by the proposal. An assessment of potential impacts to Aboriginal objects or places is included in Section 5.6.

Hunter Water Act 1991

The *Hunter Water Act 1991* provides for the establishment and operation of Hunter Water as a state-owned corporation to supply water, provide sewerage and drainage services, and dispose of wastewater. Hunter Water's primary functions are established in the Act and are regulated by the NSW Government through the current Operating Licence administered by the Independent Pricing and Regulatory Tribunal. The Operating Licence sets out conditions relating to wastewater transport as well as drinking water quality and environmental requirements.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) provides for the identification, conservation and recovery of threatened fish, aquatic invertebrates and marine vegetation. One of the key objectives of the FM Act is to conserve fish stocks and key fish habitats.

Part 7 of the FM Act establishes that a permit is generally required to dredge, reclaim, obstruct fish passage, harm marine vegetation, use explosives or electrical devices in a waterway that is classified as key fish habitat.

The section of Winding Creek which sits within the Proposal site is not mapped as key fish habitat. No marine vegetation exists within the waterway therefore, a section 205 permit under Part 7 of the FM Act is not required. Furthermore, given that the stormwater drain will remain operational during works, fish passage will not be obstructed, thereby negating the need for a Section 219 permit. Maintenance of the fish passage during works is discussed in Section 5.3.

Waste Avoidance and Resource Recovery Act 2011

The *Waste Avoidance and Resource Recovery Act 2001* (WARR Act) aims to encourage the most efficient use of resources and to reduce environmental harm in accordance with the principles of ecologically sustainable development. The proposal would involve efficient use of resources, including utilising resources from local sources where practicable. Waste generation and management is discussed in Section 5.11.

Heritage Act 1977

The *Heritage Act 1977* (Heritage Act) is designed to protect both known heritage items (such as standing structures) and items that may not be immediately obvious (such as potential archaeological remains or 'relics'). Different parts of the Heritage Act deal with different situations and types of heritage and the Act provides a number of mechanisms by which items and places of heritage significance may be protected.

Section 57(1) of the Heritage Act lists the types of activities/works that require approval from Heritage NSW (a branch of the NSW Department of Premier and Cabinet) under Section 60 of the

Heritage Act, when working on/in an item/place listed on the State Heritage Register (SHR). An application for an exemption can also be made under some circumstances. There is one item listed on the SHR that lies within the Proposal site – Former Colliery Tramway, Heritage Item ID 1910043. Given that the structural works extent avoids the heritage item (refer to the design drawings in Appendix A), and the recommended offsets for vibratory plant will be observed, no impacts are anticipated on the heritage item. Therefore, no approvals under Section 60 of the Heritage Act would be required. Non-Aboriginal heritage is further discussed in Section 5.5 with mapping of all relevant heritage items provided in Appendix D.

Environment Projection and Biodiversity Conservation Act 1999

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) a referral is required to the Australian Government Department of Agriculture, Water and the Environment for proposed actions that have the potential to significantly impact on Matters of National Environmental Significance (MNES) or the environment of Commonwealth land.

The assessment of the proposal's impact on nationally listed threatened species, endangered ecological communities and migratory species has found that there is unlikely to be a significant impact on relevant MNES. These are considered in Section 5.3.

4 CONSULTATION

4.1 State Environmental Planning Policy (Transport and Infrastructure) 2021 consultation

Part 2.2 General, Division 1 of the T&ISEPP prescribes consultation to be undertaken by a public authority prior to the commencement of certain activities. A review of the T&ISEPP consultation requirements for the proposal is provided in Table 4-1.

Table 4-1 Infrastructure SEPP consultation requirements

Is consultation with Council required under clauses 2.13-2.14 of T&ISEPP?	Yes/No
Is the proposal likely to have a substantial impact on stormwater management services which are provided by council?	No
Is the proposal likely to generate traffic to an extent that will strain the capacity of the existing road system in a local government area?	No
Will the proposal involve connection to a council owned sewerage system? If so, will this connection have a substantial impact on the capacity of any part of the system?	No
Will the proposal involve connection to a council owned water supply system? If so, will this require the use of a substantial volume of water?	No
Will the proposal involve the installation of a temporary structure on, or the enclosing of, a public place which is under local council management or control? If so, will this cause more than a minor or inconsequential disruption to pedestrian or vehicular flow?	Yes. However, disruption to pedestrian and vehicular flow is considered minor.
Will the proposal involve more than minor or inconsequential excavation of a road or adjacent footpath for which council is the roads authority and responsible for maintenance?	No
Is the proposal likely to have a more than minor or inconsequential impact on a local heritage item (that is not also a State heritage item) or a heritage conservation area? (Note: *local heritage item means —* *(a) a place, building, work, relic, tree, archaeological site or Aboriginal object that is identified as a heritage item (or by a similar description) in a local or regional environmental plan, or* *(b) an item of local heritage significance, as defined by the Heritage Act 1977, that is the subject of an interim heritage order in force under that Act or is listed as an item of local heritage significance on the State Heritage Inventory under* that Act.)	No
Is the proposal located on flood liable land? If so, will the works change flood patterns to more than a minor extent?	Yes. However, works will not change flood patterns to more than a minor extent.
Is the proposal within the coastal vulnerability area and is inconsistent with a certified coastal management program applying to that land? Note: See interactive map here: https://www.planning.nsw.gov.au/policy-and-legislation/coastal-management. Note the coastal vulnerability area has not yet been mapped. Note: a certified coastal zone management plan is taken to be a certified coastal management program	No

Is the proposal characterised as stormwater management systems under Division 20 and located on flood liable land? If so, do the works comprise more than minor alterations or additions to, or the demolition of, a building, emergency works or routine maintenance? Note: Flood liable land means land that is susceptible to flooding by the probable maximum flood event, identified in accordance with the principles set out in the manual entitled Floodplain Development Manual: the management of flood liable land published by the New South Wales Government.	Yes
Is consultation with a public authority other than Council required under clauses 2.15 and 2.16 of T&ISEPP?	**Yes/No**
Is the proposal adjacent to a national park or nature reserve, or other area reserved under the *National Parks and Wildlife Act 1974*, or on land acquired under that Act?	No
Is the proposal on land in Zone E1 National Parks and Nature Reserves or in a land use zone equivalent to that zone?	No
Does the proposal consist of a fixed or floating structure in or over navigable waters?	No
Will the proposal increase the amount of artificial light in the night sky and that is on land within the dark sky region as identified on the dark sky region map – the Director of the Observatory? Note: The dark sky region is land within 200 kilometres of the Siding Spring Observatory.	No
Is the proposal on defence communications facility buffer land within the meaning of clause 5.15 of the Standard Instrument – the Secretary of the Commonwealth Department of Defence? Note: Defence communications facility buffer land is located around the defence communications facility near Morundah. See the Defence Communications Facility Buffer Map referred to in clause 5.15 of *Lockhart Local Environmental Plan 2012, Narrandera Local Environmental Plan 2013* and *Urana Local Environmental Plan 2011*.	No
Is the proposal on land in a mine subsidence district within the meaning of the *Coal Mine Subsidence Compensation Act 2017*?	Yes
Is the proposal to be carried out in an area that is bush fire prone land? If so, has the *Planning for Bush Fire Protection* been considered before carrying out the development? Note: *bush fire prone land* means land recorded for the time being as bush fire prone land on a map certified under the Act, section 10.3(2). *Planning for Bush Fire Protection* means the document entitled *Planning for Bush Fire Protection*, ISBN 978 0 646 99126 9, prepared by the NSW Rural Fire Service in co-operation with the Department of Planning, Industry and Environment, dated November 2019.	No

4.2 T&ISEPP Consultation Letters

Under the requirements of the T&ISEPP, Hunter Water consulted with Lake Macquarie City Council (Council), Subsidence Advisory NSW (SANSW) and NSW State Emergency Services (NSW SES) on 12 April 2022 providing details about the Proposal including scope and reason for consultation.

Council and NSW SES have reviewed the consultation letter and responded without raising any concerns or comments. The Council Natural Assets Coordinator noted that their heritage planner

provided advice that they had no concerns regarding the Proposal. No response was received from SANSW.

Consultation records are included in Appendix C.

4.3 Other consultation

As part of obtaining approval from IPART for project funding, consultation was undertaken with Hunter Water customers. Engagement surveys conducted with the local community in 2018 had indicated that most residential customers were willing to pay more in their bills in return for investment in amenity works to naturalise stormwater channels.

Following this community consultation, Hunter Water worked with local councils to determine key areas where stormwater naturalisation works would have the most benefit for the community. In 2020 the key sites identified were prioritised in consultation with the councils. The Proposal was identified as a priority by Council. Hunter Water consulted again with Council in June 2021 to confirm that Winding Creek Cardiff was the site preference prior to design development.

Further consultation with Council was carried out during the concept design phase in 2021. This involved a Constraints Workshop and Deliverables Review in August and November 2021.

4.4 Department of Primary Industries

Will the proposal involve dredging or reclamation works in a waterway?	Yes/No
This includes any excavation within, or filling or draining of, water land or the removal of woody debris, snags, rocks or freshwater native aquatic vegetation or the removal of any other material from water land.	No

5 ENVIRONMENTAL ISSUES IDENTIFICATION

This section provides a description of potential impacts associated with the proposal and specifies measures to mitigate identified impacts. All aspects of the environment potentially impacted by the proposal are considered. A summary of the consideration of factors specified in clause 171 of the *Environmental Planning and Assessment Regulation 2021* is provided in Appendix B. A summary of the matters of national environmental significance under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* is provided in Appendix B.

Database searches referred to in the following tables are included as Appendix D. Further site-specific detail is contained in Appendices E (Flood Impact Assessment), F (Dewatering Memo) and G (Noise and Vibration Impact Assessment).

5.1 Topography, soils and geology

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Would the work require excavations or other ground disturbing activities?	Yes	The Proposal would require excavation and ground disturbing works. As listed in Section 2.3, excavation works will include: • removing turf and topsoil along channel • saw cutting channel wall • excavating to required depth to facilitate placement of fill and rock revetment (rip-rap) (refer typical sections in detailed design in Appendix A). • removing a section of shared pathway Mitigation measures listed in Section 6.1 will minimise potential erosion and sediment impacts.	N/A
Would the work require plant/vehicular movements on unsealed areas?	Yes	Access to the Proposal site would be via existing sealed roads as shown in Figure 2-1, however, plant and vehicles would have to track into the Proposal site and creek channel across the park using temporary access tracks.	N/A
Could the work occur in an area of high erosion risk (eg, due to nature of soils, topography)?	Yes	The Proposal site lies within the Cockle Creek soil landscape (Department of Planning, Industry and Environment, 2020). The Cockle Creek landscape soils are a flooding and water erosion hazard and prone to seasonal waterlogging. The scope of excavation and ground disturbance for this Proposal would be confined to the extent of the structural works extent. During construction, there is potential for erosion of exposed soils on cut batter	eSPADE – 6 September 2021 (updated 25 April 2022)

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		slopes to occur during storm events prior to bank protection (rock rip rap and erosion control matting) being installed. A Flow Management Plan would be developed to manage works within the channel and flood and erosion risk. The potential for erosion would also be appropriately managed by the mitigation measures listed in Section 6.1.	
Could the work impact on or have the potential to impact on Acid Sulphate Soils (ASS)?	No	The Proposal site is not located within an ASS risk area and is not mapped as having a probability of ASS. The nearest mapped ASS probability which is approximately 900m north-west of the Proposal site is 'no known occurrence'. Therefore, given the significantly low risk of ASS being discovered at the Proposal site, impacts are not expected.	Naylor, Guidelines for the Use of Acid Sulfate Soil Risk Maps, 2nd ed., 1998
Could the work impact on areas of known salinity risk?	No	Most of the site is mapped as having a predominately low overall salinity hazard, with the exception of the northern and north-eastern boundaries of the Proposal site. The majority of the Proposal site is mapped as low hazard due to land salinity, salt export and instream electrical conductivity (Department of Planning, Industry and Environment, 2020). The northern and north-eastern boundaries of the Proposal site are mapped as having high overall salinity hazard due to land salinity, salt export and instream electrical conductivity. Two soil profiles, approximately 1k m south-west and 1 km north of the site respectively, indicate no salting evident. Given that the extent of the structural works extent occurs over the area with a predominately low salinity hazard, impacts are not expected.	eSPADE – 6 September 2021 (updated 25 April 2022) Department of Planning, Industry and Environment, 2020
Could the work result in disturbance of contaminated land?	No	A search of the NSW Environment Protection Authority (EPA) contaminated land record of notices for the suburb of Cardiff returned no known contaminated sites in the vicinity of the Proposal site. The preliminary waste classification (Aurecon, 2021b) and geotechnical investigation (Aurecon, 2022) prepared by Aurecon for the Proposal site considered background and historical site information, and included field investigation, boreholes and test pits. Based on the sampling results, the preliminary classification of fill material on site is general solid waste (non-putrescible) with no contamination or asbestos containing materials (ACM) observed. Mitigation measures have allowed for unexpected finds of incidental contamination during	NSW EPA contaminated land record of notices and list of notified NSW contaminated sites (as of 25 April 2022) Preliminary waste classification (Aurecon, 2021b) Geotechnical report (Aurecon, 2022)

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		earthworks (such as illegally dumped wastes and stockpiles) and the management of asbestos if encountered.	

5.2 Hydrology and water quality

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Could the work impact a water catchment area? Do any of the work areas drain directly to Hunter Water special areas?	No	The works are not located within or upstream of a drinking water catchment or Hunter Water special area.	
Could the work impact directly or indirectly on a waterway? (including creek crossings and underboring a waterway)	Yes	The Proposal would directly impact Winding Creek by replacing the existing concrete channel walls with laid back rock revetment (rip rap) and plantings. During construction, there is a potential for exposed soils to be eroded during storm events potentially resulting in water quality impacts to Winding Creek associated with sedimentation downstream. Erosion and sediment control measures and appropriate procedures would be in place including implementation of a Flow Management Plan during construction to minimise the potential for bank erosion and impacts to water quality during storm events as well as preventing exposed construction fill material being washed into the channel prior to completion of the works. Refer to the mitigation measures in Section 6.1. The works would also be staged and completed in sections to minimise these risks during construction. In accordance with Clause 41 of the Water Management (General) Regulation 2018, as a state-owned body, Hunter Water are exempt from requiring a controlled activity approval to undertake works on waterfront land providing the activity does not cause any change in the course of the river. Hunter Water has considered the environmental impact of the activity and is satisfied that the activity is not likely to significantly affect the environment as per Clause 37 of Schedule 4 of Water Management (General) Regulation 2018. Safeguards to manage potential impacts to Winding Creek as a result of works within waterfront land are further discussed in Section 6.1.	Water Management (General) Regulation 2018 Controlled activity approval exemptions Fact Sheet, (Department of Planning, Industry and Environment 2021)
Is the work located on flood prone land?	Yes	The Proposal is located within flood prone land in the Winding Creek floodplain.	Flood impact assessment (Appendix E)

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Could the work result in impacts to flooding regimes and flows? Could the work be impacted by flooding?		A flood impact assessment was undertaken (refer Appendix E), where the bank-full flow (the approximate flow that results in the concrete channel flowing at full capacity), 10% Annual Exceedance Probability (AEP), 1% AEP and probable maximum flood (PMF) events were modelled using a newly developed two-dimensional hydraulic model (TUFLOW). A comparison between flood conditions was undertaken for the Proposal site with and without the proposed stormwater amenity works. Flow velocities and bed-shear-stresses were determined along the proposed works area to inform the design of stabilisation works. The flood impact assessment indicates there is potential for localised increases in flood levels within the park and along the downstream end of the structural works for a range of flow events. A 50mm increase of 1% AEP flood levels is likely towards Myall Road and within the park adjacent to the Bowls Club and skate park. A small area of 150mm of flood increase may occur immediately upstream of Myall Road in a 1% AEP event. No increase in 1% AEP flooding would affect existing buildings, infrastructure, roads or private property. There is also no overtopping of Myall Road up to and including the 1% AEP event. Changes in flood levels are represented in the mapping provided in Appendix E. The flood impact assessment also indicated there is potential for localised decreases in flood levels along the upper extent of work in all events up to and including the 1% AEP, which reduces levels adjacent to some private properties. The structural works are likely to result in an extensive area of decreased flood levels on land adjacent to dwellings on Mac Street and Henry Street. These decreased flood levels range up to 150mm in the 1% AEP event as shown in the mapping provided in Appendix E. In the PMF event, the proposed extent of new planting adjacent to the road corridor has the effect of increasing flood depths in this location. For the PMF event, this results in a small increase in existing flooding to the eastern extent over Myall Road (35m^2). It is noted that the PMF event inundates a significant extent to the west in both existing and proposed cases. Comparisons of flow hydrographs for existing case and the Proposal were run which indicate that while there does appear to be local flood	

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		impacts (in both an increase and decrease in levels) over the site works, the flow behaviour between existing and proposed scenarios are effectively the same, and flood plain storage remains effectively unchanged. In the absence of scour protection, the structural works would experience flooding and associated scour forces in a range of flows. The design of the structural works would reduce scour through the placement of rock and erosion control matting. It is expected that any flood events from excessive rainfall would not cause damage during construction with the implementation of weather monitoring, erosion protection and the Flow Management Plan (refer Section 6.1). Modelling results demonstrate the expected scour velocities could be withstood once all works are complete and stabilisation planting has been established.	
Would the work be likely to encounter groundwater or require discharge of accumulated water?	Yes	The Groundwater Dewatering Memorandum (Appendix F) prepared for the Proposal indicated that excavation works are likely to encounter some groundwater. The groundwater dewatering memorandum estimated the potential volume of dewatering required for the project and identified approval and licensing requirements. A conservative approach to estimating groundwater interception was adopted. It was estimated that a total of 0.33 ML of groundwater may be encountered over the duration of the works. A Flow Management Plan would be developed for managing construction works within the channel, and the works would be completed in sections to minimise the length of excavated, exposed areas requiring soil and water management. The contractor may propose to place fill materials within a wet environment if the groundwater ingress is minimal, however some dewatering may still be required to prevent uncontrolled releases to the creek in accordance with the proposed mitigation measures (refer Section 6.1). Disposal options for extracted groundwater are described in Appendix F and include discharge to Winding Creek or the stormwater system, discharge to sewer via a trade waste agreement or offsite disposal at a licensed wastewater facility. The preference would be dewatering downstream provided that water quality criteria are met. Groundwater would be tested prior to the works commencing to ensure	Groundwater dewatering memorandum (Appendix F)

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		there is no existing contamination or abnormal water quality parameters present, refer Section 6.1. Due to the minimal length of works, and the limited amount of groundwater ingress expected, temporary shoring to prevent groundwater intrusion would not be required. Any dewatering requires a Water Supply Works (WSW) approval. The groundwater assessment estimated that around 0.33 ML of groundwater would need to be dewatered. A Water Access License (WAL), under the *Water Management Act 2000* is only required where more than 3 ML/year of groundwater is anticipated to be extracted. Therefore a WAL is not expected to be required for the proposal.	
Would the works result in permanent changes to existing surface drainage patterns?	No	The proposal would retain all existing surface water drainage paths.	N/A

5.3 Biodiversity

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Would the work require vegetation removal?	No	The Proposal would not involve any removal of vegetation. Whilst there is a large tree present within the construction boundary, this tree has a high canopy and it is not expected that any pruning would be required to facilitate plant access beneath the tree canopy.	Arboricultural impact assessment (Appendix G)
Would the work occur within the Tree Protection Zone of any trees? (Defined as: 12 x diameter of the trunk at 1.4m high)	No	An arboricultural impact assessment (AIA) and tree protection plan (TPP) was prepared in accordance with AS4970:2009 Protection of trees on development sites by a suitably qualified arborist, to consider the proposal and its potential impacts on vegetation within the construction boundary. A site inspection was undertaken on 27 June 2022 with trees inspected and characteristics recorded in a tree schedule (Appendix G). A stand of *Eucalyptus tereticornis* (referred to as Tree A in the Tree Management Plan) would be avoided by the structural works footprint and construction access has been designed to ensure there is no encroachment into the TPZ boundary for this stand.	Arboricultural impact assessment (Appendix G)

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		Following the advice in the AIA, the structural works extent has been modified to avoid impact to the tree protection zone (TPZ) of Tree 1, a large *Eucalyptus microcorys*, such that the tree can be retained without any adverse effects. Planting within the TPZ would be undertaken by hand. Allowable construction access within the TPZ has been indicated on the Tree Management Plan within Appendix G. Placement of materials, site laydown areas and parking of plant and vehicles would be located outside of the tree protection zones within the Proposal site. Appropriate mitigation measures identified by the arborist to mitigate and minimise impacts to vegetation have been included in Section 6.1.	
Could the work impact directly or indirectly on *Biodiversity Conservation Act 2016 or Fisheries Management Act 1994* listed species or threatened ecological community or areas of outstanding biodiversity value under the BC Act or critical habitat under the FM Act?	No	The NSW BioNet Atlas was reviewed in June 2022 for species listed under the BC Act that have the potential to occur within 100km^2 of the proposal area. The NSW BioNet Atlas identified the Biconvex Paperbark (*Melaleuca biconvexa*) within the broader area around the Proposal site, and a record from 2017 of three species of threatened microbats within 1km of the Proposal site. Given that the proposal would not require any vegetation clearing or disturbance to potential microbat habitat (tree-hollows, tree bark, caves and cave-like structures), no impacts to any BC Act or FM Act listed species or threatened ecological communities would be expected. Groundwater drawdown of approximately 0.8m is estimated at the excavation near a Biconvex Paperbark tree roughly 7 metres away. The predicted drawdown across a 10-day period is expected to be within the seasonal variation in groundwater table the species would experience under normal conditions. Therefore, the Proposal is unlikely to impact the long-term viability of the species. The mitigation measures in Section 6.1 would be implemented to minimise any adverse biodiversity impacts.	NSW BioNet Atlas search on 3 September 2021 (Updated 24 June 2022)
Could the work impact directly or indirectly on an *Environment Protection and Biodiversity Conservation Act 1999* listed species, ecological community or migratory species?	No	A protected matters search identified the potential presence of 43 threatened species, 17 migratory species and four listed threatened ecological communities within one kilometre of the proposal. The recorded threatened fauna species include 15 birds, three frogs, eight mammals and 17 plant species.	Protected Matters database on 1 September 2021 (Updated 24 June 2022)

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		No EPBC Act listed threatened species, ecological communities and migratory species would be impacted as a result of the proposal.	
Could the work impact (directly or indirectly) on areas mapped in the Coastal Management SEPP, littoral rainforests, marine parks, national parks estate, biodiversity stewardship sites or wilderness areas?	No	There are no areas mapped in the Coastal Management SEPP, littoral rainforests, marine parks, national parks estate, biodiversity stewardship site or wilderness area near the proposal.	SEPP Coastal Management 2018 ePlanning spatial viewer in September 2021
Could the work impact (directly or indirectly) on aquatic or riparian vegetation including seagrasses, mangroves or saltmarshes?	No	Due to the nature of the concrete lined channel, there is no aquatic or riparian vegetation present. The proposal would not result in direct or indirect impacts on aquatic or riparian vegetation.	N/A
Would the work require the disturbance or removal of any priority or environmental weeds listed in the *Hunter Regional Strategic Weed Management Plan 2017-2022*?	No	The proposal would not require the disturbance or removal of any priority or environmental weeds listed in the *Hunter Regional Strategic Weed Management Plan 2017-2022*.	N/A
Would the work impact on fish passage?	No	A search of the Fisheries NSW Spatial Data Portal (Department of Primary Industries, 2012) has shown that Winding Creek is not mapped as Key Fish Habitat (KFH) within the site, however KFH is mapped approximately 570m downstream of the site. Given the scope of the proposal, with works occurring on the channel banks and not in the base of the channel, the stormwater channel will remain operational and fish passage will not be impacted by the works.	Fisheries NSW Spatial Data Portal in September 2021
Would the work have potential to displace fauna or create a barrier to fauna movements?	No	The proposal does not require any vegetation clearing, and would not introduce any new structures or barriers into the environment, therefore would not displace fauna or create a barrier to fauna movements.	N/A

5.4 Noise and vibration

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Are there any sensitive receivers in the vicinity of the proposal? (e.g. residential,	Yes	A noise and vibration impact assessment (NVIA) was undertaken by Renzo Tonin in April 2022 (Appendix H) to assess the potential noise	NVIA (Appendix H)

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
schools, church, important native fauna populations)		and vibration impacts of the Proposal on the surrounding environment and sensitive receivers. A desktop land use survey was carried out to identify sensitive receivers in the vicinity of the Proposal. Neary sensitive receivers included residential lots, educational facilities, a church, commercial facility and a recreational facility. These receivers are further detailed in Appendix H.	
Could the proposal result in construction noise impacts for longer than three weeks, or outside of standard working hours? Was a quantitative noise assessment undertaken?	Yes	Long term unattended noise monitoring was conducted for a continuous period from 26 April to 6 May 2022, to measure ambient and background noise levels in the vicinity of residential receivers around the proposed works. A summary of the unattended noise monitoring results are included in Appendix H. Given the Proposal will result in construction for a duration longer than three weeks, a quantitative assessment has been carried out. No construction works are proposed outside of standard working hours.	NVIA (Appendix H)
Could the proposal result in noise impacts on receivers during construction?	Yes	During standard construction hours, residential receivers located near the Proposal site have the potential to be affected by works during various louder construction stages. Noise impacts would be greatest during usage of high noise generating plant and equipment, such as concrete saws and excavators with hydraulic hammers. This plant would be used during removal of the shared path and concrete channel, which represent a short duration in the overall works program. Nearby residences are likely to experience moderately intrusive levels of noise – between 10 dB(A) to 20 dB(A) above the Noise Management Level. No nearby residential receivers are predicted to be highly noise affected (i.e. > 75 dB(A)) across all stages of works. Up to 20 non-residential receivers are predicted to be impacted by the works, the most impacted being the surrounding active recreation receivers including the Cardiff Bowling Club.	NVIA (Appendix H)
Could the proposal result in noise impacts on receivers during operation?	No	Operation of the Proposal (the naturalised channel) would not introduce any new noise sources and would not permanently change existing background noise levels. The Proposal would not have any operational noise impacts.	NVIA (Appendix H)

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Could the proposal result in vibration impacts on nearby properties or infrastructure?	No	The Proposal would not result in any vibration impacts on nearby properties or infrastructure as a result of the works. The nearest residential receivers are approximately 60m from the Proposal site which is further than the minimum working distance for human comfort. There are no reinforced or unreinforced non-heritage structures within the minimum working distance for cosmetic damage (5m). There is one heritage item, the Former Colliery Tramway, which is within 12m of the southern structural works extent. Plant would be operated to ensure the minimum working distances are observed (ie 10 metres for an excavator) as identified in Table 4-9 in the NVIA. A 10-m exclusion zone would also be established from the heritage item and demarcated with flagging and a sign to ensure no vibratory plant would be operated within this zone.	NVIA (Appendix H)

5.5 Non-Aboriginal heritage

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Were all relevant heritage database searches carried out?	Yes	The search of the heritage registers identified one heritage item near the Proposal site: • Former Colliery Tramway, Heritage Item ID 1910043, located adjacent to the tributary which joins the existing stormwater channel along the south-western bank (as mapped in Appendix A). The tramway is of high to very high local heritage significance under the Lake Macquarie Local Environmental Plan 2014. During concept design phase, the extent of channel naturalisation works at Winding Creek were reduced and refined to avoid any direct disturbance to this heritage item, which is 11.8 metres from the extent of structural works. In accordance with advice in the NVIA, construction plant would not be operated within 10 metres of the heritage item, to avoid any potential indirect impact such as structural damage from ground-borne vibration.	NSW Heritage database (inventory) Lake Macquarie Local Environmental Plan 2014

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		The search indicated there are 10 other heritage items within 500m of the Proposal site (these heritage items have been mapped in Appendix D): • Cardiff Masonic Hall, Heritage Item ID 1910038, located approximately 280m north of the site at 4 Margaret Street, Cardiff • House, Heritage Item ID 1910039, located approximately 350m north of the site at 309 Main Road, Cardiff • Great Northern Railway, local heritage item ID 189, located approximately 230m north of the site • Former Doctor's Surgery, Heritage Item ID 1910036, located approximately 310m north of the site at 8 Michael Street, Cardiff • House, Heritage Item ID 1910037, located approximately 310m north of the site at 6 Michael Street, Cardiff • Brick Shops, Heritage Item ID 1910035, located approximately 290m north of the site at 281 Main Road, Cardiff • Row of 4 Shops with Cottages, Heritage Item ID 1910034, located approximately 280m north of the site at 275 and 279 Main Road, Cardiff • Former Miner's Cottage, Heritage Item ID 1910042, located approximately 470m north west of the site at 251 Main Road, Cardiff • St Kevin's Cottage, Heritage Item ID 1910040, located approximately 400m north west of the site at 230a Main Road, Cardiff • St Kevin's Church, Heritage Item ID 1910041, located approximately 440m north west of the site at 226 Main Road, Cardiff These heritage items are all located over 200m from the Proposal site and would therefore not be directly or indirectly impacted by the proposal, including from ground-borne vibration.	
Could the works impact on an item of heritage significance or a heritage conservation area?	No	The structural works extent for the proposal has been designed to avoid the extent of the Former Colliery Tramway local heritage item 189. Plant would not be operated within 10 metres of the heritage item, and an	N/A

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		exclusion zone with flagging and signage would be installed to ensure this does not occur. Therefore it is unlikely that the proposed works will impact on the identified heritage value. The construction mitigation measures listed in Section 6.1 will be implemented to ensure that no impacts are expected on the heritage item.	
Could the works impact on areas of archaeological potential?	No	The proposal would require excavation to remove turf and topsoil and soil behind the existing channel walls within the works extent. However, given the disturbed nature of the area from the established stormwater drainage infrastructure, the potential for unknown archaeological features is considered negligible.	N/A

5.6 Aboriginal heritage

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Would the work require ground disturbance?	Yes	The proposal would involve excavating to remove turf, topsoil and soil behind the existing channel walls within the structural works extent, to create the naturalised channel batter slopes. Ground disturbance would also be required to remove a section of the shared pathway which will be installed by Council alongside the channel	N/A
Has an Aboriginal Heritage Information Management System (AHIMS) search been completed and were any known Aboriginal items or places identified within or in the vicinity of the proposal site?	Yes	A search of the AHIMS Web Service has shown that: • 0 aboriginal sites are recorded in or near the Proposal site • 0 aboriginal places have been declared in or near the Proposal site	AHIMS searched on 1 September 2021
Would the work occur in or near sensitive landscape features as defined in the Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW (2010)?	No	The extent of the Proposal site does not coincide with any sensitive landscape features as defined in the Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW (2010).	N/A
Could harm to AHIMS listed sites or places or landscape features be avoided?	No	No known Aboriginal heritage sites have been identified within the site or within one kilometre of the site. Construction involving ground disturbances is limited to the extent of the structural works extent. Due to the extensive previous ground disturbance in this area due to the	N/A

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		initial construction of the stormwater channel, it is unlikely that any unknown Aboriginal heritage items would be identified.	

5.7 Traffic and access

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Would the works occur on a public road and could the proposal disrupt traffic flow or access during construction?	No	The proposal is located south of Myall Road and north of Newcastle Street which are both public roads. The works would not occur on the public roads however access to the construction site from the roads would be required which may cause short-term disruption to traffic flows. Access for construction plant and vehicles to the western section of the stormwater channel would be through William Street, and through Railway Parade for the eastern section. An alternative construction access path for the eastern section is through Mac Street. A 3.1m wide access ramp to the channel is proposed through Newcastle Street, which would provide only light vehicle access. All aforementioned streets are residential and would be frequented by residents and local through traffic. A Traffic and Pedestrian Management Plan would be prepared by the contractor to manage construction traffic. There would not be a high volume of traffic generated during construction (estimated peak period construction-related traffic of three heavy vehicles per hour) and impacts on public roads or access is not expected. Vehicles would park within the site compounds shown on Figure 1.. Impacts or disruptions to local traffic would not be expected as a result of the Proposal.	N/A
Could the proposal disrupt pedestrian or cycle access during construction?	Yes	The Proposal may result in minor disruptions to pedestrian or cycle access within the Proposal site. It is understood that Council are proposing to construct a shared pathway to the east of the channel, prior to the start of the Proposal construction works. Should this be completed prior to the Proposal as planned, a section of the shared pathway may need to be blocked off and diverted prior to construction to enable works on the channel banks. The general area around the Proposal may continue to be utilised by the public for walking and riding, as there	N/A

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		would be sufficient space to divert the public around the construction boundary. A Traffic and Pedestrian Management Plan would be prepared by the contractor as part of the CEMP to manage pedestrian movements.	
Could the proposal result in permanent changes to traffic flow or access during operation?	No	The Proposal would not result in any permanent changes to traffic flow or access following completion of work.	N/A
Could the proposal result in impacts on available parking during construction or operation?	No	The Proposal would not require the use of existing public parking areas during construction or operation.	N/A

5.8 Visual environment

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Could the proposal be visible by residential or other sensitive receivers?	Yes	The Proposal would be visible from residences and road users close to the vicinity of the Proposal site on Mac Street, James Street, Newcastle Street and Orchard Street during construction. Temporary worksites established during construction may have a short-term negative visual impact from nearby viewpoints, however, the long-term visual impact is a positive improvement in amenity for residences and road users. The works would also be visible to people undertaking recreational and sporting activities in the park and oval areas, however, these receivers are transient and impacts would be considered minor and temporary.	N/A
Would the proposal result in permanent changes to the visual environment through installation of any above ground infrastructure or removal of vegetation?	Yes	The Proposal would result in net positive, permanent changes to the current existing visual environment through the channel naturalisation and bank improvements. Proposed plantings south of Myall Road would provide a beneficial level of visual modification in the long-term for nearby residents and transient users of the park.	N/A
Would the work be located in an area of high scenic value?	No	The location of the Proposal is not located in an area of high scenic value as the existing site contains a highly modified stormwater drainage	N/A

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		channel. The Proposal would not be visually intrusive and would result in a positive impact on the scenic value of the area or views upon completion. The Proposal would be in keeping with the current surroundings.	
Would the work require additional lighting during construction or operation?	No	The Proposal would take place during standard construction hours and is not expected to require lighting during construction, except in the event of unplanned emergency works. There is no lighting included in the Proposal and so there would be no new lighting during operation.	N/A

5.9 Socioeconomic, land use and services

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Could the work impact private property including access?	No	The Proposal would not impact private property or access. The Proposal site is located within Wilkinson Park and would be accessed by residential streets. Access around the Proposal site would be maintained at all times.	N/A
Could the work impact busy commercial areas or local businesses?	No	Impacts on commercial areas or local businesses are not expected as a result of the Proposal.	N/A
Could the work result in a loss of an existing land use either during construction or operation?	Yes	The Proposal would result in a minor loss of existing land use. Under the Proposal, the stormwater channel is being benched back and widened into public space, including a public park, and Council-owned land, thus reducing its existing Public Recreation land use. The increased amenity of the naturalised channel is considered to somewhat compensate for the reduced land area.	N/A
Would the proposal result in the installation of a structure or facility that could be considered objectionable or a nuisance?	No	The Proposal would not be considered objectionable or a nuisance and would be consistent with the existing land use. The Proposal is in response to community feedback and a desire to naturalise Hunter Water drainage channels.	N/A
Would the work require disruption to water or sewerage services?	No	The Proposal would not disrupt water or sewer services. All water, stormwater, sewer and other utilities locations were identified within the	N/A

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		Proposal site. Design precautions have been taken to ensure all utilities have been avoided by works.	

5.10 Energy and air quality

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Could the work result in air quality impacts on sensitive receivers during construction or operation? (e.g. dust, odours)	Yes	The Proposal would have the potential to generate dust during construction. Given the minor nature of ground disturbance and distance to receivers, sensitive receivers are not expected to be impacted. Measures would be implemented to minimise the generation of dust during the work required (refer to Section 6.1). There would be no long-term potential for air quality impacts once the disturbed areas are stabilised.	N/A
Would the work involve the use of fuel-driven machinery or equipment (other than from vehicles transporting personnel to site)?	Yes	The Proposal would involve the use of a small number of fuel driven vehicles and equipment on site during construction. This would result in minor emissions.	N/A
Would the operation of the proposal result in high energy use and was energy use considered in the design development?	No	The operation of the Proposal would not result in a change in energy use.	N/A

5.11 Waste and resource use

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Would the work result in generation of 'non-hazardous' waste? If so, how would this be managed?	Yes	It is estimated that the Proposal would generate around 1,100m^3 of spoil due to the construction methodologies and the benching back of the channel walls. Spoil would be reused onsite if suitable and practical, or separated and sent for recycling or disposal at an appropriate facility in accordance with a Spoil Management Plan (Section 6.1). All waste generated from the proposal would be managed in accordance with the principles of waste minimisation. Waste materials would be	N/A

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
		classified and disposed of in accordance with the Waste Classification Guidelines.	
Would the work result in the generation of 'wastewater' (e.g. process wastewater, chlorinated water, sediment-laden water, drilling fluid, groundwater generated by drilling)?	Yes	If water is used for dust suppression, it would be applied in a controlled manner such that runoff would not be expected. Excavation works are likely to encounter groundwater, and therefore the proposal is expected to generate some wastewater (sediment-laden water). Water treatment options may enable the water to not be classified as 'wastewater'. Disposal options for extracted groundwater are described in Appendix F, and will depend on water quality parameters.	Appendix F
Would the work result in asbestos, contaminated soils or other hazardous waste?	No	No asbestos or other hazardous waste is expected to be generated from this proposal. Given the proposal is not in an ASS risk area, and there are no known contaminated sites in the vicinity of the Proposal site, no contaminated soils are expected to be generated during excavation and ground disturbance works either.	N/A
Have opportunities for waste reduction and/or reuse been considered?	No	Given the minimal resources required and potential waste generation, waste reduction opportunities were not considered.	N/A

5.12 Hazards and risks

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Would the proposal be located in a bushfire risk area or have potential to result in a bushfire risk?	No	The proposal is not located in a bushfire risk area and has no potential to result in a bushfire risk.	ePlanning Spatial Viewer – 25 April 2022
Would the work include handling hazardous chemicals or dangerous goods?	No	The proposal would not require the use of hazardous chemicals or dangerous goods.	N/A
Would the proposal be located in a coastal area that could be subject to coastal hazards?	No	The proposal is not located in a coastal area and therefore would not be susceptible to coastal hazards.	N/A

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Would the work result in any other hazards or risks to the environment?	No	The proposal would not result in hazards or risk to the environment subject to the implementation of the mitigation measures contained in section 6.	N/A

5.13 Cumulative impacts

Risk identification	Yes/No	Description of potential impact	Source and date (if relevant)
Could impacts from other projects interact with the proposal?	No	Given the minor nature and duration of the proposal, and the restriction of the construction impacts to the park, cumulative impacts as a result of other projects in the surrounding area (road rehabilitation at Thomas Street, Cardiff, and construction of a new footpath at Lachlan and Macquarie Roads, Cardiff) are not anticipated.	City of Lake Macquarie Development Application Tracker – 25 April 2022

6 ENVIRONMENTAL SAFEGUARDS AND OTHER REQUIREMENTS

6.1 Mitigation measures

This section provides a list of environmental mitigation measures to be implemented to reduce the potential for environmental impacts during the construction and operation of the proposal. The measures must be incorporated as conditions of contract in any contract or work specification for the proposal and a Construction Environmental Management Plan (CEMP) for the works.

Aspect	Ref no.	Mitigation measure
General	G1	A Construction Environmental Management Plan (CEMP) will be prepared prior to commencement of work and will address the following: • any requirements associated with statutory approvals • details of how the project will implement the identified safeguards outlined in the REF • issue-specific environmental management plans • roles and responsibilities • communication requirements • induction and training requirements • procedures for monitoring and evaluating environmental performance, and for corrective action • reporting requirements and record-keeping • procedures for emergency, incident and hazard management • procedures for audit and review. The endorsed CEMP will be implemented during the undertaking of the activity.
	G2	All personnel working on site will receive training to ensure awareness of environment protection requirements to be implemented during the project.
	G3	Potentially affected receivers will be notified of the work at least seven working days prior to commencement and provided with contact details in the event of a complaint.
	G4	Following any significant rainfall events, inspection of works will be undertaken during the two-year contractor maintenance period to detect any significant defects. Repairs of defects are to be undertaken as required.
Soils	S1	The CEMP prepared for the works is to include an erosion and sediment control plan (ESCP) which must include as a minimum the type and location of sediment/erosion controls to be used.
	S2	Erosion and sediment controls are to be implemented and maintained consistent with Managing Urban Stormwater: Soils and Construction. Fourth Edition ed. Sydney (NSW) (Landcom, 2004) (the Blue Book). Controls include: • be installed prior to disturbance commencing

Aspect	Ref no.	Mitigation measure
		• prevent sediment moving off-site and sediment laden water entering any watercourse, drainage line, or drain inlets • divert clean surface flow around exposed areas and stockpiles • reduce water velocity and capture sediment • minimise the amount of material tracked onto paved surfaces • be cleaned out before 30% capacity of controls is reached.
	S3	The CEMP for the works must have an unexpected finds protocol (UFP) for incidental potential contamination finds during earthworks and construction (such as illegally dumped wastes and stockpiles). The CEMP must detail works methodology to identify, manage, handle and dispose of any contaminated materials or wastes.
	S4	The CEMP must include mitigation measures for ASS to demonstrate how ASS would be managed and treated if encountered.
	S5	The CEMP must also outline the management of asbestos, in the event that asbestos is encountered.
	S6	Parking of vehicles and storage of plant/equipment is to occur in clearly designated existing cleared areas. Vehicles and machinery must not be parked on vegetated areas. Access will be on designated roads/tracks.
	S7	Plant and equipment will be thoroughly cleaned down prior to arrival/departure at the site to avoid introducing contaminants, soil and seeds and to prevent soil tracking onto roads
	S8	A Spoil Management Plan would be prepared by the contractor as part of the CEMP. Excavated material will be reinstated or reused on-site where possible. Where not possible to re-use, spoil material would be tested and disposed of at a suitable waste facility.
	S9	Weather forecasts will be checked regularly and scheduled to avoid heavy rain and flood events.
Hydrology and Water Quality	HWQ1	An Incident Management Plan (IMP) will be prepared as part of the Contractor's CEMP and will include a contingency plan and emergency procedures for dealing with the potential spillage of fuel or other environmental incidents that may occur on the work site. The IMP should also contain procedures dealing with the unexpected onset of rainfall during the work period.
	HWQ2	Regular visual monitoring of local water quality would be undertaken to identify potential turbidity from deficient erosion and sediment control measures, potential spills, or other water quality impacts.
	HWQ3	In the event of a sewage spill from the adjacent pipe during construction works, the Hunter Water project manager will be notified immediately so management controls can be implemented if required.
	HWQ4	A Flow Management Plan will set out the construction approach for working in the Winding Creek channel and how works, equipment and staff will be protected during storm events during construction. This would include how

Aspect	Ref no.	Mitigation measure
		construction will be sequenced and undertaken to minimise the potential for exposed banks to be scoured during the earthworks phase as a result of flash storm events.
	HWQ5	The water quality of dewatered groundwater will be tested to demonstrate whether it is suitable for release to the environment (either to Winding Creek channel or via local land application). The proposed testing requirements and water quality discharge criteria will be documented within the Dewatering Management Plan within the CEMP. Where water quality discharge or irrigation criteria are not achieved, groundwater shall be disposed of offsite at licensed liquid waste facility or to sewer in accordance with a trade waste agreement.
	HWQ6	A Dewatering Management Plan will be incorporated into the Contractor's CEMP to document requirements for dewatering during the project.
Biodiversity	B1	The contact details of the local wildlife rescue organisation (i.e. Native Animal Trust Fund / Hunter Wildlife Rescue 0418 628 483 and Port Stephens Koalas 1800 775 625 or 1800 PS Koalas) are to be documented in the CEMP and displayed in a prominent location e.g. on wall of site office in the event of offspring (e.g. nestlings) or injured fauna being encountered on-site.
	B2	Areas for materials/equipment lay-down and vehicle parking will be shown in the CEMP(s) and located in cleared or degraded areas that are outside of tree protection zones to prevent any damage to the surrounding vegetation or habitat.
	B3	Materials, plant and equipment will not be stored within the drip-lines of any trees at the site(s) or near the site(s).
	B4	To prevent damage to vegetation outside the boundaries of access tracks/roads and minimise the spread of weeds, vehicles and machinery will be restricted to designated access roads and tracks.
	B5	Where excavated soil is to be used in site restoration, it will be excavated and stockpiled in sequential layers corresponding to the existing soil profile. Topsoil and leaf litter is to be removed first and windrowed in separate signposted stockpiles of less than 1m in height on the upslope side of excavations. Soil layers will be replaced sequentially so that the soil profile is restored as closely as possible to its pre-work status.
	B6	Disturbed areas will be stabilised as soon as possible and in a progressive manner as works are completed.
	B7	During the operational phase, works will be periodically inspected in accordance with Hunter Water maintenance regime for weeds. Weed management will be undertaken as required.
	B8	No weed spray shall be used onsite. Weeds shall be pulled by hand in accordance with the technical specification, transported in a sealed container or bag and disposed at a licenced waste disposal facility.
	B9	Works would be undertaken generally in accordance with the Aboricultural Method Statement in Appendix G, including tree protection fencing, ground protection, precautions when working within TPZs, pruning, and site management.

Aspect	Ref no.	Mitigation measure
	B10	Tree protection fencing and signs would be erected and maintained in accordance with the illustrative specification found in Appendix 4 of the AIA (Appendix G).
	B11	Root zone and trunk protection would be undertaken in accordance with the illustrative specification provided in Appendix 5 of the AIA (Appendix G).
	B12	Works within the TPZ (which may include pruning, excavation, placement of fill, access, and soft landscaping) would be undertaken in accordance with the Guideline provided in Appendix 6 of the AIA (Appendix G).
	B13	Work stages indicated in the schedule in Appendix 7 of the AIA (Appendix G) (such as establishment of tree protection) must be certified by a Project Arborist. This may be undertaken via site inspection or via certification of photographic records.
Noise and Vibration	NV1	Provide at least seven (7) days' notice to affected receivers prior to starting work unless it is emergency works or it is discussed with the affected receivers face-to-face. Include the following information in notification letters: • a description of the works and why they are being undertaken • details of the works that will be noisy • work hours and expected duration • what is being done to minimise the impacts (e.g. respite periods) • 24 hour contact number.
	NV2	Works will be carried out during standard work hours (i.e. 7:00 am to 6:00 pm Monday to Friday and 8:00 am to 1:00 pm Saturday). For any work that is performed outside normal work hours or on Sunday or public holidays, the contractor must complete the Hunter Water OOHW Approval Form and adhere to the OOHW Construction Noise Guideline.
	NV3	Use quieter and less noise/vibration emitting construction methods where feasible and reasonable.
	NV4	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. • The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. • Plant and vehicles used intermittently to be throttled down or shut down when not in use. • Noise-emitting plant to be directed away from sensitive receivers.
	NV5	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site
	NV6	Minimise disturbance arising from stockpiling, laydown and deliveries: • Loading/unloading of deliveries, laydown and stockpile areas to be located as far as possible from sensitive receivers

Aspect	Ref no.	Mitigation measure
		• Delivery vehicles to be fitted with straps rather than chains where possible • Consider shielding of loading/unloading areas where close to sensitive receivers • Consider locating site sheds to shield nearby residences from airborne noise
	NV7	Personnel will be inducted and trained in noise control measures to reduce impacts on receivers during inductions and toolbox talks.
	NV8	A register of most affected noise and vibration sensitive receivers would be kept on site. The register would include the following details for each NVSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number.
	NV9	A complaint management procedure will be developed. Community complaints will be allocated to a responsible contractor representative immediately to facilitate investigation, respond to the complainant, review noise mitigation measures and to implement any corrective actions. The details of the complaint will also be circulated to the applicable construction personnel for action, where required.
	NV10	Construction vehicles including trucks will not be allowed to queue on local roads or if it is required for safety reasons, engines will be switched off.
	NV11	A 10-m exclusion zone would be established around the Former Colliery Tramway heritage item and demarcated with flagging and a sign to ensure no vibratory plant would be operated within this zone. Plant would be operated to ensure the minimum working distances are observed (vibration damage screening level of 2.5mm/s).
Aboriginal and Non-Aboriginal Heritage	H1	If Non-Aboriginal heritage items are discovered during the course of the project, all work will cease in the area and the Contractor will inform the Hunter Water Project Manager and Archaeologist as soon as possible. HWC will determine the preferred management approach and the local council and/or NSW Heritage Office will be notified via the HWC Project Manager if required.
	H2	In the event that an Aboriginal object (or objects) is uncovered during the proposed works, ground disturbance works would cease within 20 metres of the object(s) and the Hunter Water Archaeologist should be contacted. The Hunter Water Archaeologist would advise the Heritage Office and the relevant Aboriginal parties so that appropriate management strategies can be identified.
	H3	All parties involved in the proposed works are to be made aware that it is an offence under Section 86 of the NPW Act to harm or desecrate an Aboriginal object unless that harm or desecration is the subject of an Aboriginal Heritage Impact Permit (AHIP).

Aspect	Ref no.	Mitigation measure
	H4	In the unlikely event that human skeletal material is uncovered during the proposed construction works, all works should cease within 20 metres of the skeletal remains. Should the remains be verified as human, the NSW Police and OEH will be contacted. No works will proceed within the vicinity of the skeletal remains until an appropriate course of action has been determined in consultation with NSW Police, OEH and Aboriginal parties (if the remains are identified as Aboriginal).
Traffic and Access	TA1	A Traffic and Pedestrian Management Plan would be prepared by the contractor to manage construction traffic and pedestrian movements.
	TA2	Appropriate exclusion barriers, signage and site supervision will be employed at all times to ensure that the work site is controlled and that unauthorised vehicles and pedestrians are excluded from the works area.
	TA3	Movements of heavy vehicles would be restricted to standard work hours (i.e 7:00 am to 6:00 pm Monday to Friday and 8:00 am to 1:00 pm Saturday)
	TA4	Vehicle access routes to and within the site(s) are to be defined via 'paraweb' or other clearly visible and robust fencing.
	TA5	Current traffic movements and property accesses will be maintained during the works.
Visual Environment	VE1	Restore work sites as close to their original condition as possible at completion of the works.
	VE2	On completion of the works, all vehicles, construction equipment, materials, and refuse relating to the works will be removed from the work site(s) and any adjacent affected areas.
	VE3	Work areas are to be maintained, kept free of rubbish and cleaned up at the end of each working day.
Energy and Air Quality	EAQ1	Odour or air pollutant emission complaints will be dealt with promptly and the source will be eliminated wherever practicable.
	EAQ2	Equipment, machinery and vehicles used on site would be maintained to manufacturer's specifications to minimise potential emissions.
	EAQ3	Visually monitor dust and where necessary: • apply water (or alternate measures) to exposed surfaces that are generating dust • appropriately cover loads on trucks transporting material to and from the construction site • securely fix tailgates of road transport trucks prior to loading and immediately after unloading • avoid dust generating works during strong winds • prevent where possible, or remove, mud and dirt being tracked onto sealed road surfaces.

Aspect	Ref no.	Mitigation measure
Waste and Resource Use	WR1	A Waste Management Plan will be included in the CEMP, detailing works methodology to identify wastes or resources, segregate, store and transport them in accordance with relevant legislation and guidelines. The Contractor's recycling and reuse proposal will be detailed in the CEMP following the resource management hierarchy principles (in accordance with the Waste Avoidance & Resource Recovery Act 2001): • avoid unnecessary resource consumption as a priority • avoidance is followed by resource recovery (including reuse of materials, reprocessing, recycling and energy recovery) • disposal is undertaken as a last resort.
	WR2	Dispose of all excess material (that cannot be reused or recycled) as soon as practicable, to a facility licensed to accept the waste as per the waste classification results (tested by a suitably qualified person in accordance with the NSW Waste Classification Guidelines 2014). Evidence of the lawful disposal or reuse of waste will be retained and provided to the HWC Project Manager on request.
	WR3	Segregate and label waste to improve recycling opportunities, avoid cross contamination and reduce disposal costs.
	WR4	All temporary erosion and sediment control devices will be removed from the site at the completion of the works or when the site(s) are restored/stabilised.
Hazard and Risk	HR1	Emergency contacts will be kept in an easily accessible location. All workers will be advised of these contact details and procedures.

6.2 Licensing and other requirements

Approval Requirement	Timing	Attached	Responsible for obtaining
Water Supply Works (WSW) approval	Prior to construction	N	Hunter Water
Application under Section 138 of the Roads Act	Prior to construction	N	Hunter Water

No further licenses or approvals in addition to the Division 5.1 of the (EP&A Act) approval is required for the proposal.

7 CERTIFICATION

This REF provides a true and fair review of the proposal and its potential impacts on the environment in accordance with the environmental impact assessment requirements of the EP&A Act.

Prepared by:	Reviewed by:
	
Sajana Athukorala	Katie Schultz
Consultant	Manager
Date: 12 July 2022	Date: 13 July 2022

8 REFERENCE LIST

Aurecon, 2021a. CP3559 – SR00039 Stormwater Amenity Improvement Environmental Constraints Memo. September 2021

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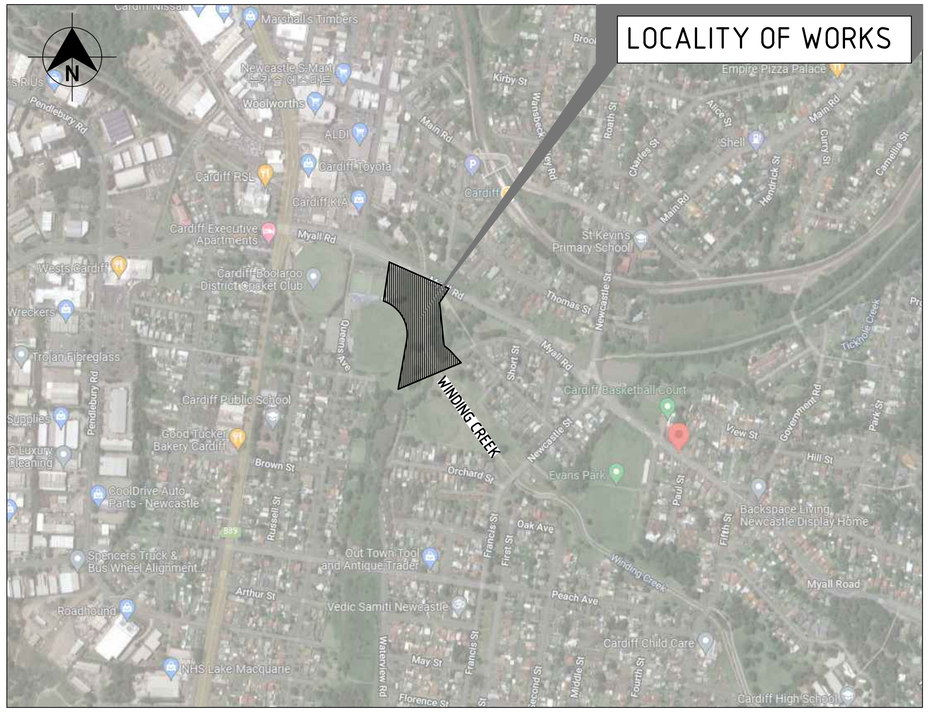
APPENDIX A

Design drawings

HUNTER WATER
STORMWATER AMENITY IMPROVEMENT – SITE L03
Winding Creek, Myall Road, Cardiff



LOCALITY PLAN

NTS

DRAWING INDEX

DRAWING No.	DRAWING TITLE
85223-16267-001	INDEX SHEET/DRAWING LIST AND LOCALITY PLAN
85223-16267-002	GENERAL NOTES
85223-16267-003	GENERAL ARRANGEMENT AND SETOUT PLAN SHEET 1
85223-16267-004	GENERAL ARRANGEMENT AND SETOUT PLAN SHEET 2
85223-16267-005	TYPICAL SECTIONS
85223-16267-006	TRANSITION WALL DETAIL
85223-16267-007	HEADWALL DETAIL
85223-16267-008	PLANTING PLAN SHEET 1
85223-16267-009	PLANTING PLAN SHEET 2
85223-16267-010	PLANTING LAYOUT DETAIL AND SPECIES LIST

CONSTRUCTION ISSUE

No.	REVISION DETAILS	DWN	DATE
0	CONSTRUCTION ISSUE	NN	05/08/22
B	100% DETAILED DESIGN ISSUE	NN	01/07/22
A	80% DETAILED DESIGN ISSUE	NN	25/05/22

CONSULTANT DETAILS:
Aurecon Australia Pty Ltd ABN 54 005 139 873
23 Warabrook Boulevard, Warabrook
NSW 2304 Australia
Telephone: +61 2 4941 5415
Email: newcastle@aurecongroup.com

CONSULTANT REFERENCE No.
521943 - HW DESP - SR00039

DESIGNED: SJ	DATE: 23/06/22	COMPANY: AURECON	
DRAWN: NN	DATE: 05/08/22	COMPANY: AURECON	
CHECKED: WL	DATE: 01/07/22	COMPANY: AURECON	
APPROVED: PG	DATE: 01/07/22	COMPANY: AURECON	

TITLE:
SR00039B
WINDING CREEK STORMWATER CHANNEL-MAIN CHANNEL

INDEX SHEET/DRAWING LIST AND LOCALITY PLAN

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
A1	NTS	85223	16267	001	0

VERSION 4

GENERAL NOTES:

1. THESE DRAWINGS ARE TO BE READ IN CONJUNCTION WITH OTHER PROVIDED REPORTS, TECHNICAL SPECIFICATIONS, SPECIFICATIONS AND WRITTEN INSTRUCTIONS ISSUED BY THE PRINCIPAL OR ITS REPRESENTATIVE.

2. ALL CONDITIONS CONTAINED WITHIN THE REVIEW OF ENVIRONMENTAL FACTORS (REF) AND ALL OTHER PLANNING APPROVAL DOCUMENTS FOR THIS PROJECT MUST BE COMPLIED WITH.

3. ALL CONSTRUCTION MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE RELEVANT SPECIFICATION FOR THE WORKS TOGETHER WITH THE REQUIREMENTS OF ALL RELEVANT CODES OF PRACTICE REFERRED TO THEREIN, THE REQUIREMENTS OF STATUTORY AUTHORITIES WHERE APPLICABLE AND ANY INSTRUCTIONS GIVEN BY THE PRINCIPAL.

4. CONSTRUCTION HOURS TO BE IN ACCORDANCE WITH THE REF.

5. ALL LOCATIONS, ORIENTATION, DIMENSIONS AND LEVELS SHALL BE VERIFIED ON SITE BEFORE COMMENCING ANY CONSTRUCTION OR FABRICATION WORK. IN THE EVENT OF ANY DISCREPANCIES, THE PRINCIPAL SHALL BE NOTIFIED WITHIN REASONABLE TIME.

6. UNLESS NOTE OTHERWISE:
   - ALL DIMENSIONS ARE IN MILLIMETRES
   - ALL CHAINAGES, STATIONS AND CO-ORDINATES ARE IN METRES
   - ALL REDUCED LEVELS ARE QUOTED RELATIVE TO AUSTRALIAN HEIGHT DATUM (mAHD)

7. EXISTING SERVICES SHOWN ON PLANS ARE NOT GUARANTEED COMPLETE OR CORRECT AND HAVE BEEN SOURCED INFORMATION SUPPLIED BY THE RELEVANT AUTHORITIES AND / OR FIELD INVESTIGATIONS. THE CONTRACTOR IS TO CONFIRM THE LOCATIONS AND LEVELS OF ALL EXISTING SERVICES PRIOR TO COMMENCING CONSTRUCTION AND MAKE ARRANGEMENTS WITH THE RELEVANT AUTHORITY TO RELOCATE OR ADJUST THESE SERVICES IF NECESSARY.

8. THE CONTRACTOR IS RESPONSIBLE FOR THE REPAIR OF ANY DAMAGE TO THE NATURAL ENVIRONMENT AND INFRASTRUCTURE INCLUDING SERVICES, STORMWATER AND CYCLEWAY INFRASTRUCTURE, SUCH REPAIR OR REINSTATEMENT IS TO BE CARRIED OUT IMMEDIATELY TO THE SATISFACTION OF THE PRINCIPAL.

9. THE CONTROL OF CREEK FLOWS AND STORMWATER FLOWS THROUGH AND AROUND THE WORKS DURING CONSTRUCTION SHALL BE IN ADHERENCE TO THE PRINCIPAL REQUIREMENTS AND WILL BE THE RESPONSIBILITY OF THE CONTRACTOR.

10. UNLESS DRAWINGS ARE IDENTIFIED AS "FOR CONSTRUCTION", THEY SHALL NOT BE USED FOR CONSTRUCTION PURPOSES.

11. NOMINATIONS OF A PROPRIETARY ITEM DOES NOT INDICATE EXCLUSIVE PREFERENCE BUT INDICATES THE REQUIRED PROPERTIES OF THE ITEM. SIMILAR ALTERNATIVES HAVING THE REQUIRED PROPERTIES MAY BE SUBMITTED FOR APPROVAL BY THE PRINCIPAL.

12. DO NOT OBTAIN DIMENSIONS BY SCALING FROM THE DRAWINGS.

13. REFER ANY DISCREPANCY TO THE PRINCIPAL BEFORE PROCEEDING WITH THE WORKS.

14. DURING CONSTRUCTION, THE CONTRACTOR SHALL ENSURE THAT THE STRUCTURES ARE MAINTAINED IN A STABLE CONDITION AND NO PART IS OVER STRESSED.

15. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL ENSURE THAT ANY NECESSARY FOUNDATION TREATMENT IS COMPLETED PRIOR TO COMMENCEMENT OF CONSTRUCTION OF THE STRUCTURES.

16. ABBREVIATIONS USED IN THESE DRAWINGS:

APPROX.	– APPROXIMATE
℄	– CONTROL LINE
CFW	– CONTINUOUS FILLET
CRS	– CENTRES
DIA	– DIAMETER
DWG	– DRAWING
DRG	– DRAWING
D/S	– DOWNSTREAM
FF	– FAR FACE
FSL	– FULL SUPPLY LEVEL

G	– GALVANIZED
LV	– LENGTH VARIES –
MIN	– MINIMUM
C.J	– CONSTRUCTION JOINT
CRJ	– CONTRACTION JOINT
NOM	– NOMINAL
PC	– PRECAST CONCRETE
PL	– PLATE
QTY	– QUANTITY
RC	– REINFORCED CONCRETE
REQ'D	– REQUIRED

REF	– REFERENCE LINE
REW	– REINFORCED EARTH WALL
RL	– REDUCED LEVEL
EL	– ELEVATED LEVEL
REINF	– REINFORCEMENT
S.S.	– STAINLESS STEEL
STN	– STATION
TYP	– TYPICAL
T.O.C	– TOP OF CONCRETE –
UNO	– UNLESS NOTED OTHERWISE
U/S	– UPSTREAM

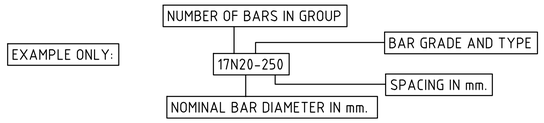
REINFORCEMENT:

1. STEEL REINFORCING MATERIALS SHALL COMPLY WITH AS/NZS 4671 (AS4671). REINFORCEMENT SHALL BE FABRICATED AND PLACED IN ACCORDANCE WITH AS3600 AND THE PROJECT'S TECHNICAL SPECIFICATION.

2. SYMBOLS ON DRAWINGS FOR GRADE AND TYPE OF REINFORCEMENT ARE AS FOLLOWS:

   N DENOTES GRADE 500 NORMAL DUCTILITY DEFORMED BAR TO AS4671
   R DENOTES GRADE 250 NORMAL DUCTILITY PLAIN ROUND BAR TO AS4671
   SL DENOTES GRADE 500 LOW DUCTILITY WELDED SQUARE MESH TO AS4671
   RL DENOTES GRADE 500 LOW DUCTILITY WELDED RECTANGULAR MESH TO AS4671

   DESIGNATION OF REINFORCEMENT BARS IS AS FOLLOWS:



   THE NUMBERS AND DISTRIBUTION OF BARS ARE INDICATED AS FOLLOWS (BY EXAMPLE):

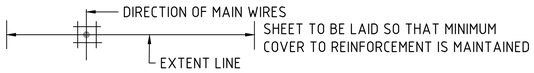
   20N32 INDICATES 20 GRADE 500N 32mm DIAMETER BARS.
   N20-200 INDICATES GRADE 500N 20mm DIAMETER BARS AT 200mm SPACING FOR THE EXTENT INDICATED.
   10N24-200 INDICATES 10 GRADE 500N 24mm DIAMETER BARS AT 200mm SPACING.

3. THE FOLLOWING ABBREVIATIONS APPLY TO THE LOCATION OF REINFORCEMENT:

B – DENOTES BOTTOM FACE	NF – DENOTES NEAR FACE
CP – DENOTES CENTRALLY PLACED	FF – DENOTES FAR FACE
T – DENOTES TOP FACE	H – DENOTES HORIZONTAL
EW – DENOTES EACH WAY	V – DENOTES VERTICAL
EF – DENOTES EACH FACE	

   COGS AND HOOKS TO BE STANDARD IN ACCORDANCE WITH AS3600.

4. MAIN WIRES OF FABRIC AND WIDTH OF SHEETS SHOWN IN FLOOR PLAN OR WALL ELEVATION THUS:



5. EXTENT OF BARS SHOWN THUS: EXTENT OF BARS SHOWN THUS:

6. REINFORCEMENT IS REPRESENTED DIAGRAMMATICALLY AND IS NOT NECESSARILY IN EXACT POSITION.

7. SPLICE REINFORCEMENT ONLY AT LOCATIONS SHOWN ON DRAWINGS OR AS APPROVED BY CONSTRUCTION MANAGER.

8. REINFORCEMENT SPLICES SHALL CONFORM TO THE FOLLOWING TABLE UNLESS NOTED OTHERWISE:

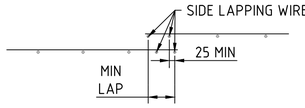
BAR SIZE:	N12	N16	N20	N24	N28	N32
a) HORIZONTAL BARS WITH >300mm OF CONCRETE CAST BELOW THE BAR:	460	650	940	1250	1580	1930
b) OTHER BARS:	350	500	720	960	1210	1490

9. WHERE THE BAR SIZES AT LAP VARY, THE LAP LENGTH SHALL BE BASED ON THE SIZE OF THE SMALLER BAR

10. REINFORCEMENT MAY BE DISPALCED SLIGHTLY WHERE NECESSARY TO CLEAR CLASHES WITH PROJECTING REINFORCEMENT, DOWELS, ETC.

11. STEEL MESH SPLICES SHALL BE MADE BY EITHER OF THE FOLLOWING METHODS:

(1) LAPPING OF STANDARD STEEL MESH WITHOUT SIDE LAPPING WIRES.



(2) LAPPING OF STEEL MESH WITH EDGE SIDE LAPPING WIRES

12. WELDING OF REINFORCEMENT IS ONLY PERMITTED WHERE SHOWN ON THE DRAWINGS OR OTHERWISE APPROVED BY WELDING OF REINFORCEMENT IS ONLY PERMITTED WHERE SHOWN ON THE DRAWINGS OR OTHERWISE APPROVED BY THE PRINCIPAL. WHERE WELDING OF REINFORCEMENT IS APPROVED, IT SHALL BE CARRIED OUT IN ACCORDANCE WITH AS 1554, PART 3.

13. DOWELS SHALL BE SAWN TO LENGTH. IN SKEWED JOINTS, DOWELS SHALL BE ALIGNED WITH THE LONGITUDINAL REINFORCEMENT. DOWEL ALIGNMENT TO BE MAINTAINED BY USE OF A SUPPORT ASSEMBLY SUITABLE TO ENSURE A HORIZONTAL AND VERTICAL TOLERANCE OF 1 IN 100.

CONCRETE:

1. OTHERWISE SPECIFIED IN DRAWINGS, A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF REINFORCED CONCRETE SHALL BE 32MPa.

2. CONCRETE EXPOSURE CLASSIFICATION: B1

3. NOMINAL COVER TO REINFORCEMENT NEAREST TO THE CONCRETE SURFACE SHALL BE 50mm, UNO.

4. CONCRETE SUPPLY AND CONSTRUCTION TO BE IN COMPLIANCE WITH HUNTER WATER SPECIFICATION STS 104.

5. NO-FINES CONCRETE WORK TO BE IN COMPLIANCE WITH HUNTER WATER SPECIFICATION STS 404 IN CONJUCTION WITH TfNSW QA SPECIFICATION 3222 FOR NO-FINES CONCRETE MIX .

LEGEND:

- ROCK WORKS
- INDICATIVE PROPOSED SHARED PATH ALIGNMENT (WORKS BY OTHERS)
- PLANTING
- PLANTING ZONE WC1
- PLANTING ZONE WC2
- HERITAGE TRAM WAY
- CONSTRAINT OFFSETS
- FENCING
- SETOUT POINT
- ROCK RIP RAP
- SELECT BACKFILL
- BEDDING LAYER
- TOP SOIL
- SUBGRADE
- NO-FINES CONCRETE
- MASS CONCRETE
- EROSION CONTROL MATTING
- GEOTEXTILE
- TURF

EXISTING LEGEND:

- W — WATER SERVICES
- S — SEWER SERVICES
- E — ELECTRIC SERVICES
- T — COMMS SERVICES
- G — GAS SERVICES
- 12.00 — EXISTING CONTOUR
- EXISTING FENCING
- SEWER MANHOLE

CONSTRUCTION ISSUE

No.	REVISION DETAILS	DWN	DATE
0	CONSTRUCTION ISSUE	NN	05/08/22
B	100% DETAILED DESIGN ISSUE	NN	01/07/22
A	80% DETAILED DESIGN ISSUE	NN	25/05/22

CONSULTANT DETAILS:
Aurecon Australia Pty Ltd ABN 54 005 139 873
23 Warabrook Boulevard, Warabrook
NSW 2304 Australia
Telephone: +61 2 4941 5415
Email: newcastle@aurecongroup.com

CONSULTANT REFERENCE No.
521943 – HW DESP – SR00039

HUNTER WATER

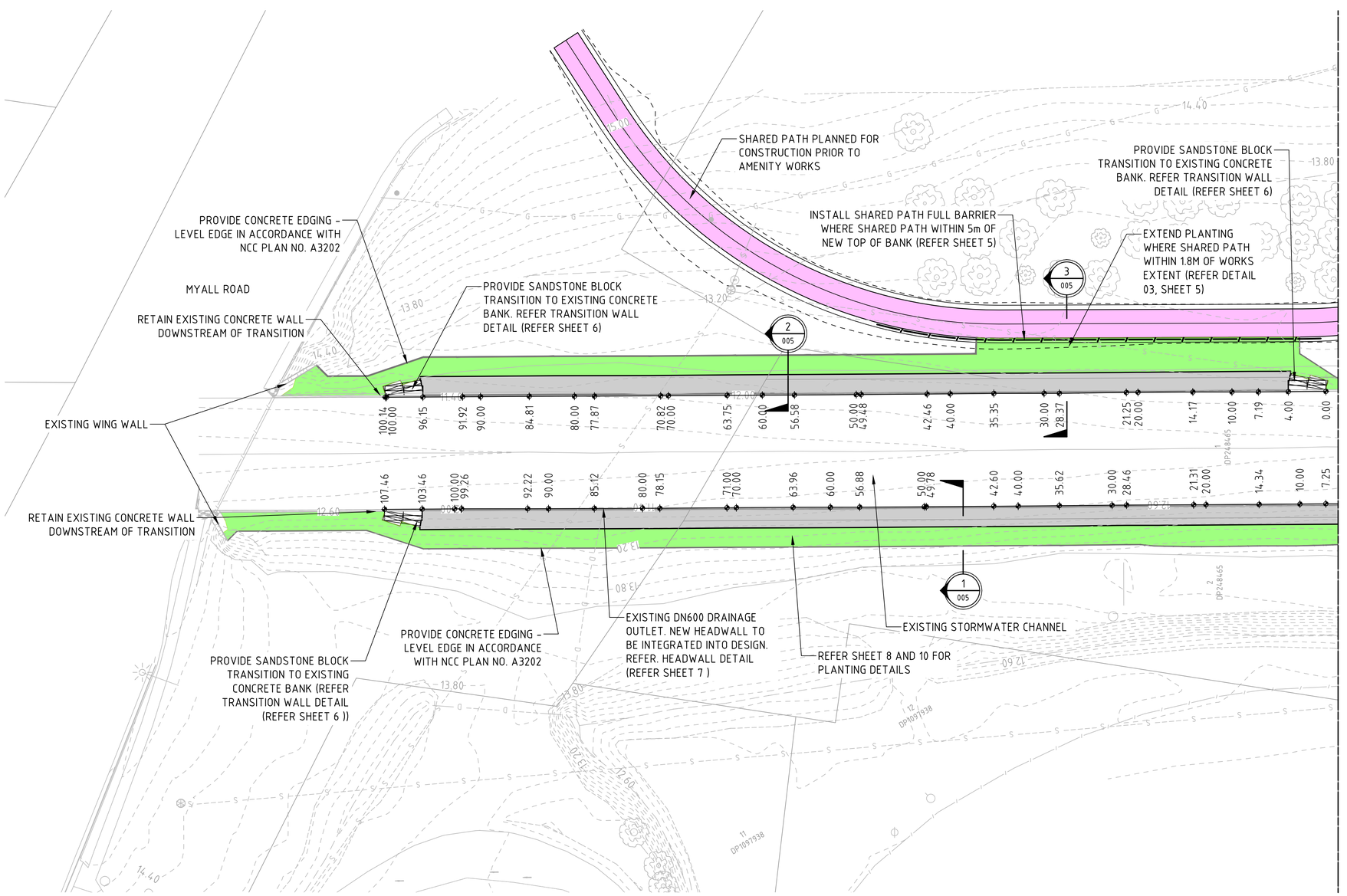
DESIGNED: SJ	DATE: 23/06/22	COMPANY: AURECON	
DRAWN: NN	DATE: 05/08/22	COMPANY: AURECON	
CHECKED: WL	DATE: 01/07/22	COMPANY: AURECON	
APPROVED: PG	DATE: 01/07/22	COMPANY: AURECON	

TITLE:
SR00039B
WINDING CREEK STORMWATER CHANNEL–MAIN CHANNEL

GENERAL NOTES

SIZE:	SCALE:	INDEX No.	DRAWING No.	SHEET	REV No.
A1	NTS	85223	16267	002	0

VERSION 4



LEGEND

- ROCK WORKS
- INDICATIVE PROPOSED SHARED PATH ALIGNMENT (WORKS BY OTHERS)
- PLANTING
- HERITAGE TRAM WAY
- MASS CONCRETE
- FENCING
- SETOUT POINT

EASTERN BANK CONTROL LINE SETOUT TABLE

POINT	CHAINAGE	EASTING	NORTHING
1	0.00	374829.982	6354080.501
2	3.99	374829.962	6354084.4929
3	7.25	374829.949	6354087.747
4	10.00	374829.9236	6354090.5011
5	14.34	374829.8835	6354094.8426
6	20.00	374829.8552	6354100.5008
7	21.31	374829.8487	6354101.8130
8	28.46	374829.8112	6354108.9585
9	30.00	374829.7963	6354110.5006
10	35.62	374829.7423	6354116.1199
11	40.00	374829.7081	6354120.5002
12	42.60	374829.6878	6354123.0970
13	49.78	374829.6391	6354130.2836
14	50.00	374829.6376	6354130.5000
15	56.88	374829.5882	6354137.3797
16	60.00	374829.5819	6354140.4998
17	63.96	374829.5738	6354144.4636
18	70.00	374829.5342	6354150.4997
19	71.00	374829.5277	6354151.5021
20	78.15	374829.4731	6354158.6475
21	80.00	374829.4641	6354160.4994
22	85.12	374829.4392	6354165.6204
23	90.00	374829.4297	6354170.4993
24	92.22	374829.4254	6354172.7222
25	99.26	374829.4090	6354179.7563
26	100.00	374829.4046	6354180.4993
27	103.46	374829.3840	6354183.9573
28	107.46	374829.3555	6354187.9600

WESTERN BANK CONTROL LINE SETOUT TABLE

POINT	CHAINAGE	EASTING	NORTHING
1	0.00	374841.9149	6354087.7405
2	4.00	374841.8834	6354091.7416
3	7.19	374841.8583	6354094.9263
4	10.00	374841.8553	6354097.7403
5	14.17	374841.8507	6354101.9055
6	20.00	374841.8100	6354107.7402
7	21.25	374841.8013	6354108.9854
8	28.37	374841.7126	6354116.1139
9	30.00	374841.7088	6354117.7396
10	35.35	374841.6964	6354123.0880
11	40.00	374841.6577	6354127.7394
12	42.46	374841.6373	6354130.1970
13	49.48	374841.5785	6354137.2184
14	50.00	374841.5751	6354137.7391
15	56.58	374841.5328	6354144.3149
16	60.00	374841.5132	6354147.7389
17	63.75	374841.4918	6354151.4872
18	70.00	374841.4498	6354157.7387
19	70.82	374841.4443	6354158.5617
20	77.87	374841.4069	6354165.6063
21	80.00	374841.4007	6354167.7385
22	84.81	374841.3866	6354172.5505
23	90.00	374841.3515	6354177.7384
24	91.92	374841.3386	6354179.6545
25	96.15	374841.3155	6354183.8847
26	100.00	374841.2972	6354187.7382
27	100.14	374841.2965	6354187.8804

CONSTRUCTION ISSUE

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HUNTER WATER

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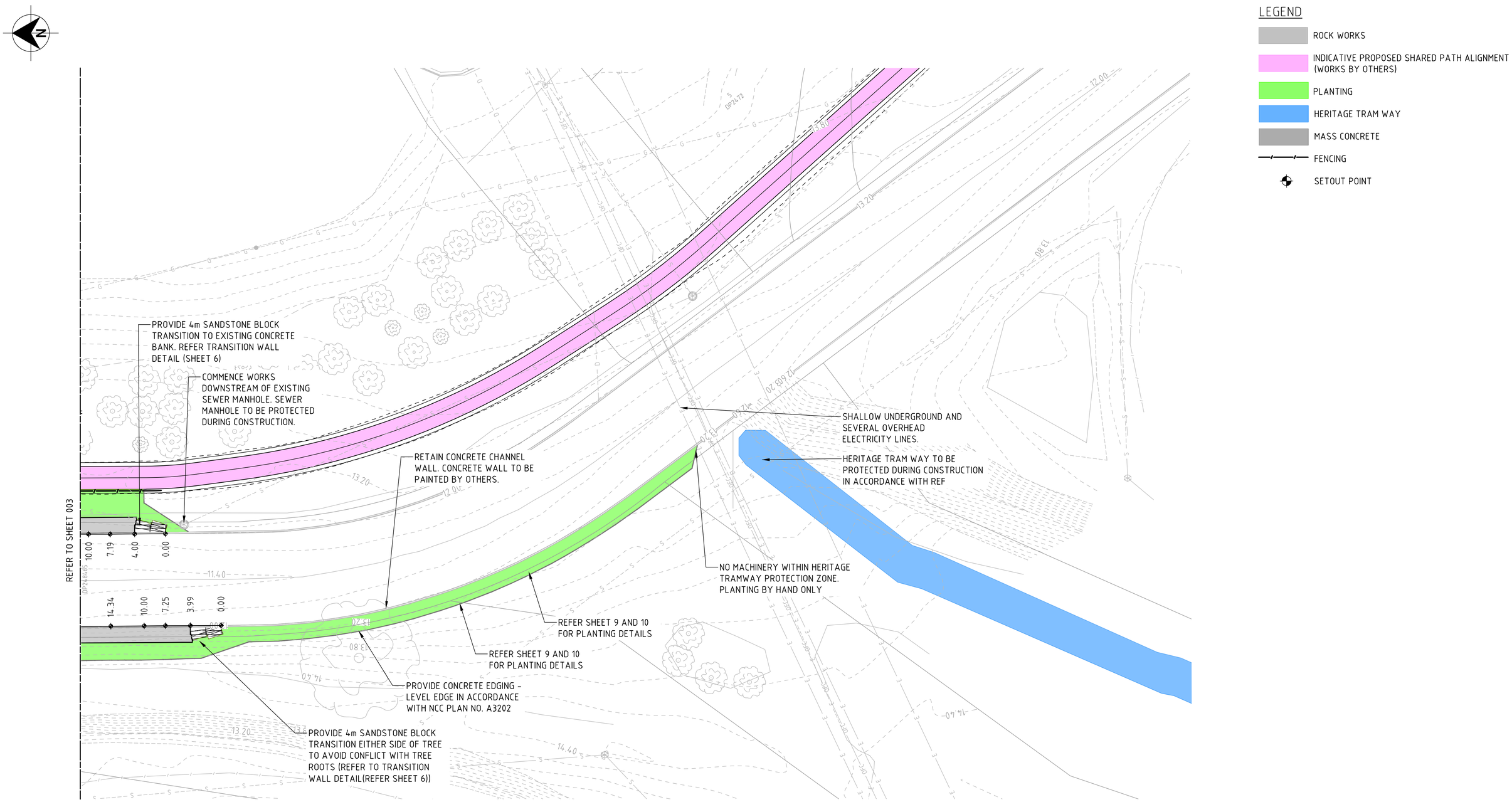
TITLE:
SR00039B
WINDING CREEK STORMWATER CHANNEL-MAIN CHANNEL

GENERAL ARRANGEMENT AND SETOUT PLAN
SHEET 1

SIZE:	SCALE:	INDEX No.	DRAWING No.	SHEET	REV No.
A1	1:250	85223	16267	003	0

VERSION 4



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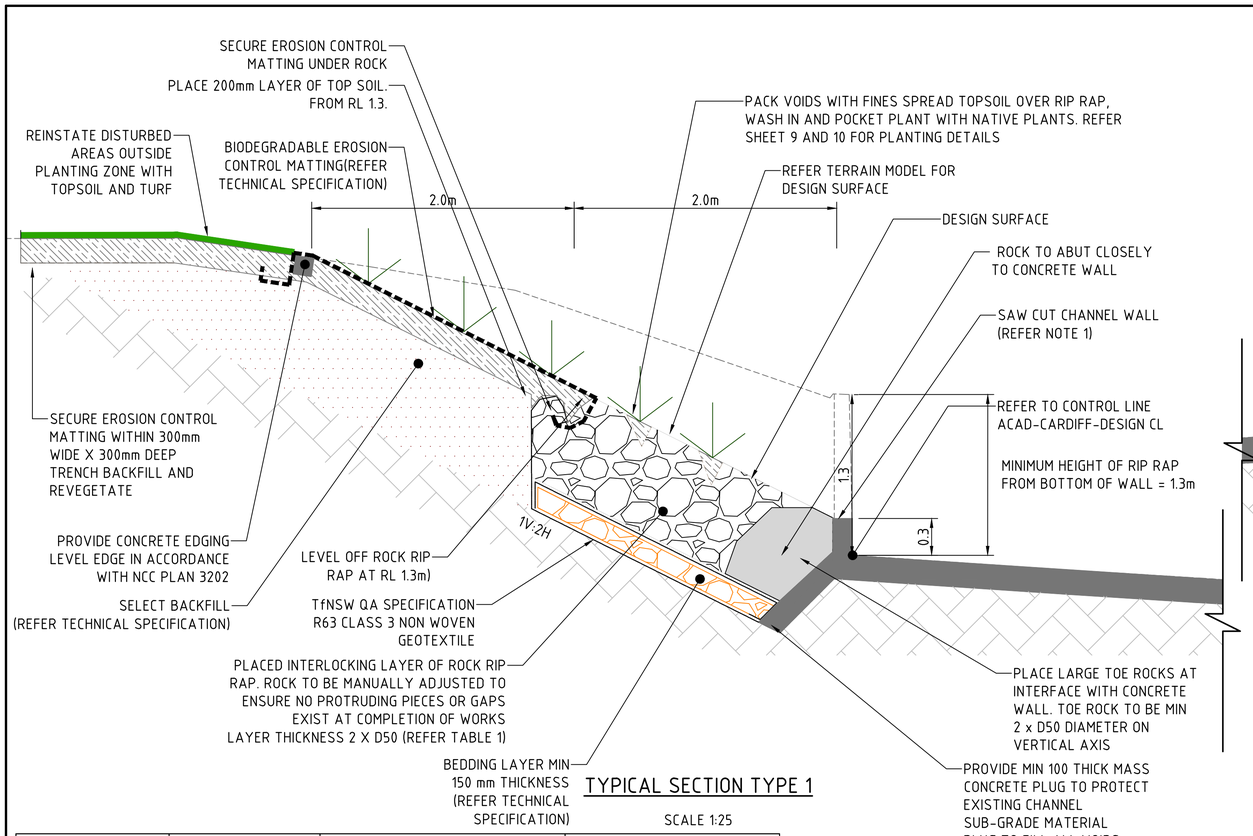
TITLE:
SR00039B
WINDING CREEK STORMWATER CHANNEL-MAIN CHANNEL

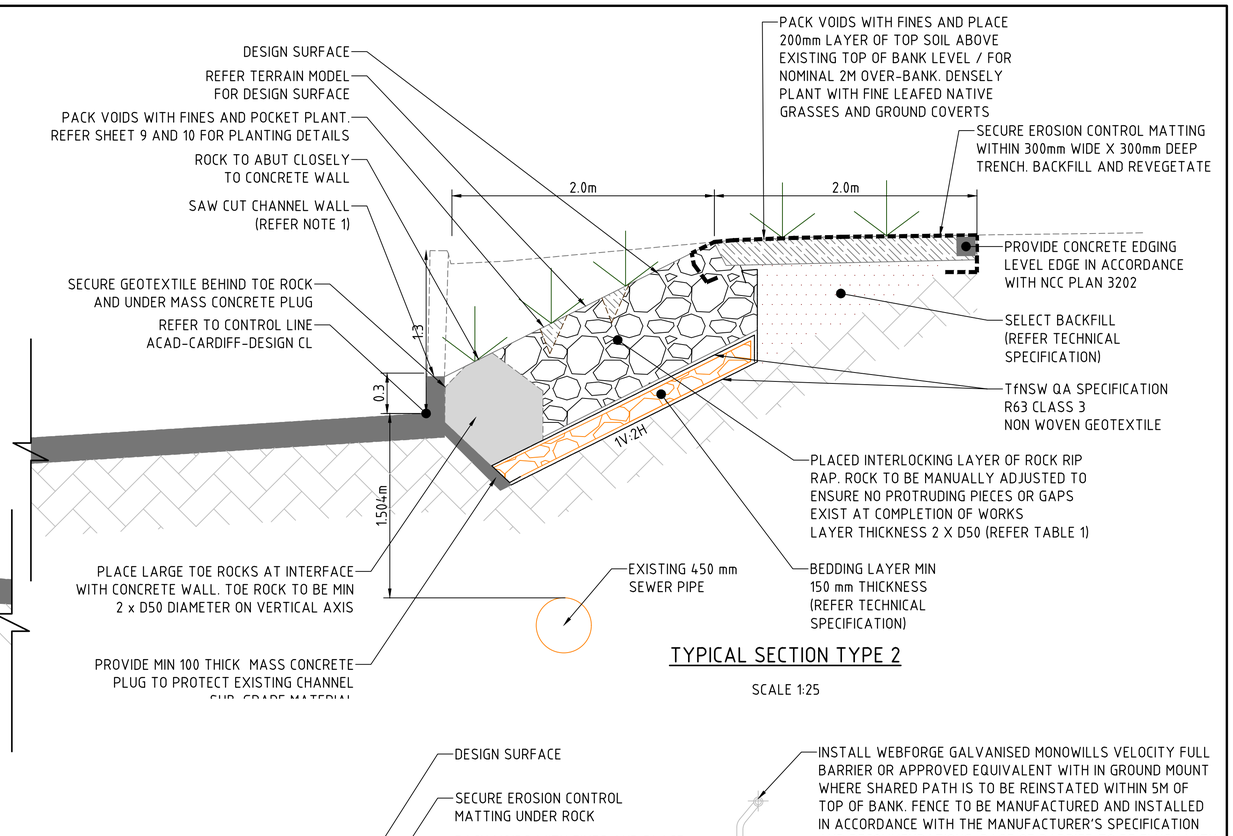
GENERAL ARRANGEMENT AND SETOUT PLAN
SHEET 2

SIZE:	SCALE:	INDEX No.	DRAWING No.	SHEET	REV No.
A1	1:250	85223	16267	004	0



TYPICAL SECTION TYPE 1

SCALE 1:25



TYPICAL SECTION TYPE 2

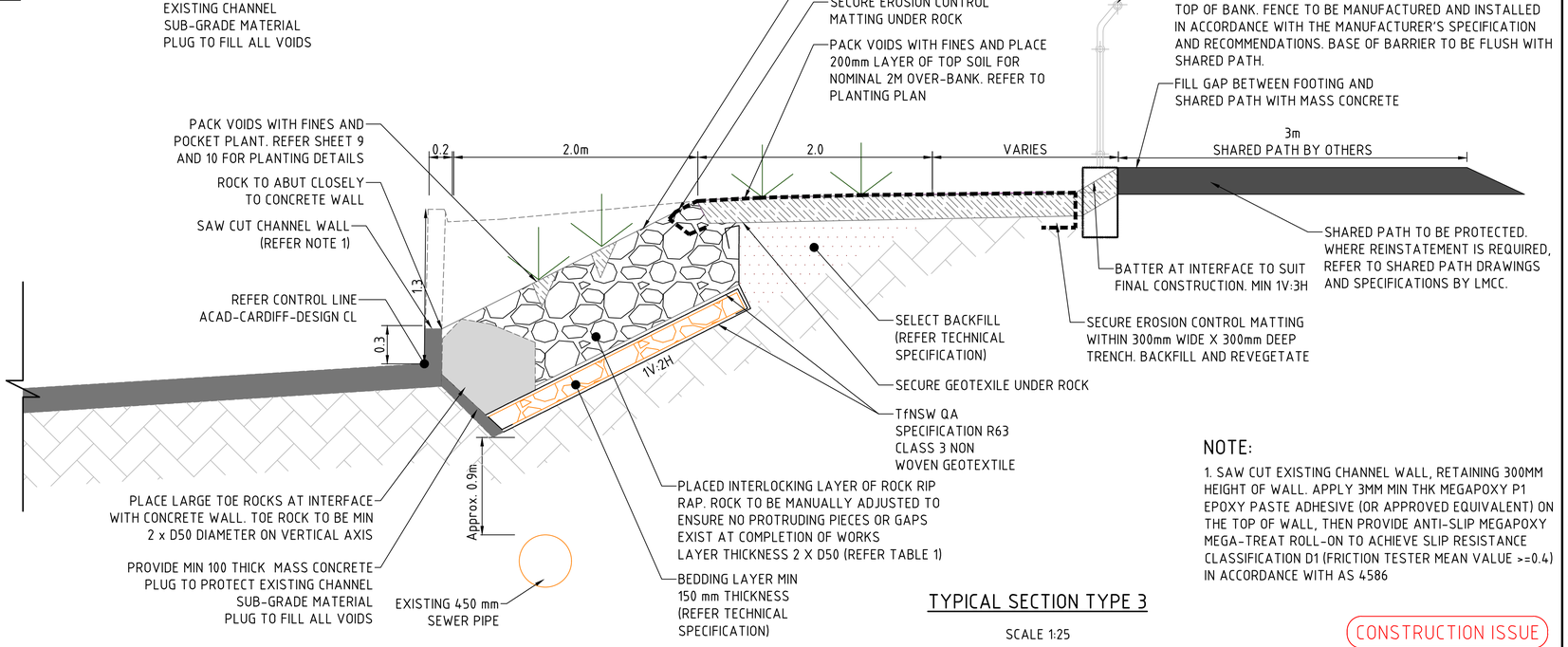
SCALE 1:25

START CHAINAGE	END CHAINAGE	WEST BANK RIPRAP SIZING (D50mm)	SECTION TYPE
0	4	N/A	TRANSITION
4	10	400	TYPICAL SECTION TYPE 1
10	103.46	300	TYPICAL SECTION TYPE 1
103.46	107.46	N/A	TRANSITION

START CHAINAGE	END CHAINAGE	EAST BANK RIPRAP SIZING (D50mm)	SECTION TYPE
0	4	N/A	TRANSITION
4	37.21	300	TYPICAL SECTION TYPE 3
37.21	96.14	300	TYPICAL SECTION TYPE 2
96.14	100.14	N/A	TRANSITION

LEGEND

- ROCK RIP RAP
- SELECT BACKFILL
- BEDDING LAYER
- TOP SOIL
- SUBGRADE
- MASS CONCRETE
- EROSION CONTROL MATTING
- GEOTEXTILE
- TURF



TYPICAL SECTION TYPE 3

SCALE 1:25

NOTE:

1. SAW CUT EXISTING CHANNEL WALL, RETAINING 300MM HEIGHT OF WALL. APPLY 3MM MIN THK MEGAPOXY P1 EPOXY PASTE ADHESIVE (OR APPROVED EQUIVALENT) ON THE TOP OF WALL, THEN PROVIDE ANTI-SLIP MEGAPOXY MEGA-TREAT ROLL-ON TO ACHIEVE SLIP RESISTANCE CLASSIFICATION D1 (FRICTION TESTER MEAN VALUE >=0.4) IN ACCORDANCE WITH AS 4586

CONSTRUCTION ISSUE

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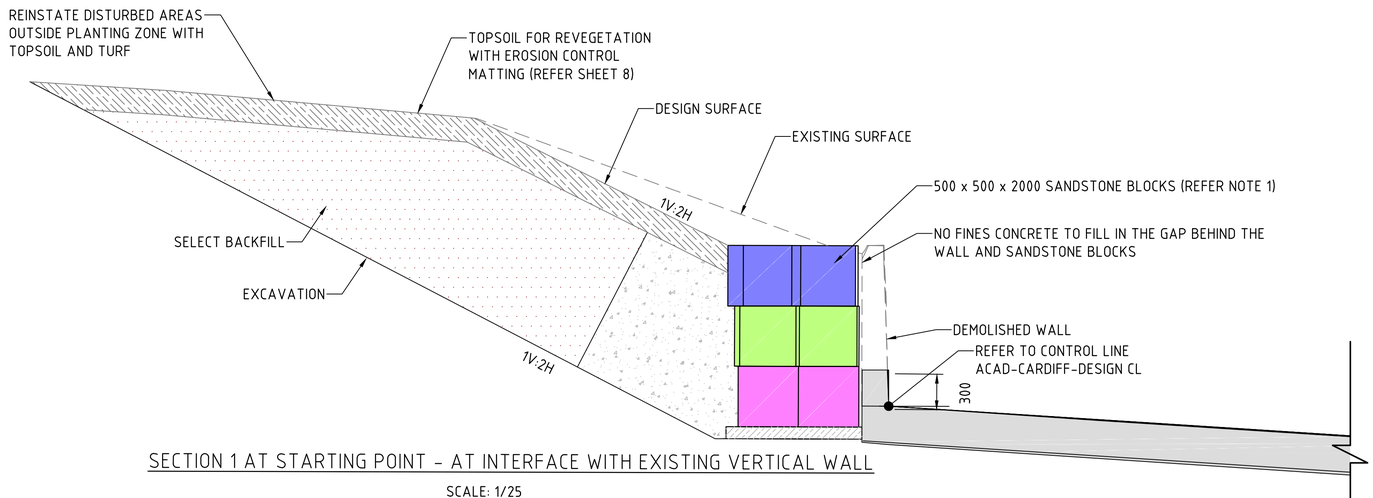
TITLE:
SR00039B
WINDING CREEK STORMWATER CHANNEL-MAIN CHANNEL

TYPICAL SECTION
DETAIL

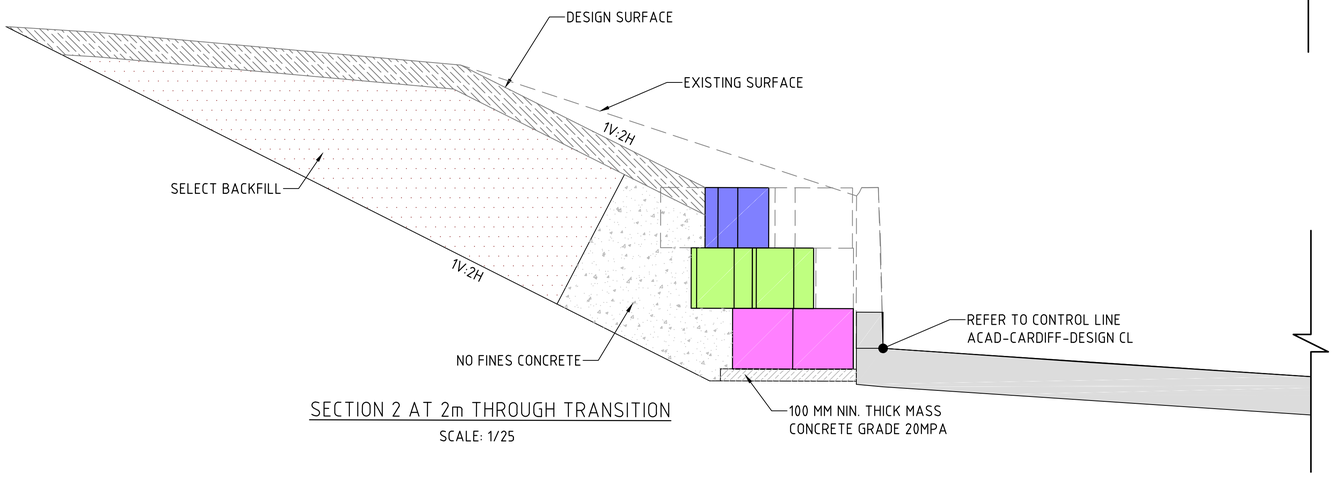
SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
A1	1:50	85223	16267	005	0

VERSION 4



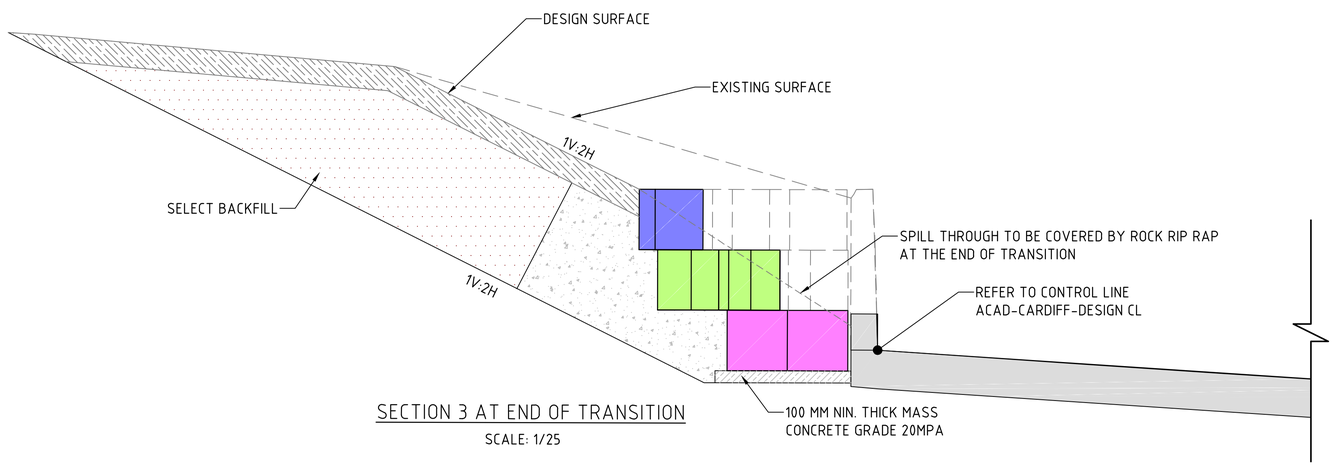
SECTION 1 AT STARTING POINT - AT INTERFACE WITH EXISTING VERTICAL WALL

SCALE: 1/25



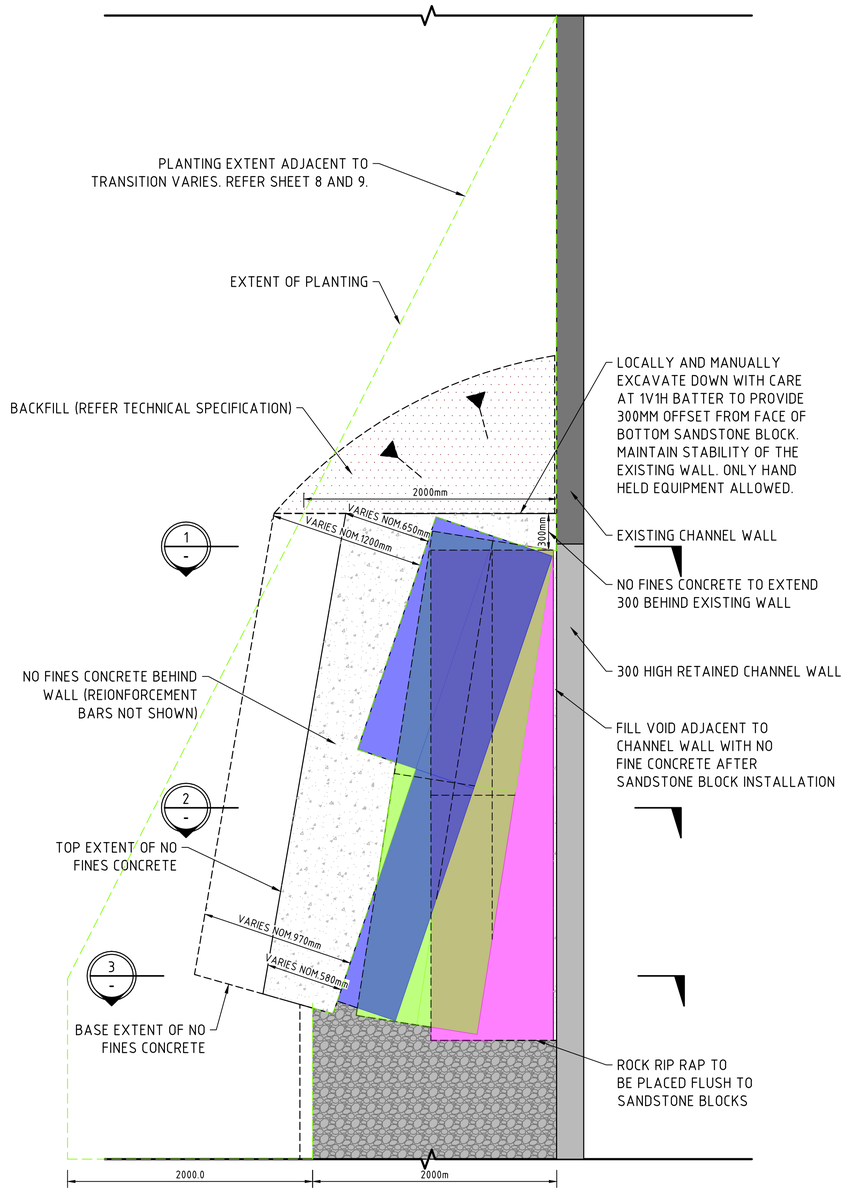
SECTION 2 AT 2m THROUGH TRANSITION

SCALE: 1/25



SECTION 3 AT END OF TRANSITION

SCALE: 1/25



CONSTRUCTION ISSUE

No.	REVISION DETAILS	DWN	DATE
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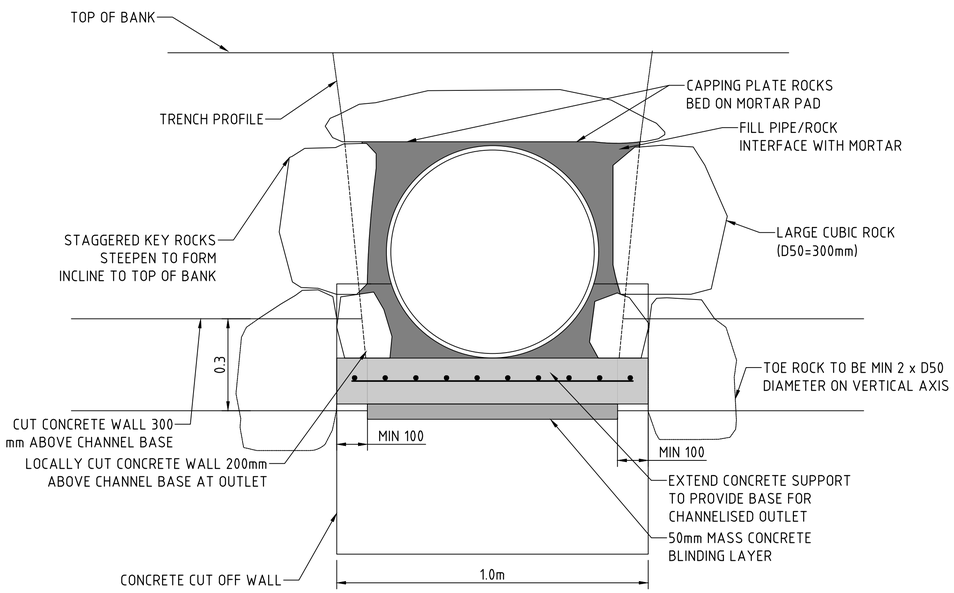
TITLE:
SR00039B
WINDING CREEK STORMWATER CHANNEL-MAIN CHANNEL

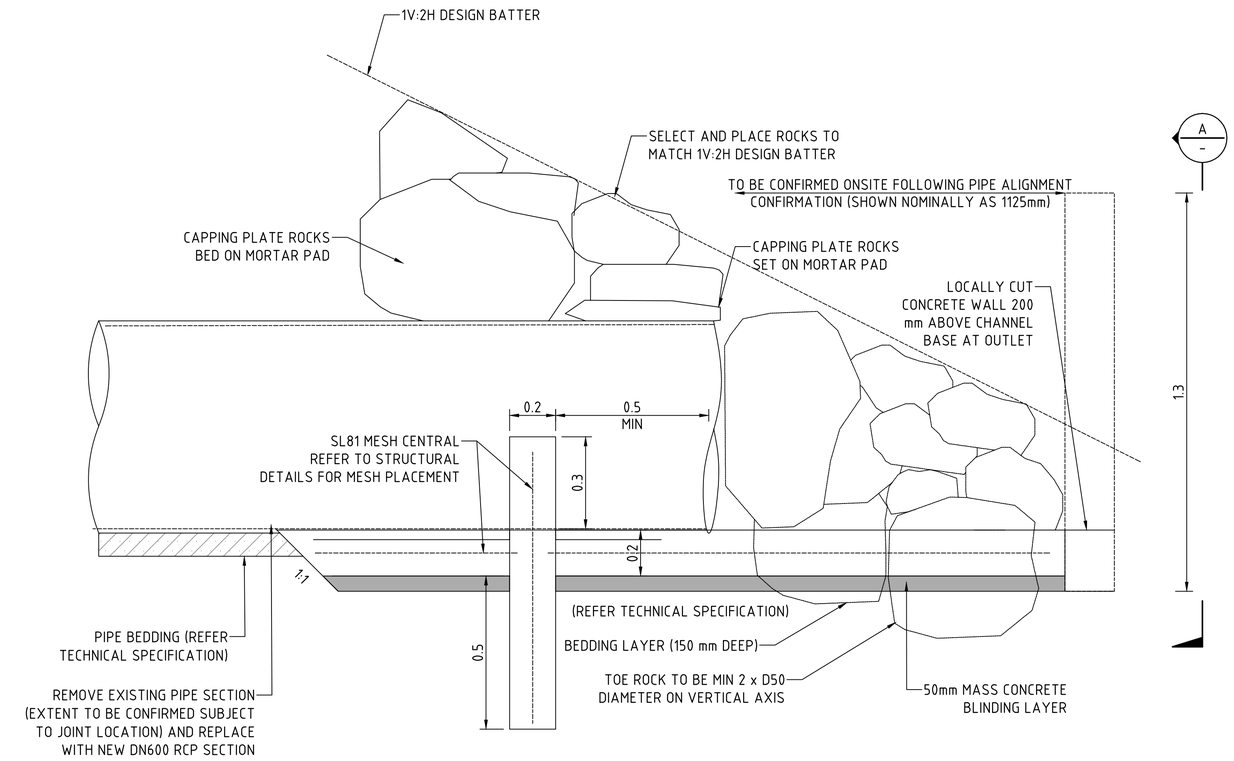
TRANSITION WALL TYPICAL SECTIONS AND PLAN

SIZE:	SCALE:	INDEX No.	DRAWING No.	SHEET	REV No.
A1	NTS	85223	16267	006	0

VERSION 4



VIEW A-A



SECTION

STORMWATER PIPE HEADWALL TYPICAL DETAIL

NTS

CONSTRUCTION ISSUE

No.	REVISION DETAILS	DWN	DATE
0	CONSTRUCTION ISSUE	NN	05/08/22
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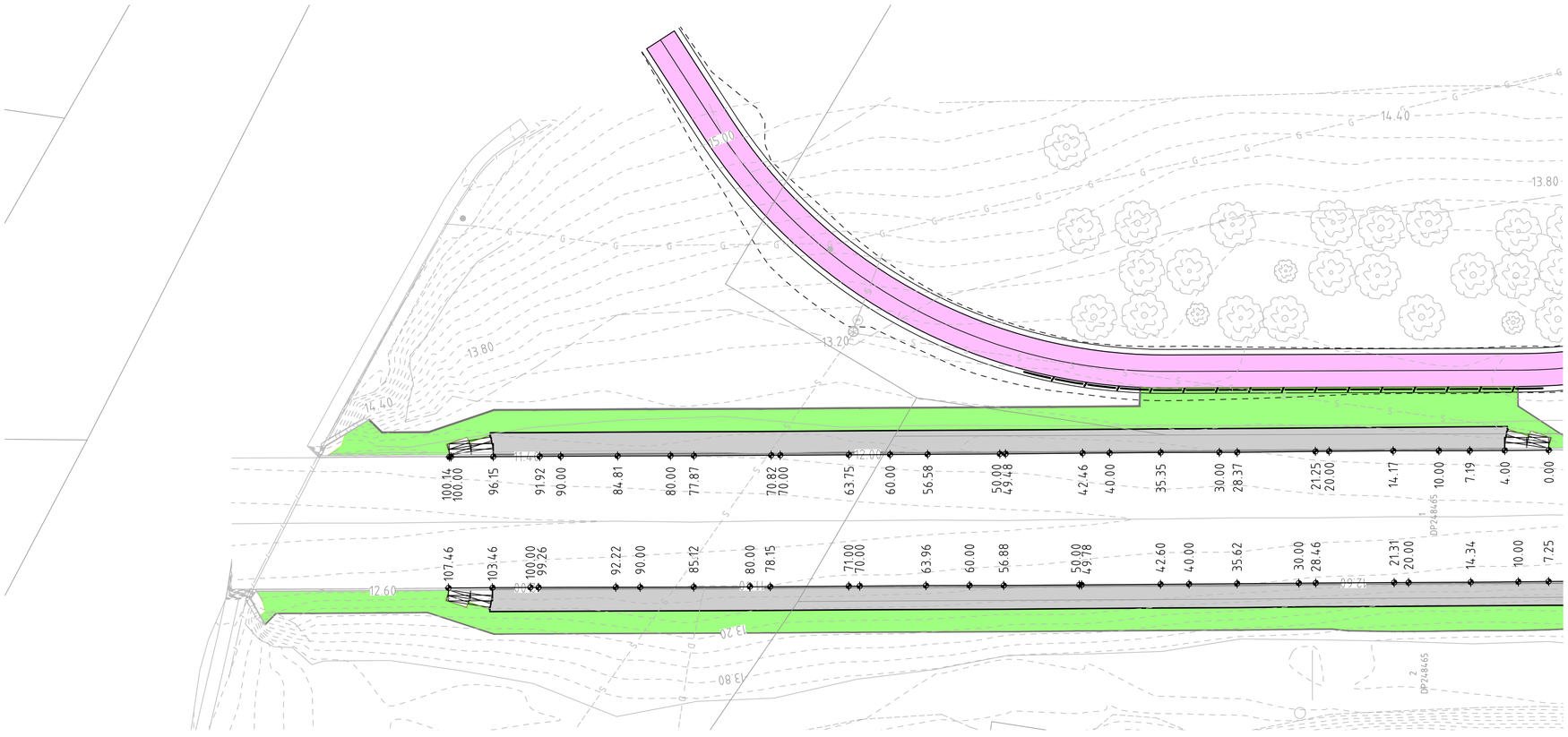
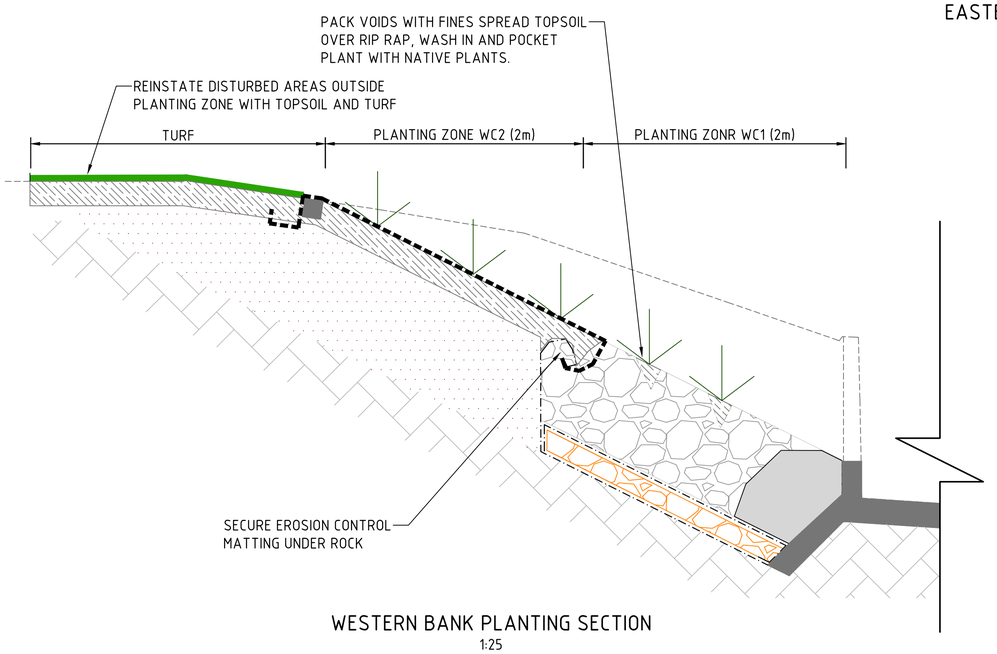
TITLE:
SR00039B
WINDING CREEK STORMWATER CHANNEL-MAIN CHANNEL

HEADWALL
DETAIL

SIZE:	SCALE:	INDEX No.	DRAWING No.	SHEET	REV No.
A1	NTS	85223	16267	007	0



EASTERN BANK PLANTING SECTION
1:25



WESTERN BANK PLANTING SECTION
1:25

PLANTING ZONE	DESCRIPTION	DENSITY	SPECIES
WC1	LOWER BANK POCKET PLANTING	REFER SPECIES LIST (SHEET 10)	REFER SPECIES LIST (SHEET 10)
WC2	UPPER BANK /OVERBANK PLANTING	REFER SPECIES LIST (SHEET 10)	REFER SPECIES LIST (SHEET 10)

CONSTRUCTION ISSUE

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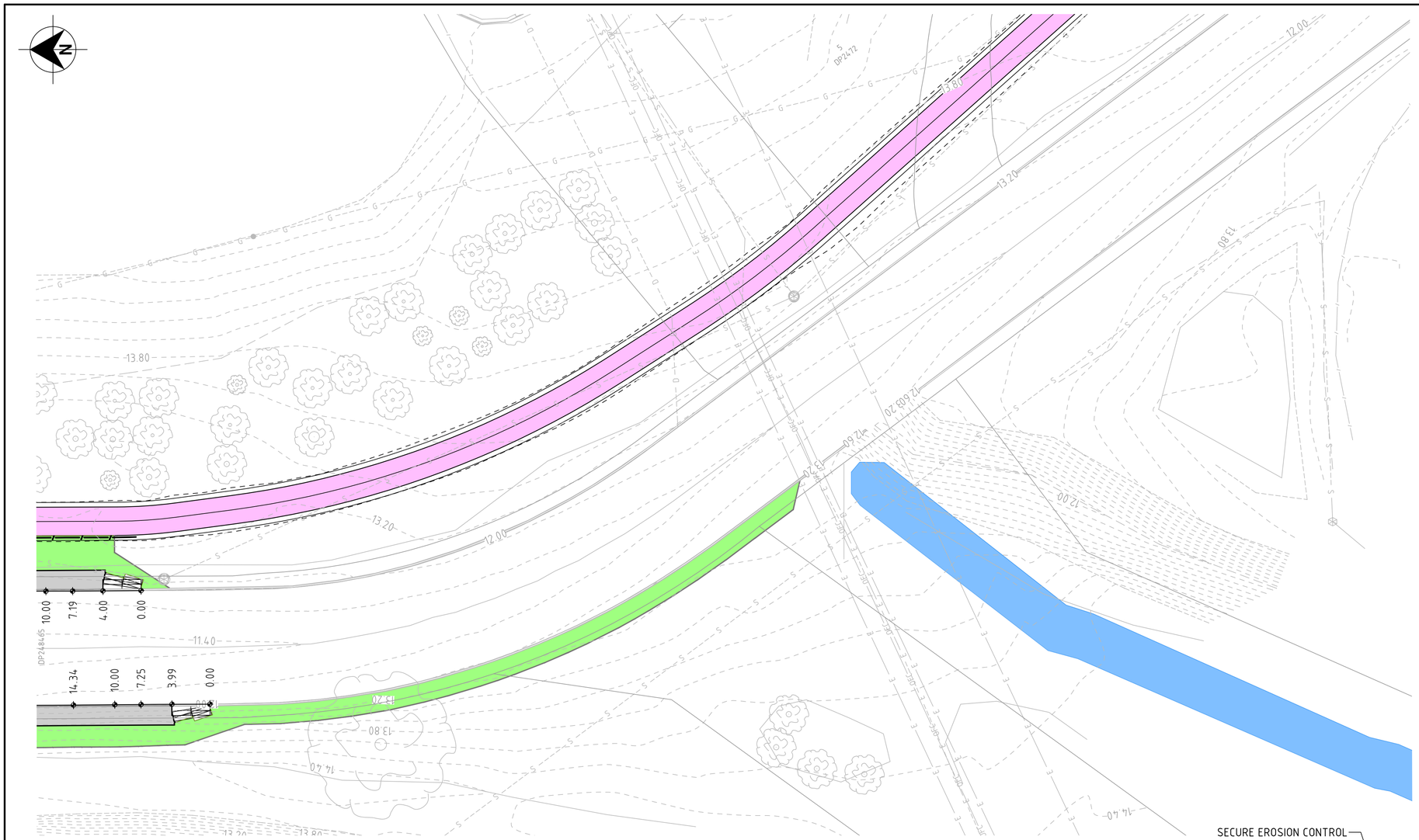
TITLE:
SR00039B
WINDING CREEK STORMWATER CHANNEL-MAIN CHANNEL

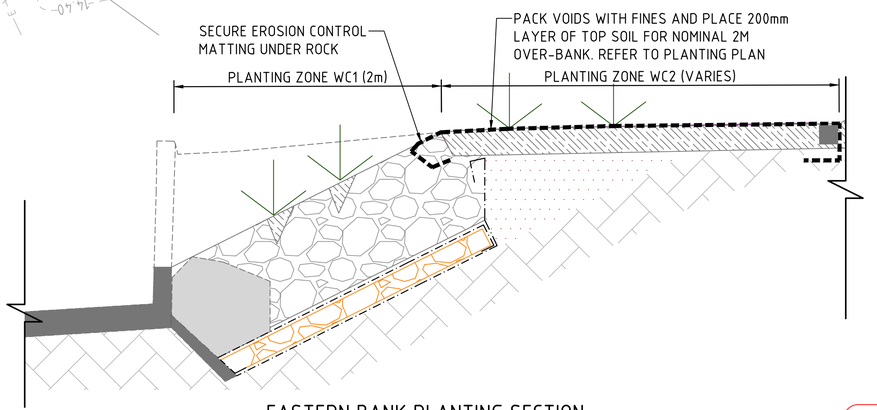
PLANTING PLAN
SHEET 1

SIZE:	SCALE:	INDEX No.	DRAWING No.	SHEET	REV No.
A1	1:250	85223	16267	008	0

VERSION 4



PLANTING ZONE	DESCRIPTION	DENSITY	SPECIES
WC1	LOWER BANK POCKET PLANTING	REFER SPECIES LIST (SHEET 10)	REFER SPECIES LIST (SHEET 10)
WC2	UPPER BANK /OVERBANK PLANTING	REFER SPECIES LIST (SHEET 10)	REFER SPECIES LIST (SHEET 10)



EASTERN BANK PLANTING SECTION
1:25

CONSTRUCTION ISSUE

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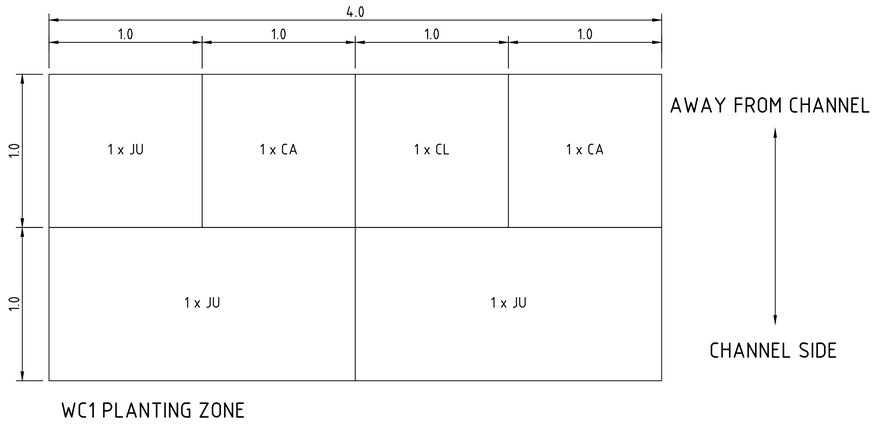
WINDING CREEK STORMWATER CHANNEL-MAIN CHANNEL

PLANTING PLAN
SHEET 2

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
A1	1:250	85223	16267	009	0

VERSION 4

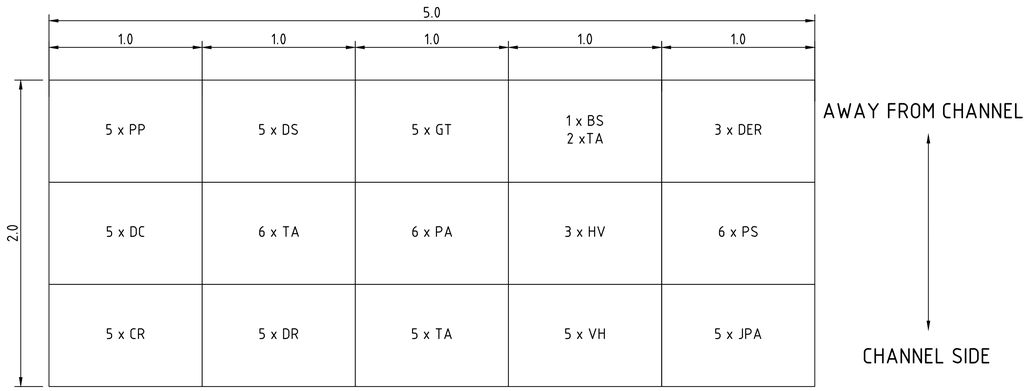


WC1 PLANTING ZONE

SCALE 1:20

WC1 PLANTING ZONE

SCIENTIFIC NAME	COMMON NAME	POT
Carex appressa (CA)	Tussock Grass	Tube
Carex longebrachiata (CL)	Drooping Sedge	Tube
Juncus usitatis (JU)	Common Rush	Tube



WC2 PLANTING ZONE

SCALE 1:20

WC2 PLANTING ZONE

SCIENTIFIC NAME	COMMON NAME	POT
Cymbopogon refractus (CR)	Barbed Wire Grass	Tube
Dampiera stricta (DS)	Blue Dampiera	Tube
Dianella caerulea (DC)	Blue Flax Lily	Tube
Dianella revoulta (DR)	Flax Lily	Tube
Desmodium rhytidophyllum (DeR)	Rusty Tick-Trefoil	Tube
Gonocarpus tetregynus (GT)	Common Raspwort	Tube
Hardenbergia violacea (HV)	Happy Wanderer	Tube
Joycea Pallida (syn Rytidosperma pallidum) (JP)	Red-Anther Wallaby Grass	Tube
Banksia Spinulosa (BS)	Hairpin Banksia	Tube
Lomandra hystrix (LH)	Lucky Stripe	Tube
Themeda australis (TA)	Kangaroo Grass	Tube
Panicum simile (PS)	Two Colour Panic	Tube
Pratia purpurascens (PP)	White Root	Tube
Poa affinis (PA)	Tussock Grass	Tube

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Telephone: +61 2 4941 5415
Email: newcastle@aurecongroup.com

CONSULTANT REFERENCE No.
521943 - HW DESP - SR00039

HUNTER WATER

DESIGNED: SJ	DATE: 23/06/22	COMPANY: AURECON	
DRAWN: NN	DATE: 05/08/22	COMPANY: AURECON	
CHECKED: WL	DATE: 01/07/22	COMPANY: AURECON	
APPROVED: PG	DATE: 01/07/22	COMPANY: AURECON	

TITLE:
SR00039B
WINDING CREEK STORMWATER CHANNEL-MAIN CHANNEL

PLANTING LAYOUT AND SPECIES

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
A1	1:20	85223	16267	010	0

APPENDIX B

Clause 171(2) factors and matters of national environmental significance

Clause 171(2) checklist

The following factors listed in section 171(2) of the *Environmental Planning and Assessment Regulation 2021* have been considered to assess the likely impacts of the proposal on the environment.

Factor	Impact
(a) the environmental impact on a community? There would be potential for short-term negative impacts on the community during construction of the proposal including noise, air and minor visual impacts. Potential visual amenity impact during construction would include the placement and movement of construction vehicles and stockpile areas within the proposal area. Construction noise would be generated from construction activities and vehicles. Air quality impacts would result from dust and vehicle emissions. These impacts would likely occur for the duration of construction. Measures have been proposed to minimise these potential impacts (refer to Section 6.1).	Short-term negative
(b) the transformation of a locality? Construction of the proposal would temporarily impact the existing locality, predominantly through a negative visual, noise and air quality impacts, associated with the placement and movement of construction plant and equipment and construction compounds. The proposal would result in improved amenity for the stormwater system by replacing the concrete channel banks with natural materials and providing planting adjacent to Myall Road. Thus increasing the value of the waterway and encouraging more recreational activity by the local community.	Short-term, minor, negative Long-term, minor, positive
(c) the environmental impact on the ecosystems of a locality? The proposal would not result in the removal of any vegetation or impact on the ecosystems of a locality.	Nil
(d) reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality? During construction, the proposal would have the potential to create a reduction in the overall aesthetic and recreational quality of the immediate proposal area due to the equipment associated with construction, dust and noise generation. However, impacts would be minimised as far as practicable through the implementation of safeguards outlined in Section 6.1. No scientific or other qualities of the proposal area are anticipated to be impacted during the construction or operation of the proposal. The proposal would improve the aesthetic and recreational quality and value of the environment through naturalisation of the stormwater system and plantings, providing longer-term beneficial outcomes to the local community.	Short-term, minor, negative Long-term, minor, positive

Factor	Impact
(e) the effects on a locality, place or building that has – **i. aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance** **ii. other special value for present or future generations** The proposal would not have any effect on locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historic, scientific or social significance or other special values.	Nil
(f) impact on habitat of any protected animals (within the meaning of the *Biodiversity Conservation Act 2016*)? The proposal is not anticipated to endanger any species of animal, plant or other form of life. Any potential biodiversity impacts associated with the proposal would be mitigated through the implementation of safeguards outlined in Section 6.1. The proposal would not impact any habitat of any protected animals within the meaning of the BC Act.	Nil
(g) the endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air? The proposal is not anticipated to endanger any species of animal, plant or other form of life. There are no biodiversity impacts anticipated from the proposal. Any potential impacts will be mitigated through the implementation of mitigation measures outlined in Section 6.1.	Nil
(h) long-term effects on the environment? There would be a positive long-term impact on the environment through the channel naturalisation and planting. This would create a more natural ecosystem and may encourage fauna and aquatic vegetation to establish in the area.	Long-term, positive
(i) degradation of the quality of the environment? The proposal has the potential to degrade the quality of the environment through accidental spills and erosion and sediment impacts during construction. Soil and erosion impacts associated with the proposal would be minor and short-term, and mitigated through the implementation of mitigation measures outlined in Section 6.1.	Short-term, minor, negative
(j) risk to the safety of the environment? There would be a minor risk to the safety of the environment during construction of the proposal in the event of an accidental release of sediment to the environment.	Short-term, minor, negative
(k) reduction in the range of beneficial uses of the environment? Beneficial uses of the environment would increase in the long-term due to the proposal. Improving the amenity of the stormwater system will increase the value of the waterway and encourage more recreational activity by the community.	Long-term, positive
(l) pollution of the environment? The proposal would have the potential to result in some minor negative short-term water pollution risks including from sediments, soil nutrients, concrete, and waste. Management of water quality impacts would be carried out in accordance with the safeguards and mitigation measures outlined in Section 6. Short-term noise and air quality impacts (dust and exhaust emissions) would be expected during the construction of the proposal. Management	Short-term, minor, negative

Factor	Impact
of noise and air quality impacts would be carried out in accordance with the safeguards and mitigation measures summarised in Section 6. The operation of the proposal would not alter the air quality from the existing conditions.	
(m) environmental problems associated with the disposal of waste? Waste associated with the proposal would be managed in accordance with the *Waste Avoidance and Resource Recovery Act 2001* and recycled where possible or disposed of by a license contractor at a license facility. Issues associated with the disposal of waste are not expected.	Nil
(n) increased demands on resources, natural or otherwise which are, or are likely to become, in short supply? The proposal would not result in an increase in demand for resources which are, or are likely to become, short in supply.	Nil
(o) the cumulative environmental effect with other existing or likely future activities? Given the minor nature and duration of the proposal, cumulative impacts would not be expected with identified developments.	Nil
(p) the impact on coastal processes and coastal hazards, including those under projected climate change conditions? The proposal is not located within a coastal area and would not result in any impact on coastal processes and coastal hazards.	Nil
(q) applicable local strategic planning statements, regional strategic plans or district strategic plans made under the Act, Division 3.1 The expected outcomes of the proposal following the amenity improvement works around the stormwater channel align with the objectives of the Hunter Regional Plan 2036. The proposal enhances quality of life within the local community by creating attractive public spaces.	Long-term, positive
(r) other relevant environmental factors No other relevant environmental factors.	Nil

Matters of National Environmental Significance

The following matters of national environmental significance have been considered as required by the environmental assessment provisions of the EPBC Act. This review assists in determining whether the proposal should be referred to the Australian Government Department of the Environment and Energy.

Environmental factor	Impact
Any impact on a World Heritage property? There would be no impact to World Heritage properties by the proposal.	Nil
Any impact on a National Heritage place? There would be no impact to National Heritage places by the proposal.	Nil
Any impact on a wetland of international importance (often called 'Ramsar' wetlands)? There would be no impact to wetlands of international importance by the proposal.	Nil
Any impact on nationally threatened species, ecological communities or migratory species? The proposal would not impact any nationally threatened species, ecological communities or listed migratory species.	Nil
Any impact on a Commonwealth marine area? There would be no impact to Commonwealth marine areas by the proposal.	Nil
Does the proposal involve a nuclear action (including uranium mining)? The proposal does not involve a nuclear action (including uranium mining).	Nil
Any impact on a water resource, in relation to coal seam gas development and large coal mining development? The proposal would not impact on a water resource, in relation to coal.	Nil
Additionally, any impact (direct or indirect) on the environment of Commonwealth land? The proposal does not involve any impact on Commonwealth land.	Nil

APPENDIX C

Consultation Records

Hunter Water Corporation
ABN 46 228 513 446

PO Box 5171
HRMC NSW 2310
36 Honeysuckle Drive
NEWCASTLE NSW 2300
hunterwater.com.au
1300 657 657 (T)
enquiries@hunterwater.com.au

12 April 2022

Our Ref: HW2018-1118/8/10.001

Attention:
Graham Pritchard
Natural Assets Coordinator
Lake Macquarie City Council
Box 1906
Hunter Regional Mail Centre, NSW, 2310

Dear Graham,

Consultation regarding proposed stormwater amenity improvement at one of Hunter Water's stormwater systems, Winding Creek, located in Wilkinson Park, Cardiff

Hunter Water Corporation (Hunter Water) is currently preparing a Review of Environmental Factors (REF) for proposed stormwater amenity works along 200m of the Winding Creek stormwater channel within Wilkinson Park in Cardiff (the Proposal). The Winding Creek stormwater channel is located within land zoned as 'RE1 Public Recreation' under the *Lake Macquarie Local Environment Plan 2014*.

In accordance with the *State Environmental Planning Policy (Transport and Infrastructure) 2021* (ISEPP), Hunter Water wishes to notify Lake Macquarie City Council (Council) of its intentions to carry out works associated with the Proposal. Hunter Water are required to consult with Council under clause 2.10(1)(a) due to impacts on council stormwater management services, under clause 2.11(1) due to potential impacts on local heritage and under clause 2.12(1) due to the proposed developments impacting flood liable land.

Hunter Water's proposed scope of works are illustrated in Figures 1-3 and include:

- Amenity works up to 200m including 180m of channel and 20m of planting along the Winding Creek stormwater channel;
- Replacement of concrete channel banks with natural (rock and plant) materials on either side of the channel; and
- Planting adjacent to Myall Road.

Hunter Water is currently preparing a REF in accordance with Part 5 of the *Environmental Planning & Assessment Act 1979* with Hunter Water as the determining authority. The proposed works are expected to commence in November 2022 and be completed by June 2024. The REF would identify a range of measures to mitigate potential environmental risks and these would form the basis of a Construction Environmental Management Plan to be implemented during the proposed works.

As can be seen in Figures 1 and 2 the proposed works are limited to the extent of Wilkinson Park and at this stage no impacts to vegetation are anticipated for the Proposal. The structural works footprint does not overlap with the heritage overlay for the "Former Collier Tramway", however pending the construction footprint and methodology, there may be indirect vibration impacts given the proximity to the heritage item.

A key design requirement for the works is that the works will not adversely affect channel conveyance or result in increased flooding. An initial assessment has been completed in the concept design and extensive flood modelling will be completed in detail design to confirm this.

The purpose of this letter is to make Council aware of the proposal and to invite your comment for consideration in the REF. It would be appreciated if you could provide any comments about this proposal by 3 May 2022.

Note that Hunter Water has consulted with Council during the initial planning phase, and also throughout the subsequent concept design phase of this project completed between August 2021 and December 2021. During the concept design phase Council has reviewed and provided input on the proposed works. Our Council contact to date has been Graham Prichard, Natural Assets Coordinator, who is familiar with the history of Council involvement and the currently proposed works. We have recently commenced detail design and plan for continued involvement and collaboration with Council during final development of the design that is planned for completion in July 2022.

Hunter Water would be pleased to provide further information if required. In this regard please contact Shaun Murphy, shaun.murphy@hunterwater.com.au.

Yours faithfully,

Shaun Murphy
Project Manager
Asset Solutions – Hunter Water Corporation
shaun.murphy@hunterwater.com.au

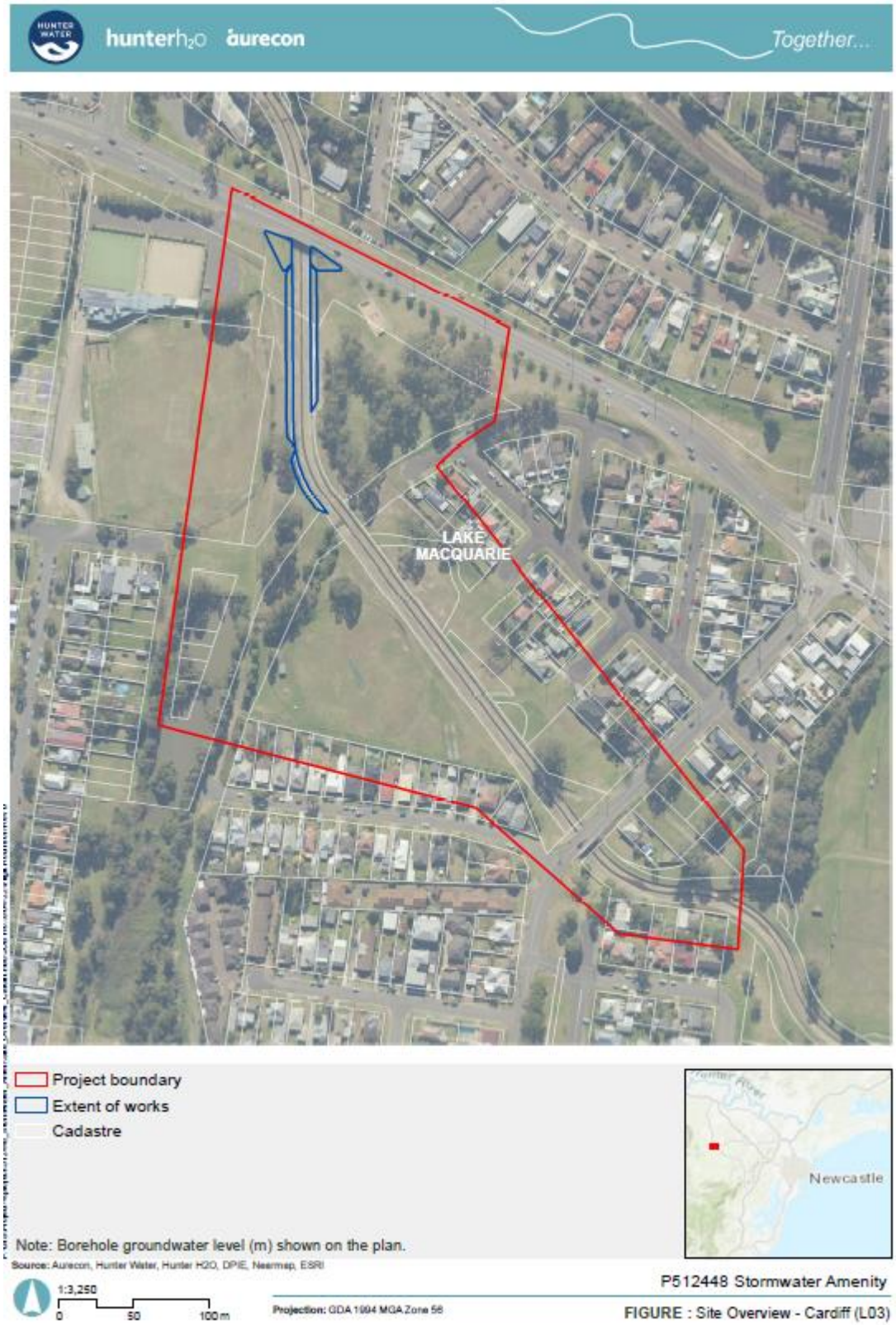

Figure 1 Site Overview – Winding Creek, Cardiff

Figure 2 Extent of Works

Hunter Water Corporation
ABN 46 228 513 446

PO Box 5171
HRMC NSW 2310
36 Honeysuckle Drive
NEWCASTLE NSW 2300
hunterwater.com.au
1300 657 657 (T)
enquiries@hunterwater.com.au

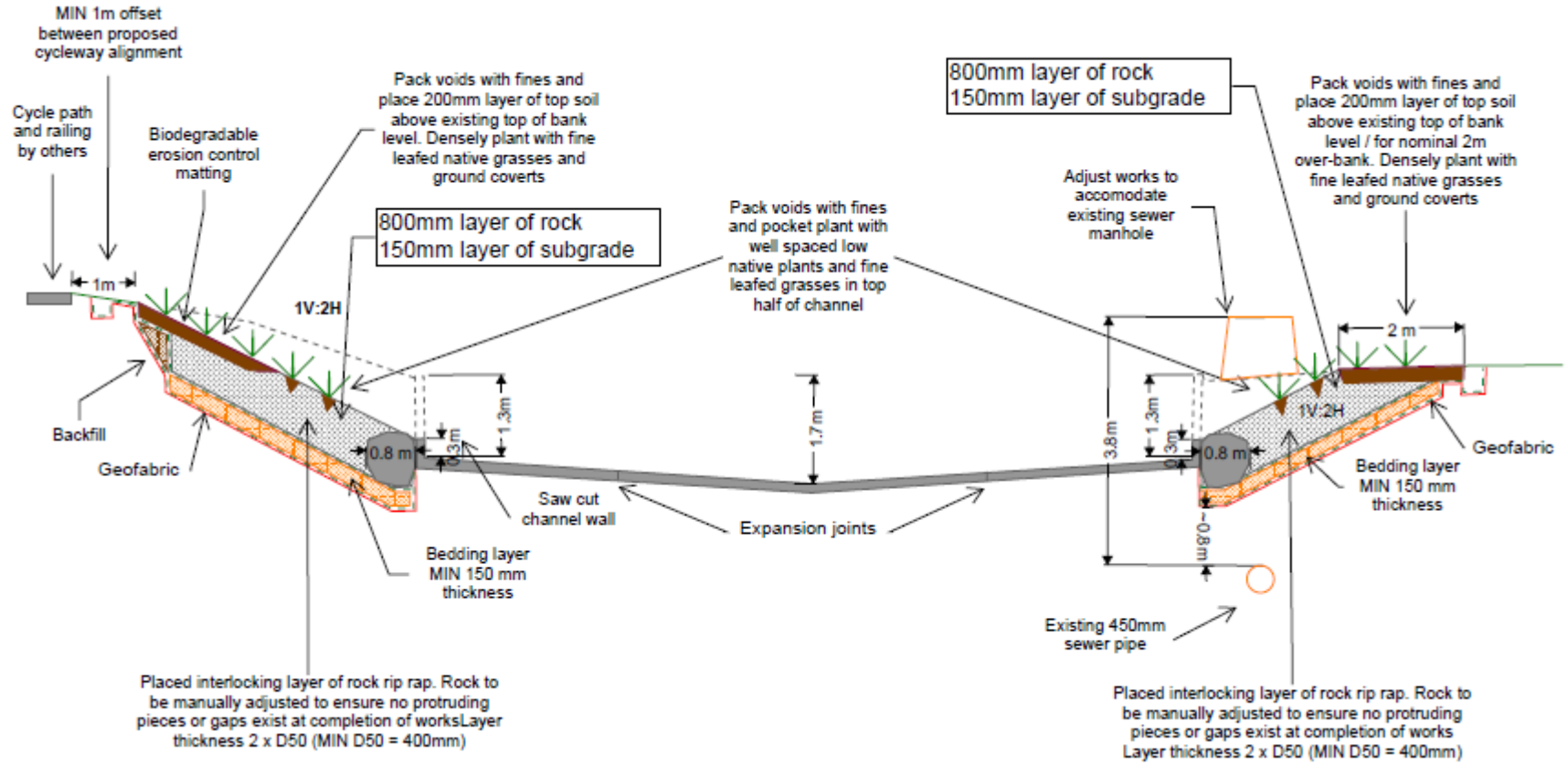

Figure 3 Structural Works

Hunter Water Corporation
ABN 46 228 513 446

PO Box 5171
HRMC NSW 2310
36 Honeysuckle Drive
NEWCASTLE NSW 2300
hunterwater.com.au
1300 657 657 (T)
enquiries@hunterwater.com.au

12 April 2022

Our Ref: HW2018-1118/8/10.004

Subsidence Advisory NSW
PO Box 488G
Newcastle NSW 2300

To Whom it may concern,

Consultation regarding proposed stormwater amenity improvement at one of Hunter Water's stormwater systems, Winding Creek, located within Wilkinson Park, Cardiff

Hunter Water Corporation (Hunter Water) is currently preparing a Review of Environmental Factors (REF) for proposed stormwater amenity works along 200m of the Winding Creek stormwater channel within Wilkinson Park in Cardiff (the Proposal). The Winding Creek stormwater channel is located within land zoned as 'RE1 Public Recreation' under the *Lake Macquarie Local Environment Plan 2014*.

In accordance with the *State Environmental Planning Policy (Transport and Infrastructure) 2021* (ISEPP), Hunter Water wishes to notify Subsidence Advisory New South Wales (SANSW) of its intentions to carry out works associated with the Proposal. Hunter Water are required to consult with Council under clause 2.15(2)(f) due to proposed developments in a mine subsidence district.

Hunter Water's proposed scope of works are illustrated in Figures 1-2 and include:

- Amenity works up to 200m including 180m of channel and 20m of planting along the Winding Creek stormwater channel;
- Replacement of concrete channel banks with natural (rock and plant) materials on either side of the channel; and
- Planting adjacent to Myall Road.

Hunter Water is currently preparing a REF in accordance with Part 5 of the *Environmental Planning & Assessment Act 1979* with Hunter Water as the determining authority. The proposed works are expected to commence in November 2022 and be completed by June 2024. The REF would identify a range of measures to mitigate potential environmental risks and these would form the basis of a Construction Environmental Management Plan to be implemented during the proposed works.

As can be seen in Figures 1 and 2 the proposed works are limited to the extent of Wilkinson Park and at this stage no impacts to vegetation are anticipated for the Proposal.

A key design requirement for the works is that the works will not adversely affect channel conveyance or result in increased flooding. An initial assessment has been completed in the concept design and extensive flood modelling will be completed in detail design to confirm this.

The purpose of this letter is to make SANSW aware of the proposal and to invite your comment for consideration in the REF. It would be appreciated if you could provide any comments about this proposal by 3 May 2022.

Hunter Water would be pleased to provide further information if required. In this regard please contact Shaun Murphy, shaun.murphy@hunterwater.com.au.

Yours faithfully,

Shaun Murphy
Project Manager
Asset Solutions – Hunter Water Corporation
shaun.murphy@hunterwater.com.au

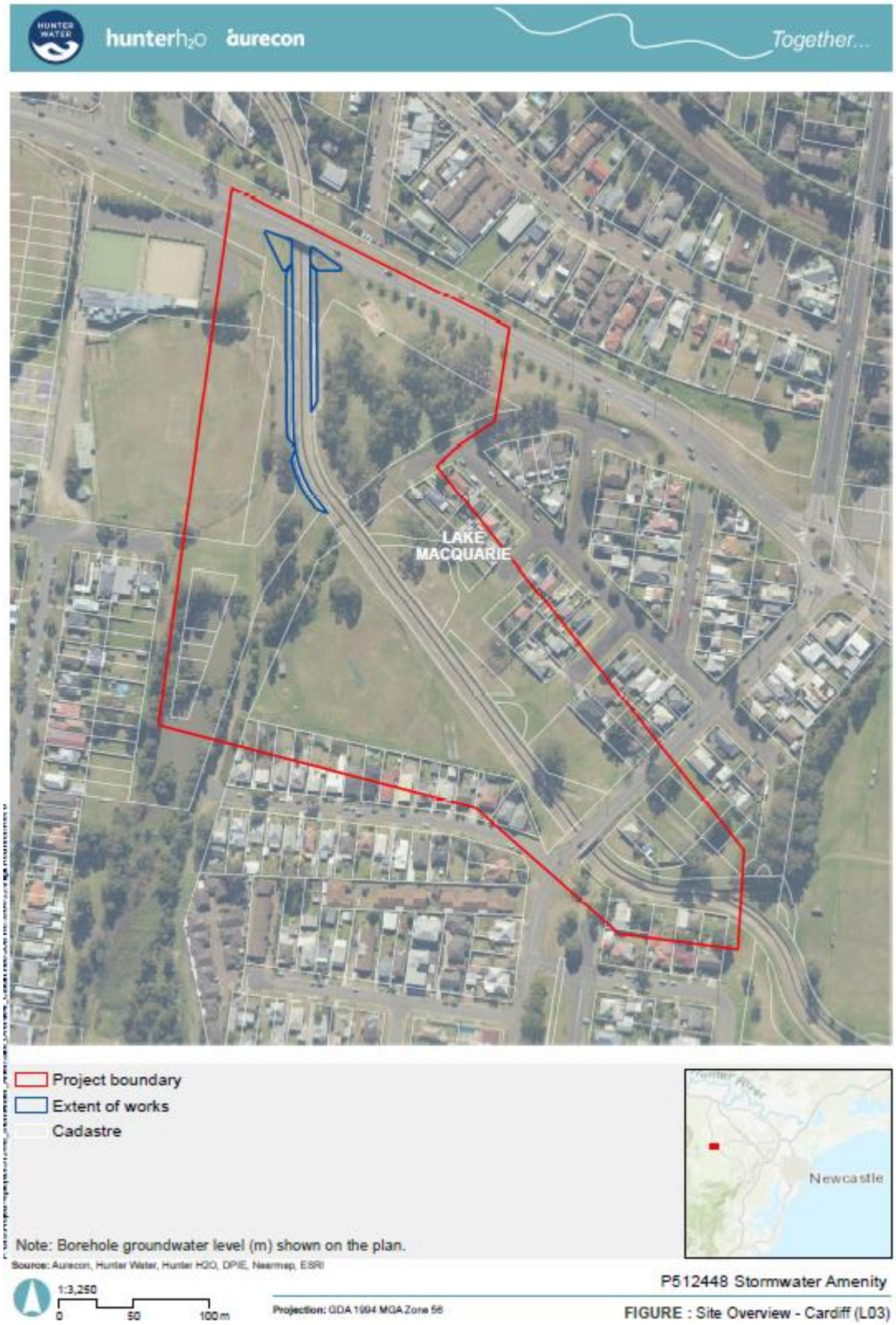

Figure 1 Site Overview – Winding Creek, Cardiff

Figure 2 Extent of Works

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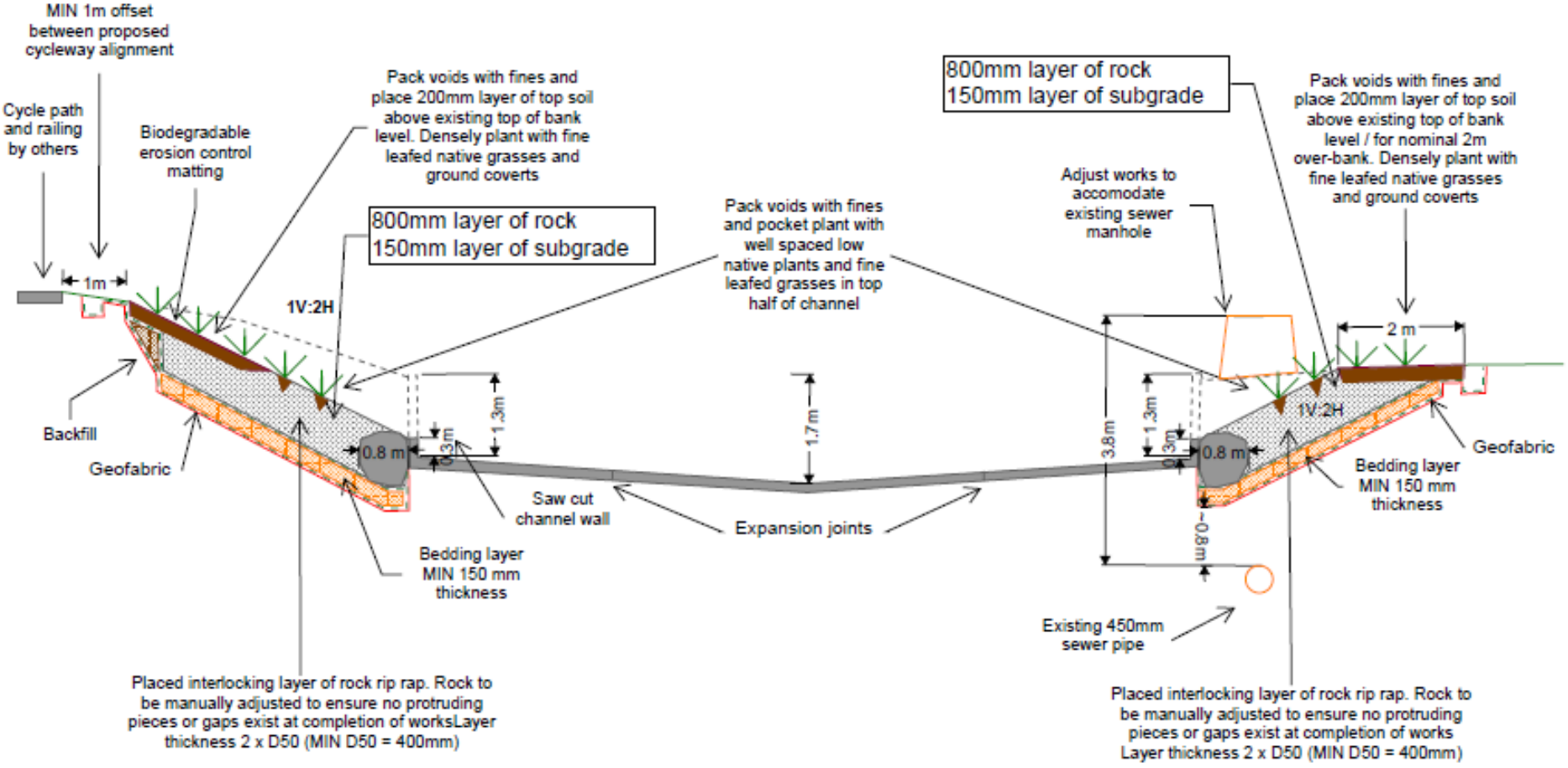

Figure 3 Structural Works

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1300 657 657 (T)
enquiries@hunterwater.com.au

12 April 2022

Our Ref: HW2018-1118/8/10.006

PO BOX 6126
WOLLONGONG NSW 2500
State Emergency Services New South Wales

To whom it may concern,

Consultation regarding proposed stormwater amenity improvement at one of Hunter Water's stormwater systems, Winding Creek, located within Wilkinson Park, Cardiff

Hunter Water Corporation (Hunter Water) is currently preparing a Review of Environmental Factors (REF) for proposed stormwater amenity works along 200m of the Winding Creek stormwater channel within Wilkinson Park in Cardiff (the Proposal). The Winding Creek stormwater channel is located within land zoned as 'RE1 Public Recreation' under the *Lake Macquarie Local Environment Plan 2014*.

In accordance with the *State Environmental Planning Policy (Transport and Infrastructure) 2021* (ISEPP), Hunter Water wishes to notify the State Emergency Service (SES) of its intentions to carry out works associated with the Proposal. Under clause 2.13(1), Hunter Water are required to consult with SES due to the proposed developments on flood liable land.

Hunter Water's proposed scope of works are illustrated in Figures 1-2 and include:

- Amenity works up to 200m including 180m of channel and 20m of planting along the Winding Creek stormwater channel;
- Replacement of concrete channel banks with natural (rock and plant) materials on either side of the channel; and
- Planting adjacent to Myall Road.

Hunter Water is currently preparing a REF in accordance with Part 5 of the *Environmental Planning & Assessment Act 1979* with Hunter Water as the determining authority. The proposed works are expected to commence in November 2022 and be completed by June 2024. The REF would identify a range of measures to mitigate potential environmental risks and these would form the basis of a Construction Environmental Management Plan to be implemented during the proposed works.

As can be seen in Figures 1 and 2 the proposed works are limited to the extent of Wilkinson Park and at this stage no impacts to vegetation are anticipated for the Proposal.

A key design requirement for the works is that the works will not adversely affect channel conveyance or result in increased flooding. An initial assessment has been completed in the concept design and extensive flood modelling will be completed in detail design to confirm this.

The purpose of this letter is to make SES aware of the proposal and to invite your comment for consideration in the REF. It would be appreciated if you could provide any comments about this proposal by 3 May 2022.

Hunter Water would be pleased to provide further information if required. In this regard please contact Shaun Murphy, shaun.murphy@hunterwater.com.au.

Yours faithfully,

Shaun Murphy
Project Manager
Asset Solutions – Hunter Water Corporation
shaun.murphy@hunterwater.com.au

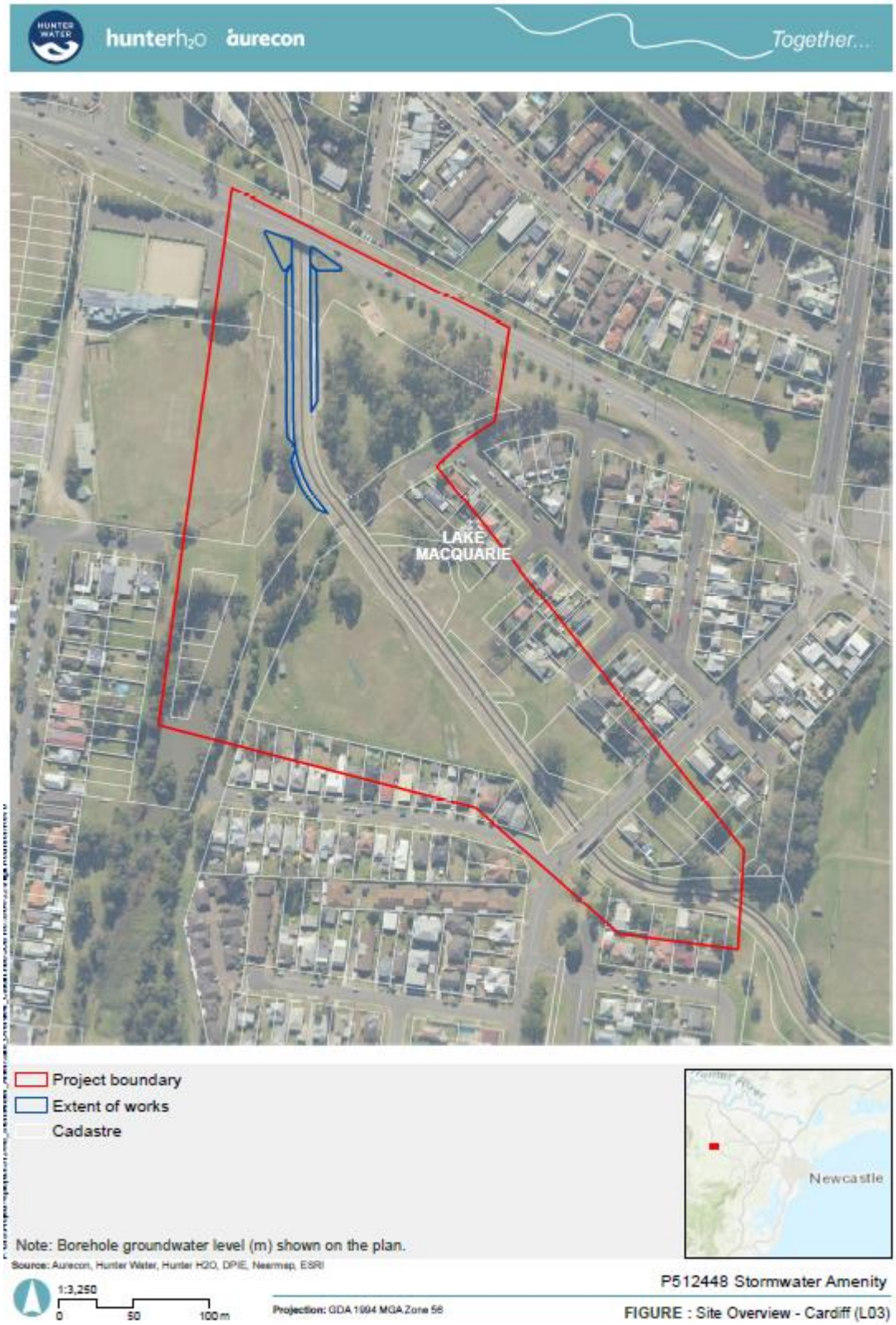

Figure 1 Site Overview – Winding Creek, Cardiff

Figure 2 Extent of Works

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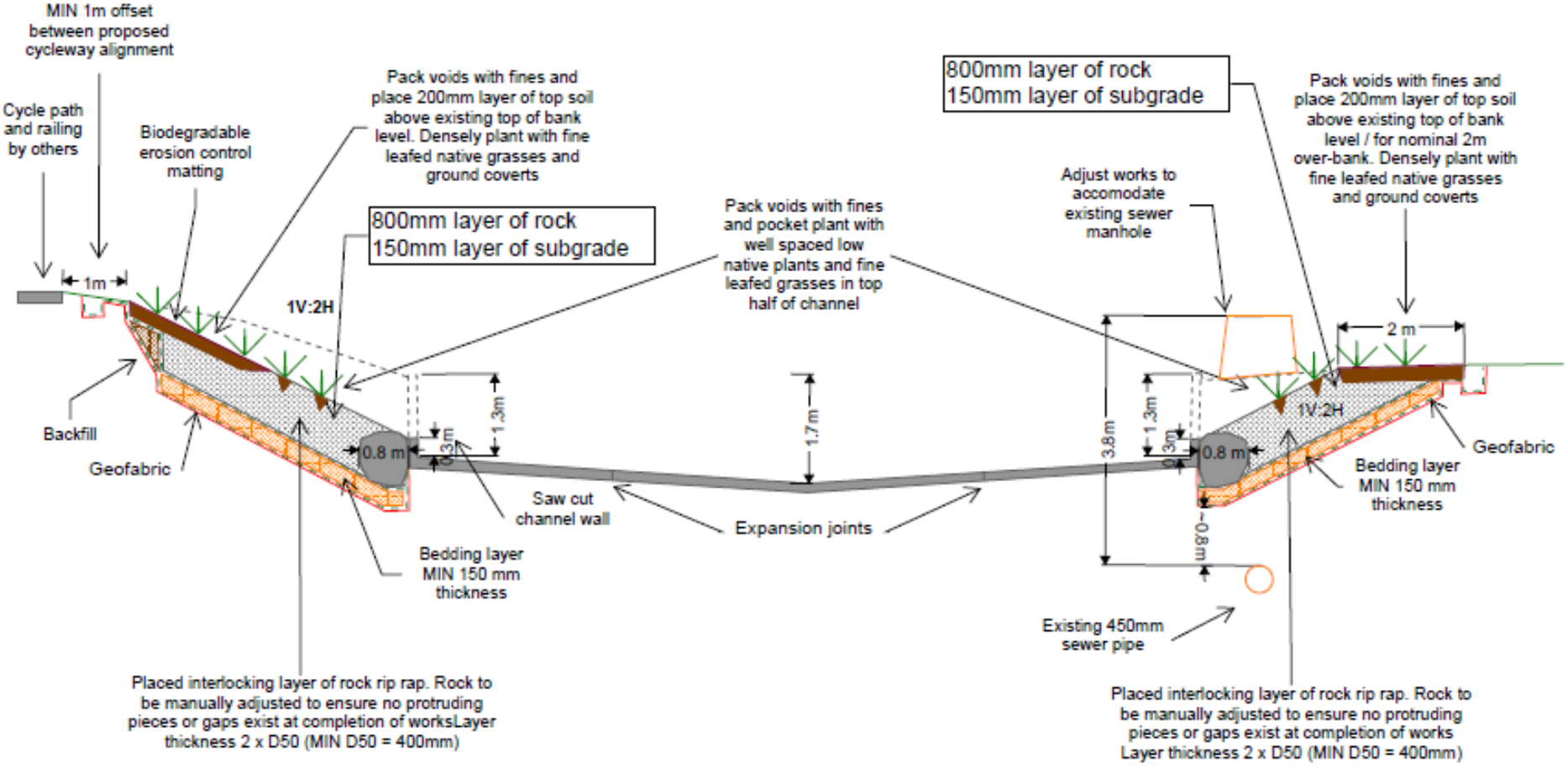

Figure 3 Structural Works

Sajana Athukorala

From: Katie Schultz
Sent: Tuesday, 24 May 2022 2:29 PM
To: Sajana Athukorala
Subject: FW: Attention Graham Pritchard - Infrastructure SEPP Consultation regarding proposed stormwater amenity improvement at one of Hunter Water's stormwater systems, Winding Creek, located in Wilkinson Park, Cardiff

Follow Up Flag: Follow up
Flag Status: Flagged

LMCC Cardiff response to ISEPP letter FYI

Katie Schultz (she/her)
Manager, Environment and Planning, Aurecon

From: Katie Schultz
Sent: Thursday, 5 May 2022 9:36 AM
To: Rodney Phillips <Rodney.Phillips@renzotonin.com.au>
Subject: FW: Attention Graham Pritchard - Infrastructure SEPP Consultation regarding proposed stormwater amenity improvement at one of Hunter Water's stormwater systems, Winding Creek, located in Wilkinson Park, Cardiff

Hi Rodney

This just came in from Council; good news that they are not concerned about the heritage item at Cardiff.

Will call now
Katie

Katie Schultz (she/her)
Manager, Environment and Planning, Aurecon

From: Sarah Saunders <Sarah.Saunders@hunterwater.com.au>
Sent: Wednesday, 4 May 2022 12:22 PM
To: Katie Schultz <Katie.Schultz@aurecongroup.com>; Will Legg <William.Legg@aurecongroup.com>
Cc: Shaun Murphy <shaun.murphy@hunterwater.com.au>
Subject: FW: Attention Graham Pritchard - Infrastructure SEPP Consultation regarding proposed stormwater amenity improvement at one of Hunter Water's stormwater systems, Winding Creek, located in Wilkinson Park, Cardiff

Hi Katie,

See below LMCC response below.

Regards,

Sarah Saunders

Environmental Advisor l Asset Solutions l Hunter Water Corporation
Level 1 426 King Street Newcastle West NSW 2300 l PO BOX 5171 HRMC NSW 2310
M 0429 994 487 | sarah.saunders@hunterwater.com.au
Please consider the environment before printing this email

From: Graham Prichard <gprichard@lakemac.nsw.gov.au>
Sent: Wednesday, 4 May 2022 12:09 PM
To: Shaun Murphy <shaun.murphy@hunterwater.com.au>; Craig Holland <cholland@lakemac.nsw.gov.au>; Stephen Prince <sprince@lakemac.nsw.gov.au>; Steven Cowen <SCowen@lakemac.nsw.gov.au>; Morgan Spruce <mspruce@lakemac.nsw.gov.au>; Peter Nichols <pnichols@lakemac.nsw.gov.au>
Cc: Sarah Saunders <Sarah.Saunders@hunterwater.com.au>; Council Council <council@lakemac.nsw.gov.au>
Subject: RE: Attention Graham Pritchard - Infrastructure SEPP Consultation regarding proposed stormwater amenity improvement at one of Hunter Water's stormwater systems, Winding Creek, located in Wilkinson Park, Cardiff

Hello Sarah, Shaun,

Thankyou for the opportunity to comment.

I received advice from our heritage planner they had no concerns based on the information provided to date. I haven't received any other feedback and think it is reasonable to assume everyone is ok with the proposal.

I am not sure our communications people are aware of the proposal, when it gets close to construction we can bring them into the story so our customer service centre staff and communications staff are aware of what they need to know in order to respond to enquiries.

Thank you

Graham Prichard
Natural Assets Coordinator

LAKE MACQUARIE CITY

T +61 2 4921 0056
E gprichard@lakemac.nsw.gov.au
lakemac.com.au

From: Shaun Murphy <shaun.murphy@hunterwater.com.au>
Sent: Tuesday, 19 April 2022 10:35 AM
To: Craig Holland <cholland@lakemac.nsw.gov.au>; Stephen Prince <sprince@lakemac.nsw.gov.au>; Steven Cowen <SCowen@lakemac.nsw.gov.au>; Morgan Spruce <mspruce@lakemac.nsw.gov.au>; Peter Nichols <pnichols@lakemac.nsw.gov.au>
Cc: Sarah Saunders <Sarah.Saunders@hunterwater.com.au>; Graham Prichard <gprichard@lakemac.nsw.gov.au>; Council Council <council@lakemac.nsw.gov.au>
Subject: FW: Attention Graham Pritchard - Infrastructure SEPP Consultation regarding proposed stormwater amenity improvement at one of Hunter Water's stormwater systems, Winding Creek, located in Wilkinson Park, Cardiff

---

FYI

From: Sarah Saunders
Sent: Tuesday, 12 April 2022 9:56 AM
To: council@lakemac.nsw.gov.au
Cc: Shaun Murphy <shaun.murphy@hunterwater.com.au>
Subject: Attention Graham Pritchard - Infrastructure SEPP Consultation regarding proposed stormwater amenity improvement at one of Hunter Water's stormwater systems, Winding Creek, located in Wilkinson Park, Cardiff

Dear Graham,

Please find attached a consultation letter regarding In accordance with the *State Environmental Planning Policy (Transport and Infrastructure) 2021* (ISEPP).

Hunter Water is currently preparing a Review of Environmental Factors (REF) for proposed stormwater amenity works along 200m of the Winding Creek stormwater channel within Wilkinson Park in Cardiff. Hunter Water are required to consult with Council under clause 2.10(1)(a) due to impacts on council stormwater management services, under clause 2.11(1) due to potential impacts on local heritage and under clause 2.12(1) due to the proposed developments impacting flood liable land.

The purpose of this letter is to make Council aware of the proposal and to invite your comment for consideration in the REF. It would be appreciated if you could provide any comments about this proposal by 3 May 2022.

Regards,

Sarah Saunders
Environmental Advisor l Asset Solutions l Hunter Water Corporation
Level 1 426 King Street Newcastle West NSW 2300 l PO BOX 5171 HRMC NSW 2310
M 0429 994 487 | sarah.saunders@hunterwater.com.au
Please consider the environment before printing this email

Please consider the environment before printing this email.
Hunter Water acknowledges the Traditional Owners and Custodians of the land and we pay our respects to their Elders, past, present and future. We are an inclusive workplace that embraces diversity in all its forms.

Disclaimer

Our Ref: ID 1604
Your Ref: HW2018-1118/8/10.006

20 April 2022

Mr Shaun Murphy
Hunter Water Corporation
PO Box 5171
HRMC NSW 2310

Via email: shaun.murphy@hunterwater.com.au
sarah.saunders@hunterwater.com.au

Dear Mr Murphy,

Notification under section 2.13 of the State Environmental Planning Policy (Transport and Infrastructure) 2021 in relation to the proposed Winding Creek Upgrade

Thank you for the notification under section 2.13 of the *State Environmental Planning Policy (Transport and Infrastructure) 2021* in relation to the proposed stormwater amenity improvement at Winding Creek, Wilkinson Park, Cardiff.

The NSW State Emergency Service (NSW SES) has reviewed the proposed upgrade using the information provided with the proposal and the flood risk information (e.g. local flood Plan, flood studies etc.) available to the NSW SES. Based on this review the proposed works appear to have minimal impact to NSW SES response operations.

Please feel free to contact me via email at rra@ses.nsw.gov.au should you wish to discuss any of the matters raised in this correspondence.

Yours sincerely,

Nicholas Kuster
Manager Emergency Planning
NSW State Emergency Service

STATE HEADQUARTERS
93 - 99 Burelli Street, Wollongong 2500
PO Box 6126, Wollongong NSW 2500
P (02) 4251 6111
F (02) 4251 6190
www.ses.nsw.gov.au
ABN: 88 712 649 015

APPENDIX D

Database searches

AHIMS Web Services (AWS)
Search Result

Your Ref/PO Number : 512448 - HW DESP SR00039

Client Service ID : 618762

Aurecon - Neutral Bay

PO Box 538

Neutral Bay New South Wales 2089

Attention: Claire Mcgarity

Email: claire.mcgarity@aurecongroup.com

Date: 01 September 2021

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lat, Long From : -32.95, 151.66 - Lat, Long To : -32.94, 151.66, conducted by Claire Mcgarity on 01 September 2021.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.

A search of Heritage NSW AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

0	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (https://www.legislation.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Heritage NSW upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Heritage NSW and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date. Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

Level 6, 10 Valentine Ave, Parramatta 2150
Locked Bag 5020 Parramatta NSW 2124
Tel: (02) 9585 6345

ABN 34 945 244 274
Email: ahims@environment.nsw.gov.au
Web: www.heritage.nsw.gov.au

Your Organization | Site L03 Winding Creek Wilkinson Park

Legend

- State Heritage Register
- Aboriginal Place
- Local Environmental Plan
  - Aboriginal Place
  - Conservation Area - General
  - Conservation Area - Landscape
  - Heritage Conservation Area
  - Item - Aboriginal
  - Item - Archaeological
  - Item - General
  - Item - Landscape
- Local Environmental Plan
  - Cluster (label denotes number)
- Aboriginal Place
  - Cluster (label denotes number)
- State Heritage Register
  - Cluster (label denotes number)
- Interim Heritage Order
  - Cluster (label denotes number)

Notes

Wilkinson Park denoted on the map.

458.6 0 229.31 458.6 Meters

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Lake Macquarie LGA EPLs

Number	Name	Location	Type	Status	Issued
11259	AQUABAIT PTY LTD	LOT 29 ROCKY POINT ROAD, ERARING, NSW 2264	POEO licence	Issued	12-Aug-01
1021	AUSTRALIAN HEALTH & NUTRITION ASSOCIATION LIMITED	582 FREEMANS DRIVE , COORANBONG, NSW 2265	POEO licence	Surrendered	31-May-00
11324	AUSTRALIAN NATIVE LANDSCAPES PTY LTD	60 Crawford Road, COORANBONG, NSW 2265	POEO licence	Surrendered	12-Jul-01
692	BARTTER ENTERPRISES PTY. LIMITED	16 NELSON ROAD , CARDIFF, NSW 2285	POEO licence	Issued	4-Apr-00
1246	BETTERGROW PTY. LIMITED	LOT 1 PACIFIC HIGHWAY, FRAZER PARK, NSW 2259	POEO licence	Issued	5-Dec-00
2063	BORAL RESOURCES (COUNTRY) PTY.	35 OAKDALE ROAD, GATESHEAD, NSW 2290	POEO licence	No longer in force	15-Oct-99
994	BORAL RESOURCES (COUNTRY) PTY.	65 SEVENTH ST , BOOLAROO, NSW 2284	POEO licence	No longer in force	25-Feb-00
2318	BORAL RESOURCES (COUNTRY) PTY. LIMITED	LOT 335 DARRAMBAL CLOSE, RATHMINES, NSW 2283	POEO licence	No longer in force	28-Feb-00
5225	BUTTAI GRAVEL PTY LTD	HOPKINS STREET, SPEERS POINT, NSW 2284	POEO licence	Surrendered	15-Nov-99
365	CENTENNIAL MANDALONG PTY LIMITED	KERRY ANDERSON DRIVE, GRADWELLS ROAD AND RUTLEYS ROAD, MANDALONG, WYEE AND, DORA CREEK, NSW 2264	POEO licence	Issued	30-May-00
366	CENTENNIAL MYUNA PTY LIMITED	14 SUMMERHILL DRIVE, WANGI WANGI, NSW 2267	POEO licence	Issued	6-Apr-00
443	CENTENNIAL NEWSTAN PTY LIMITED	WILTON RD , AWABA, NSW 2283	POEO licence	Issued	7-Apr-00
395	CENTENNIAL NEWSTAN PTY LIMITED	100 MILLER ROAD, FASSIFERN, NSW 2283	POEO licence	Issued	7-Apr-00
11184	CENTRAL LAKES HOSPITALS PTY LTD	CNR CARY ST & EXCELSIOR PDE, TORONTO, NSW 2283	POEO licence	No longer in force	29-Nov-00
6094	CLEANAWAY EQUIPMENT SERVICES PTY LTD	41 MUNIBUNG ROAD, CARDIFF, NSW 2285	POEO licence	Surrendered	19-Jun-00
3139	COAL & ALLIED INDUSTRIES LIMITED	RHONDDA ROAD, WAKEFIELD, NSW 2278	POEO licence	Surrendered	31-Jul-00
13351	CONCRUSH PTY LIMITED	21 Racecourse Rd, TERALBA, NSW 2284	POEO licence	Issued	20-May-11
471	CSR LIMITED	16 PENDLEBURY ROAD, CARDIFF, NSW 2285	POEO licence	Surrendered	7-Jan-00
20489	DEPARTMENT OF INDUSTRY	SWANSEA, NSW 2281	POEO licence	Surrendered	17-Nov-14
11470	DULUXGROUP (AUSTRALIA) PTY LTD	34 WYEE ROAD, WYEE, NSW 2259	POEO licence	Issued	2-Jul-02
12088	EDL (TT) PTY LIMITED	1 Railway Street, TERALBA, NSW 2284	POEO licence	Surrendered	2-Jun-04
21230	EDL CSM (NSW) PTY LTD	LOT 5 KERRY ANDERSON DRIVE, MANDALONG, NSW 2264	POEO licence	Issued	19-Mar-20
1321	EMOLEUM ROAD SERVICES PTY LTD	RHONDDA ROAD, TERALBA, NSW 2284	POEO licence	No longer in force	15-Aug-00
3780	FLYASH AUSTRALIA PTY LIMITED	CORNER OF HILL ROAD AND CONSTRUCTION ROAD, MYUNA BAY, NSW	POEO licence	Issued	28-Feb-00
1502	FLYASH AUSTRALIA PTY LIMITED	GOROKAN ROAD, WYEE, NSW 2259	POEO licence	Surrendered	1-Nov-00
13403	G P MARINE (LAKE MACQUARIE) PTY LTD	25 Sara Street, TORONTO, NSW 2283	POEO licence	Surrendered	16-May-12
678	HANSON CONSTRUCTION MATERIALS PTY LTD	230 MANDALONG ROAD, MORISSET, NSW 2264	POEO licence	No longer in force	6-Mar-00
1083	HANSON CONSTRUCTION MATERIALS PTY LTD	59 PACIFIC HIGHWAY , BENNETTS GREEN, NSW 2290	POEO licence	No longer in force	21-Mar-00
11728	HCOA OPERATIONS (AUSTRALIA) PTY	FAIRFAX ROAD, WARNERS BAY, NSW 2282	POEO licence	No longer in force	27-Feb-03
2103	HOLCIM (AUSTRALIA) PTY LTD	CNR. PITT & WILLIAM STREETS, TERALBA, NSW 2284	POEO licence	No longer in force	12-Nov-99
5042	HUNTER & CENTRAL COAST DEVELOPMENT CORPORATION	MAIN ROAD, BOOLAROO, NSW 2284	POEO licence	Issued	2-Jan-01
11190	HUNTER AND NEW ENGLAND AREA HEALTH SERVICE	Off Macquarie Street, MORISSET, NSW 2264	POEO licence	No longer in force	29-Nov-00
11208	HUNTER AND NEW ENGLAND AREA HEALTH SERVICE	CROUDACE RD, BELMONT, NSW 2280	POEO licence	No longer in force	29-Nov-00
1463	HUNTER READYMIXED CONCRETE PTY LTD	8 NEVIN CLOSE, GATESHEAD, NSW 2290	POEO licence	No longer in force	21-Mar-00
1771	HUNTER WATER CORPORATION	OFF OCEAN PARK ROAD, BELMONT, NSW 2280	POEO licence	Issued	1-Oct-99
2541	HUNTER WATER CORPORATION	MARCONI ROAD, DORA CREEK, NSW 2264	POEO licence	Surrendered	15-May-00
714	HYMIX AUSTRALIA PTY LIMITED	34 KALAROO ROAD, REDHEAD, NSW 2290	POEO licence	No longer in force	6-Mar-00
1127	HYMIX AUSTRALIA PTY LIMITED	361 AWABA ROAD, TORONTO, NSW 2283	POEO licence	No longer in force	9-May-00

208	INCITEC PIVOT LIMITED	MAIN ROAD, BOOLAROO, NSW 2284	POEO licence	Surrendered	10-Feb-00
11401	INGHAMS ENTERPRISES PTY. LIMITED	42 PENDLEBURY ROAD, CARDIFF, NSW 2285	POEO licence	Surrendered	6-Dec-01
21027	J E T GROUP AUSTRALIA PTY LIMITED	76 Nomad Road, TORONTO, NSW 2283	POEO licence	Issued	29-Jun-18
4719	KIMBAK PTY LTD	9 PARK STREET, TERALBA, NSW 2284	POEO licence	Surrendered	7-Sep-00
21349	LAKE MACQUARIE AIRPORT ADMINISTRATION PTY LTD	864 PACIFIC HIGHWAY, MARKS POINT, NSW 2280	POEO licence	Issued	1-Jul-20
5873	LAKE MACQUARIE CITY COUNCIL	367 WILTON ROAD, AWABA, NSW 2283	POEO licence	Issued	2-Aug-00
6332	LAKE MACQUARIE CITY COUNCIL	LAKE MACQUARIE, SPEERS POINT, NSW	POEO licence	Issued	15-Aug-00
6098	LAKE MACQUARIE CITY COUNCIL	56 FISHERY POINT ROAD, MIRRABOOKA, NSW 2264	POEO licence	Surrendered	8-Sep-00
6095	LAKE MACQUARIE CITY COUNCIL	112 BAYVIEW STREET , MOUNT HUTTON, NSW 2290	POEO licence	Surrendered	27-Sep-00
13016	LAKE MACQUARIE CITY COUNCIL	118 TC Frith Street, BOOLAROO, NSW 2284	POEO licence	Surrendered	21-May-09
13381	LAKE MACQUARIE CITY COUNCIL	106 Reservoir Road, GLENDALE, NSW 2285	POEO licence	Surrendered	14-Apr-11
13424	LAKE MACQUARIE CITY COUNCIL	465 Pacific Highway, SWANSEA, NSW 2281	POEO licence	Surrendered	17-Nov-11
11339	LAKE MACQUARIE YACHT CLUB	1 ADA STREET, BELMONT, NSW 2280	POEO licence	Issued	27-Jun-02
1558	LAKECOAL PTY LTD	FLOWERS DRIVE, CATHERINE HILL BAY, NSW 2281	POEO licence	Surrendered	19-Oct-00
11161	MARMONG MARINA PROPERTIES PTY LTD	1 NANDA STREET, MARMONG POINT, NSW 2284	POEO licence	Issued	21-Nov-01
11162	MELISSA J PTY LIMITED	19/21/23 EDITH STREET , MARKS POINT, NSW 2280	POEO licence	Issued	26-Sep-01
536	METROMIX PTY. LIMITED	RHONDDA ROAD, TERALBA, NSW 2284	POEO licence	Issued	25-Sep-00
13015	METROMIX PTY. LIMITED	Rhondda Road, TERALBA, NSW 2284	POEO licence	Issued	17-Jul-09
20296	NAVIO VELA PTY LTD	25 Sara Street, TORONTO, NSW 2283	POEO licence	Issued	29-Oct-13
12417	NEUMANN CONTRACTORS PTY LTD	Swan Bay, SWAN BAY, NSW 2324	POEO licence	Surrendered	2-Feb-06
12483	NEWCASTLE COAL COMPANY PTY LTD	GEORGE BOOTH DRIVE, SEAHAMPTON, NSW 2286	POEO licence	Surrendered	8-May-06
1360	OCEANIC COAL AUSTRALIA PTY LIMITED	WEST WALLSEND COLLIERY, MACQUARIE COAL PREPARATION PLANT AND WESTSIDE MINE, TERALBA, NSW 2284	POEO licence	Issued	24-Aug-00
4033	OCEANIC COAL AUSTRALIA PTY LIMITED	935 WAKEFIELD ROAD, KILLINGWORTH, NSW 2278	POEO licence	Surrendered	18-Sep-00
1429	ORIGIN ENERGY ERARING PTY LTD	ROCKY POINT ROAD, ERARING, NSW 2264	POEO licence	Issued	6-Jun-00
4297	ORIGIN ENERGY ERARING PTY LTD	CONSTRUCTION ROAD, DORA CREEK, NSW 2264	POEO licence	Surrendered	25-Sep-00
20987	RAY JOHNSONS SCRAP TYRE DISPOSALS PTY LTD	2/23 Currans Road, COORANBONG, NSW 2265	POEO licence	Issued	29-May-18
12064	REDICRETE PTY LIMITED	7 Stenhouse Drive, CAMERON PARK, NSW 2285	POEO licence	No longer in force	12-Mar-04
20949	REMONDIS AUSTRALIA PTY LTD	OFF 367 WILTON ROAD, AWABA, NSW 2283	POEO licence	Issued	14-Jun-17
4045	RIVERVIEW HOSTELS PTY LTD	300 FREEMANS DRIVE, COORANBONG, NSW 2265	POEO licence	Surrendered	13-Nov-00
7248	ROADS & TRAFFIC AUTHORITY OF NEW SOUTH WALES	Pacific Highway, CHARLESTOWN, NSW 2290	POEO licence	Surrendered	4-Jan-01
13285	ROADS AND MARITIME SERVICES	Hunter Expressway, SEAHAMPTON, NSW 2286	POEO licence	Surrendered	1-Jul-10
5905	RODNEY KEITH CROWHURST	REAR NO 5 NELSON ROAD, CARDIFF, NSW 2285	POEO licence	Surrendered	23-Mar-00
20427	Solo Waste Pty Ltd	27 Oakdale Road, GATESHEAD, NSW 2290	POEO licence	Issued	31-Oct-14
12216	THIESS PTY LTD	Main Road 217, TERALBA, NSW 2284	POEO licence	Surrendered	2-Dec-04
13296	THIESS PTY LTD	1416 George Booth Drive, BUCHANAN, NSW 2323	POEO licence	Surrendered	23-Jul-10
11361	TRANSGRID	101 Killingworth Road, KILLINGWORTH, NSW 2301	POEO licence	No longer in force	5-May-01
20631	TRINITY POINT MARINA PTY LIMITED	71 Trinity Point Drive, MORISSET PARK, NSW 2264	POEO licence	Issued	4-Dec-15

11686	TYRECYCLE PTY LTD	36 STENHOUSE DRIVE, CAMERON PARK, NSW 2285	POEO licence	Issued	30-Aug-02
13212	VEOLIA ENVIRONMENTAL SERVICES (AUSTRALIA) PTY LTD	107-111 Stenhouse Drive, CAMERON PARK, NSW 2285	POEO licence	Issued	23-Apr-10

Australian Government
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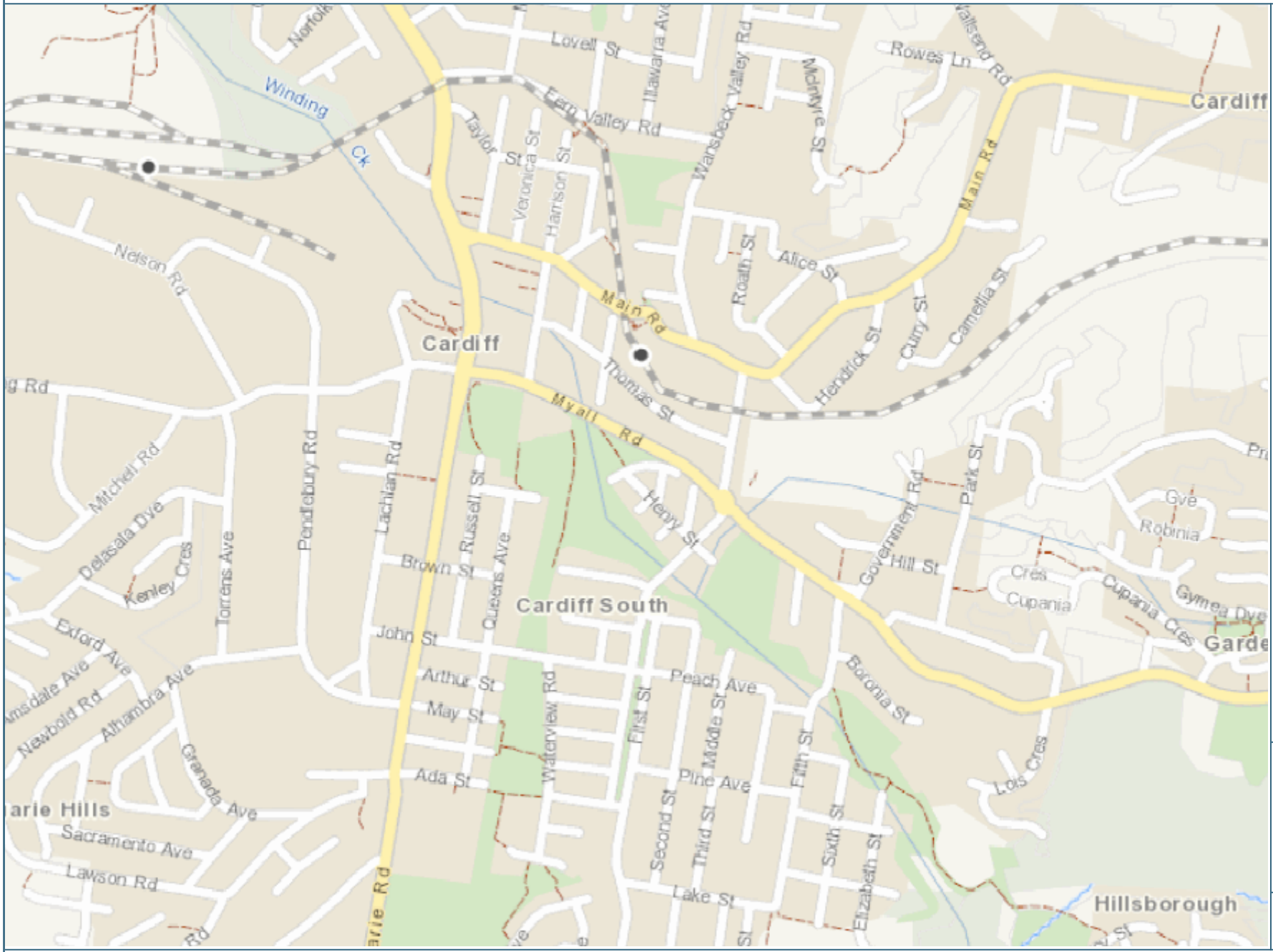
Groundwater Dependent Ecosystems Atlas

L03 Winding Creek



Aquatic GDE

- Known GDE (regional study)
- High potential GDE (regional study)
- Moderate potential GDE (regional study)
- Low potential GDE (regional study)
- Unclassified potential GDE (regional study)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)
- Unclassified potential GDE (national assessment)

N

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Kilometres 0.2 0.4 0.6

Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: Click here

Australian Albers GDA94

Date: 1 September, 2021

Australian Government
Bureau of Meteorology

Groundwater Dependent Ecosystems Atlas

L03 Winding Creek

Terrestrial GDE (no data)

No ecosystems analysed

Terrestrial GDE

- Known GDE (regional study)
- High potential GDE (regional study)
- Moderate potential GDE (regional study)
- Low potential GDE (regional study)
- Unclassified potential GDE (regional study)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)
- Unclassified potential GDE (national assessment)

N

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Kilometres 1 2 3

Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: Click here

Australian Albers GDA94

Date: 1 September, 2021

Name	State	Ecosystem type	Supplied ecosystem type	GDE Potential	IDE likelihood	River region	Groundwater management area
Spotted Gum/ Broad-leaved Mahogany/ Grey Gum grass/ shrub open forest on Coastal Lowlands of t*	NSW	Vegetation	Hunter-Macleay Dry Sclerophyll Forests	High potential GDE - from regional studies	1	MACQUARIE-TUGGERAH LAKES	NSW Great Artesian Basin Shallow Groundwater - Central
Spotted Gum/ Broad-leaved Mahogany/ Red Ironbark shrubby open forest	NSW	Vegetation	Hunter-Macleay Dry Sclerophyll Forests	Moderate potential GDE - from regional studies	3	MACQUARIE-TUGGERAH LAKES	NSW Great Artesian Basin Groundwater - Central
Spotted Gum/ Broad-leaved Mahogany/ Grey Gum grass/ shrub open forest on Coastal Lowlands of t*	NSW	Vegetation	Hunter-Macleay Dry Sclerophyll Forests	Moderate potential GDE - from regional studies	4	MACQUARIE-TUGGERAH LAKES	NSW Great Artesian Basin Groundwater - Central
Spotted Gum/ Broad-leaved Mahogany/ Grey Gum grass/ shrub open forest on Coastal Lowlands of t*	NSW	Vegetation	Hunter-Macleay Dry Sclerophyll Forests	Moderate potential GDE - from regional studies	1	MACQUARIE-TUGGERAH LAKES	NSW Great Artesian Basin Groundwater - Central
Smooth-barked Apple/ Red Bloodwood/ Brown Stringybark/ Hairpin Banksia heathy open forest of c*	NSW	Vegetation	Sydney Coastal Dry Sclerophyll Forests	High potential GDE - from regional studies	1	MACQUARIE-TUGGERAH LAKES	North Western Unregulated and Fractured Rock
Spotted Gum/ Broad-leaved Mahogany/ Grey Gum grass/ shrub open forest on Coastal Lowlands of t*	NSW	Vegetation	Hunter-Macleay Dry Sclerophyll Forests	Moderate potential GDE - from regional studies	6	MACQUARIE-TUGGERAH LAKES	North Western Unregulated and Fractured Rock
Narrow-leaved Apple/ Parramatta Red Gum/ Persoonia oblongata heathy woodland of the Howes Vall*	NSW	Vegetation	Sydney Sand Flats Dry Sclerophyll Forests	Moderate potential GDE - from regional studies	5	MACQUARIE-TUGGERAH LAKES	North Western Unregulated and Fractured Rock
Smooth-barked Apple/ Red Bloodwood/ Brown Stringybark/ Hairpin Banksia heathy open forest of c*	NSW	Vegetation	Sydney Coastal Dry Sclerophyll Forests	Moderate potential GDE - from regional studies	3	MACQUARIE-TUGGERAH LAKES	North Western Unregulated and Fractured Rock
Smooth-barked Apple/ Red Bloodwood/ Brown Stringybark/ Hairpin Banksia heathy open forest of c*	NSW	Vegetation	Sydney Coastal Dry Sclerophyll Forests	Moderate potential GDE - from regional studies	5	MACQUARIE-TUGGERAH LAKES	North Western Unregulated and Fractured Rock
Blackbutt/ Turpentine/ Sydney Blue Gum mesic tall open forest on ranges of the Central Coast	NSW	Vegetation	North Coast Wet Sclerophyll Forests	Low potential GDE - from regional studies	5	MACQUARIE-TUGGERAH LAKES	Lower Murray Darling Unregulated and Alluvial

Australian Government
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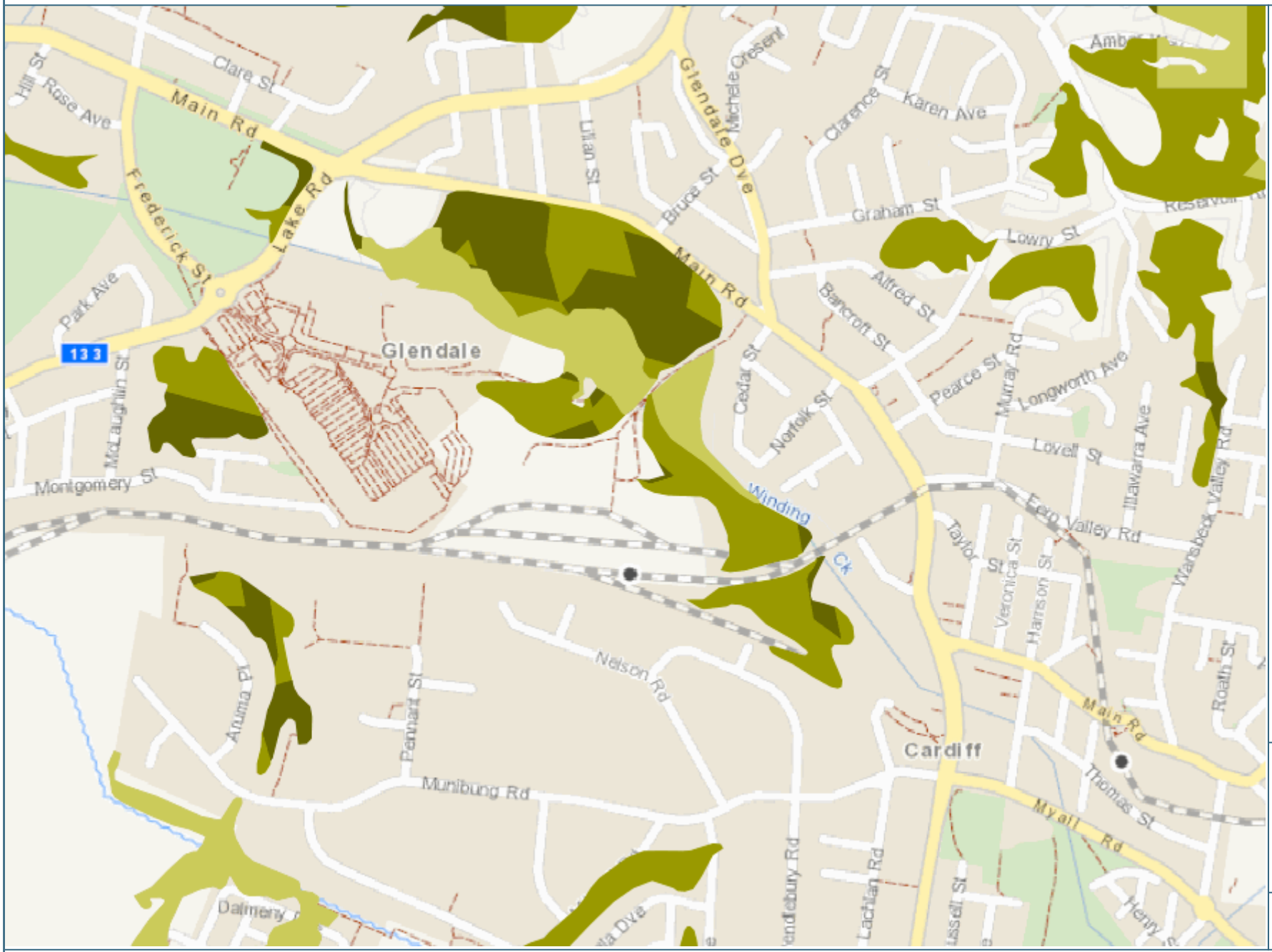
Groundwater Dependent Ecosystems Atlas

L03 Winding Creek downstream



Terrestrial GDE (no data)

No ecosystems analysed

Terrestrial GDE

- Known GDE (regional study)
- High potential GDE (regional study)
- Moderate potential GDE (regional study)
- Low potential GDE (regional study)
- Unclassified potential GDE (regional study)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)
- Unclassified potential GDE (national assessment)

N

1:15,680

Kilometres 0.2 0.4 0.6

Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: Click here

Australian Albers GDA94

Date: 1 September, 2021

Department of Primary Industries

L03 - Winding Creek Wilkinson Park

Legend

- Key Fish Habitat - Central Rive
- Southern Pygmy Perch
- Highways
- Regional Roads
- Major Roads
- Minor Roads
- Major Rivers
- Other Streams and Tributaries
- Alpine Redspot Dragonfly
- Australian Grayling
- Darling River Hardyhead
- Darling River Snail
- Eastern Freshwater Cod
- Eel Tailed Catfish
- Fitzroy Falls Spiny Crayfish
- Flathead Galaxias
- Hanleys River Snail
- Macquarie Perch
- Murray Crayfish
- Olive Perchlet
- Oxleyan Pygmy Perch
- Southern Purple Spotted Gudg
- River Blackfish

Notes

Site located at Wilkinson Park denoted on map.

0.5 0 0.23 0.5 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

01-Sep-2021

Australian Government

Department of Agriculture, Water and the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

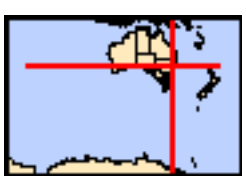
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 01/09/21 23:11:21

This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2015

Coordinates

Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	38
Listed Migratory Species:	17

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	3
Commonwealth Heritage Places:	None
Listed Marine Species:	21
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	1
Invasive Species:	42
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Hunter estuary wetlands	Within 10km of Ramsar

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community may occur within area
River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat may occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Thinornis cucullatus cucullatus Eastern Hooded Plover, Eastern Hooded Plover [90381]	Vulnerable	Species or species habitat may occur within area
Frogs		
Heleioporus australiacus Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat may occur within area
Litoria aurea Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat likely to occur within area
Mixophyes balbus Stuttering Frog, Southern Barred Frog (in Victoria) [1942]	Vulnerable	Species or species habitat may occur within area
Uperoleia mahonyi Mahony's Toadlet [89189]	Endangered	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat likely to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat likely to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE Mainland) [66645]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Plants		
Angophora inopina Charmhaven Apple [64832]	Vulnerable	Species or species habitat likely to occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat likely to occur within area
Diuris praecox Newcastle Doubletail [55086]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Eucalyptus camfieldii Camfield's Stringybark [15460]	Vulnerable	Species or species habitat may occur within area
Euphrasia arguta [4325]	Critically Endangered	Species or species habitat may occur within area
Grevillea parviflora subsp. parviflora Small-flower Grevillea [64910]	Vulnerable	Species or species habitat likely to occur within area
Melaleuca biconvexa Biconvex Paperbark [5583]	Vulnerable	Species or species habitat known to occur within area
Persicaria elatior Knotweed, Tall Knotweed [5831]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis gibbosa Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood [4562]	Endangered	Species or species habitat may occur within area
Rhizanthella slateri Eastern Underground Orchid [11768]	Endangered	Species or species habitat may occur within area
Rhodamnia rubescens Scrub Turpentine, Brown Malletwood [15763]	Critically Endangered	Species or species habitat likely to occur within area
Rhodomyrtus psidioides Native Guava [19162]	Critically Endangered	Species or species habitat likely to occur within area
Syzygium paniculatum Magenta Lilly Pilly, Magenta Cherry, Daguba, Scrub Cherry, Creek Lilly Pilly, Brush Cherry [20307]	Vulnerable	Species or species habitat likely to occur within area
Tetratheca juncea Black-eyed Susan [21407]	Vulnerable	Species or species habitat known to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat likely to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat may occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Australian Postal Commission
Commonwealth Land - Australian Telecommunications Commission
Commonwealth Land - Director of War Service Homes

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Thinornis rubricollis rubricollis		
Hooded Plover (eastern) [66726]	Vulnerable*	Species or species habitat may occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Extra Information

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
North East NSW RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax,		Species or species

Name	Status	Type of Presence
Florist's Smilax, Smilax Asparagus [22473]		habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-32.947297 151.663303,-32.947036 151.662853,-32.946568 151.662574,-32.946118 151.660524,-32.944758 151.660846,-32.943642 151.66075,-32.943074 151.660857,-32.943336 151.661426,-32.944704 151.661587,-32.946937 151.663807,-32.947297 151.663303

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Atlas Map

September 3, 2021

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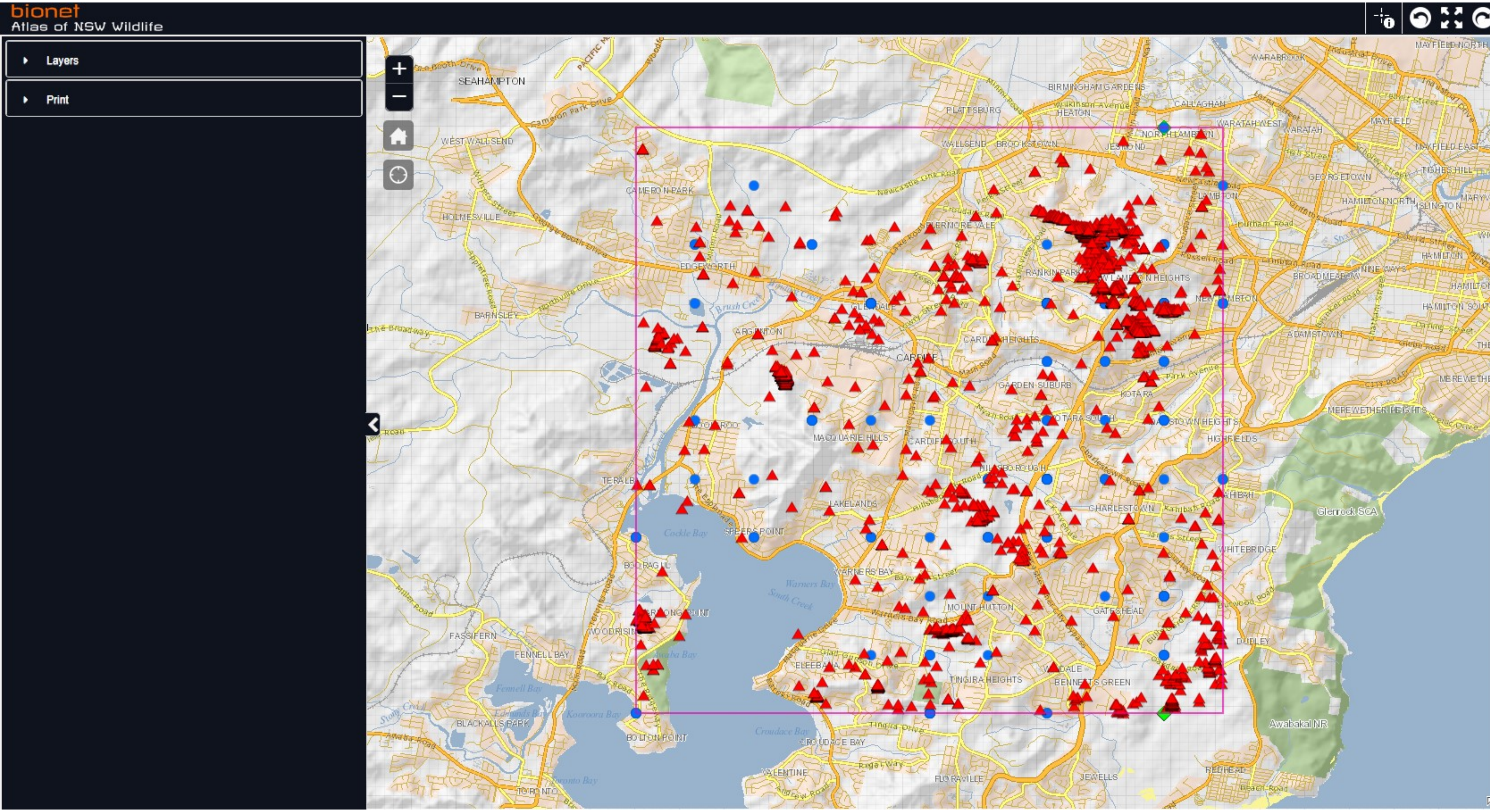
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Atlas of NSW Wildlife
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Print
SEAHAMPTON
WEST WALLSEND
CAMERON PARK
HOLMESVILLE
EDGEWORTH
BARNSLEY
ARGENTON
TERALBA
BOORAGUL
FASSIFERN
FENNELL BAY
BLACKALLS PARK
BOLTON POINT
TORONTO
SPEERS POINT
WARNERS BAY
MACQUARIE HILLS
LAKELANDS
CARDIFF
CARDIFF HEIGHTS
CARDIFF SOUTH
GARDEN SUBURB
KOTARA
KOTARA SOUTH
HILLSBOROUGH
CHARLESTOWN
MOUNT HUTTON
GATESHEAD
ELEEBANA
TINGIRA HEIGHTS
BENNETTS GREEN
WINDALE
CROUDACE BAY
VALENTINE
FLORAVILLE
JEWELLS
REDHEAD
DUDLEY
WHITEBRIDGE
KAHIBAH
HIGHFIELDS
ADAMSTOWN
ADAMSTOWN HEIGHTS
NEW LAMBTON
NEW LAMBTON HEIGHTS
RANKIN PARK
LAMBTON
NORTH LAMBTON
JESMOND
WALLSEND
PLATTSBURG
BIRMINGHAM GARDENS
CALLAGHAN
WARATAH WEST
WARATAH
WARABROOK
MAYFIELD NORTH
MAYFIELD
MAYFIELD EAST
GEORGETOWN
HAMILTON NORTH
HAMILTON
HAMILTON EAST
HAMILTON SOUTH
BROADMEADOW
MEREWETHER
MEREWETHER HEIGHTS
Glenrock SCA
Awabakal NR
Cockle Bay
Warners Bay
Fennell Bay
Kooroora Bay
Croudace Bay
Toronto Bay

Data from the BioNet Atlas website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions. Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1°C; ^^ rounded to 0.01°C. Search criteria : Public Report of all Valid Records of Threatened (listed on BC Act 2016) or Commonwealth listed Entities in selected area [North: -32.90 West: 151.61 East: 151.71 South: -33.00] returned a total of 4,625 records of 52 species.
Report generated on 3/09/2021 4:14 PM

Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	NSW status	Comm. status	Records	Info
Animalia	Amphibia	Myobatrachidae	3137	*Crinia tinnula*		Wallum Froglet	V,P		2	
Animalia	Reptilia	Cheloniidae	2007	*Chelonia mydas*		Green Turtle	V,P	V	2	
Animalia	Aves	Anatidae	0216	*Oxyura australis*		Blue-billed Duck	V,P		1	
Animalia	Aves	Columbidae	0025	*Ptilinopus magnificus*		Wompoo Fruit-Dove	V,P		3	
Animalia	Aves	Columbidae	0021	*Ptilinopus regina*		Rose-crowned Fruit-Dove	V,P		4	
Animalia	Aves	Columbidae	0023	*Ptilinopus superbus*		Superb Fruit-Dove	V,P		2	
Animalia	Aves	Apodidae	0334	*Hirundapus caudacutus*		White-throated Needletail	P	V,C,J,K	3	
Animalia	Aves	Ciconiidae	0183	*Ephippiorhynchus asiaticus*		Black-necked Stork	E1,P		1	
Animalia	Aves	Ardeidae	0196	*Ixobrychus flavicollis*		Black Bittern	V,P		1	
Animalia	Aves	Accipitridae	0226	*Haliaeetus leucogaster*		White-bellied Sea-Eagle	V,P		10	
Animalia	Aves	Accipitridae	0225	*Hieraaetus morphnoides*		Little Eagle	V,P		1	
Animalia	Aves	Accipitridae	0230	*^^Lophoictinia isura*		Square-tailed Kite	V,P,3		1	
Animalia	Aves	Accipitridae	8739	*^^Pandion cristatus*		Eastern Osprey	V,P,3		7	
Animalia	Aves	Charadriidae	0139	*Charadrius mongolus*		Lesser Sand-plover	V,P	E,C,J,K	1	
Animalia	Aves	Scolopacidae	0161	*Calidris ferruginea*		Curlew Sandpiper	E1,P	CE,C,J,K	4	
Animalia	Aves	Cacatuidae	0268	*^^Callocephalon fimbriatum*		Gang-gang Cockatoo	V,P,3		2	
Animalia	Aves	Cacatuidae	0265	*^Calyptorhynchus lathami*		Glossy Black-Cockatoo	V,P,2		2	
Animalia	Aves	Psittacidae	0260	*Glossopsitta pusilla*		Little Lorikeet	V,P		3	
Animalia	Aves	Psittacidae	0309	*^^Lathamus discolor*		Swift Parrot	E1,P,3	CE	5	
Animalia	Aves	Strigidae	0246	*^^Ninox connivens*		Barking Owl	V,P,3		3	
Animalia	Aves	Strigidae	0248	*^^Ninox strenua*		Powerful Owl	V,P,3		112	
Animalia	Aves	Tytonidae	0250	*^^Tyto novaehollandiae*		Masked Owl	V,P,3		12	
Animalia	Aves	Tytonidae	9924	*^^Tyto tenebricosa*		Sooty Owl	V,P,3		1	
Animalia	Aves	Meliphagidae	0603	*Anthochaera phrygia*		Regent Honeyeater	E4A,P	CE	1	
Animalia	Aves	Meliphagidae	0448	*Epthianura albifrons*		White-fronted Chat	V,P		3	
Animalia	Aves	Neosittidae	0549	*Daphoenositta chrysoptera*		Varied Sittella	V,P		2	
Animalia	Aves	Artamidae	8519	*Artamus cyanopterus cyanopterus*		Dusky Woodswallow	V,P		2	
Animalia	Mammalia	Dasyuridae	1008	*Dasyurus maculatus*		Spotted-tailed Quoll	V,P	E	5	
Animalia	Mammalia	Phascolarctidae	1162	*Phascolarctos cinereus*		Koala	V,P	V	4	
Animalia	Mammalia	Burramyidae	1150	*Cercartetus nanus*		Eastern Pygmy-possum	V,P		2	
Animalia	Mammalia	Petauridae	1137	*Petaurus norfolcensis*		Squirrel Glider	V,P		75	
Animalia	Mammalia	Pseudocheiridae	1133	*Petauroides volans*		Greater Glider	P	V	2	
Animalia	Mammalia	Pteropodidae	1280	*Pteropus poliocephalus*		Grey-headed Flying-fox	V,P	V	234	
Animalia	Mammalia	Emballonuridae	1321	*Saccolaimus flaviventris*		Yellow-bellied Sheathtail-bat	V,P		1	
Animalia	Mammalia	Molossidae	1329	*Micronomus norfolkensis*		Eastern Coastal Free-tailed Bat	V,P		23	
Animalia	Mammalia	Vespertilionidae	1353	*Chalinolobus dwyeri*		Large-eared Pied Bat	V,P	V	2	
Animalia	Mammalia	Vespertilionidae	1372	*Falsistrellus tasmaniensis*		Eastern False Pipistrelle	V,P		1	
Animalia	Mammalia	Vespertilionidae	1357	*Myotis macropus*		Southern Myotis	V,P		1	
Animalia	Mammalia	Vespertilionidae	1361	*Scoteanax rueppellii*		Greater Broad-nosed Bat	V,P		8	
Animalia	Mammalia	Vespertilionidae	1025	*Vespadelus troughtoni*		Eastern Cave Bat	V,P		1	

Animalia	Mammalia	Miniopteridae	1346	*Miniopterus australis*	Little Bent-winged Bat	V,P		102
Animalia	Mammalia	Miniopteridae	3330	*Miniopterus orianae oceanensis*	Large Bent-winged Bat	V,P		51
Animalia	Mammalia	Muridae	1455	*Pseudomys novaehollandiae*	New Holland Mouse	P	V	1
Plantae	Flora	Elaeocarpaceae	6205	*Tetratheca glandulosa*		V		1
Plantae	Flora	Elaeocarpaceae	6206	*Tetratheca juncea*	Black-eyed Susan	V	V	3300
Plantae	Flora	Myrtaceae	9619	*Angophora inopina*	Charmhaven Apple	V	V	580
Plantae	Flora	Myrtaceae	4007	*^^Callistemon linearifolius*	Netted Bottle Brush	V,3		4
Plantae	Flora	Myrtaceae	6809	*Melaleuca biconvexa*	Biconvex Paperbark	V	V	8
Plantae	Flora	Myrtaceae	4283	*Rhodamnia rubescens*	Scrub Turpentine	E4A		6
Plantae	Flora	Myrtaceae	4293	*Syzygium paniculatum*	Magenta Lilly Pilly	E1	V	5
Plantae	Flora	Orchidaceae	9027	*^Diuris praecox*	Rough Doubletail	V,P,2	V	5
Plantae	Flora	Proteaceae	10009	*Grevillea parviflora subsp. parviflora*	Small-flower Grevillea	V	V	12

NSW Status

1	Sensitivity Class 1 (Sensitive Species Data Policy)
2	Sensitivity Class 2 (Sensitive Species Data Policy)
3	Sensitivity Class 3 (Sensitive Species Data Policy)
CC	Collapsed Ecological Community (Biodiversity Conservation Act 2016)
CH	Critical Habitat (Biodiversity Conservation Act 2016)
E1	Endangered (Biodiversity Conservation Act 2016)
E2	Endangered Population (Biodiversity Conservation Act 2016)
E3	Endangered Ecological Community (Biodiversity Conservation Act 2016)
E4	Presumed Extinct (Biodiversity Conservation Act 2016)
E4A	Critically Endangered (Biodiversity Conservation Act 2016)
E4B	Critically Endangered Ecological Community (Biodiversity Conservation Act 2016)
EW	Extinct in the Wild (Biodiversity Conservation Act 2016)
FCE	Critically Endangered Fish (Fisheries Management Act 1994)
FE	Endangered Fish (Fisheries Management Act 1994)
FEC	Endangered Ecological Community of Fish (Fisheries Management Act 1994)
FEP	Endangered Population of Fish (Fisheries Management Act 1994)
FKTP	Key Threatening Process of Fish (Fisheries Management Act 1994)
FP	Protected Fish (Fisheries Management Act 1994)
FV	Vulnerable Fish (Fisheries Management Act 1994)
FX	Extinct Fish (Fisheries Management Act 1994)
KTP	Key Threatening Process (Biodiversity Conservation Act 2016)
P	Protected (National Parks & Wildlife Act 1974)
V	Vulnerable (Biodiversity Conservation Act 2016)
V2	Vulnerable Ecological Community (Biodiversity Conservation Act 2016)

Commonwealth Status

C	Listed on China Australia Migratory Bird Agreement
CD	Conservation Dependent (Commonwealth EPBC Act 1999)
CE	Critically Endangered (Commonwealth EPBC Act 1999)
E	Endangered (Commonwealth EPBC Act 1999)
J	Listed on Japan Australia Migratory Bird Agreement
K	Listed on Republic of Korea Australia Migratory Bird Agreement
KTP	Key Threatening Process (Commonwealth EPBC Act 1999)
V	Vulnerable (Commonwealth EPBC Act 1999)
X	Extinct (Commonwealth EPBC Act 1999)
XW	Extinct in the Wild (Commonwealth EPBC Act 1999)

SEED | Sharing and Enabling Environmental Data

Winding Creek Wilkinson Park

0.9 0 0.45 0.9 Kilometers

Scale 1: 18,055.95

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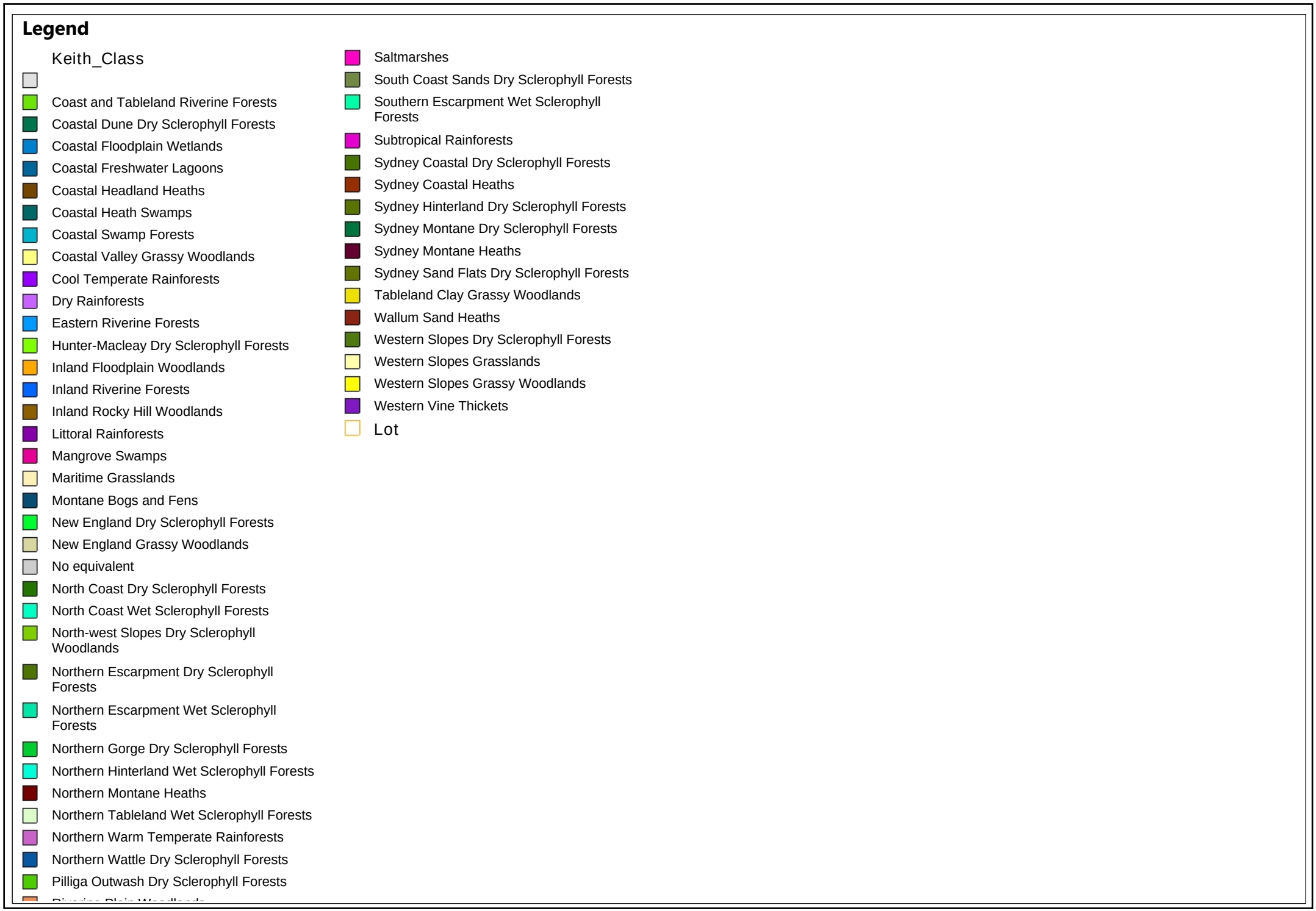
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Coastal Dune Dry Sclerophyll Forests
Coastal Floodplain Wetlands
Coastal Freshwater Lagoons
Coastal Headland Heaths
Coastal Heath Swamps
Coastal Swamp Forests
Coastal Valley Grassy Woodlands
Cool Temperate Rainforests
Dry Rainforests
Eastern Riverine Forests
Hunter-Macleay Dry Sclerophyll Forests
Inland Floodplain Woodlands
Inland Riverine Forests
Inland Rocky Hill Woodlands
Littoral Rainforests
Mangrove Swamps
Maritime Grasslands
Montane Bogs and Fens
New England Dry Sclerophyll Forests
New England Grassy Woodlands
No equivalent
North Coast Dry Sclerophyll Forests
North Coast Wet Sclerophyll Forests
North-west Slopes Dry Sclerophyll Woodlands
Northern Escarpment Dry Sclerophyll Forests
Northern Escarpment Wet Sclerophyll Forests
Northern Gorge Dry Sclerophyll Forests
Northern Hinterland Wet Sclerophyll Forests
Northern Montane Heaths
Northern Tableland Wet Sclerophyll Forests
Northern Warm Temperate Rainforests
Northern Wattle Dry Sclerophyll Forests
Pilliga Outwash Dry Sclerophyll Forests
Saltmarshes
South Coast Sands Dry Sclerophyll Forests
Southern Escarpment Wet Sclerophyll Forests
Subtropical Rainforests
Sydney Coastal Dry Sclerophyll Forests
Sydney Coastal Heaths
Sydney Hinterland Dry Sclerophyll Forests
Sydney Montane Dry Sclerophyll Forests
Sydney Montane Heaths
Sydney Sand Flats Dry Sclerophyll Forests
Tableland Clay Grassy Woodlands
Wallum Sand Heaths
Western Slopes Dry Sclerophyll Forests
Western Slopes Grasslands
Western Slopes Grassy Woodlands
Western Vine Thickets
Lot

Site L03 Nationally Important Wetlands

September 1, 2021

Ramsar Wetlands

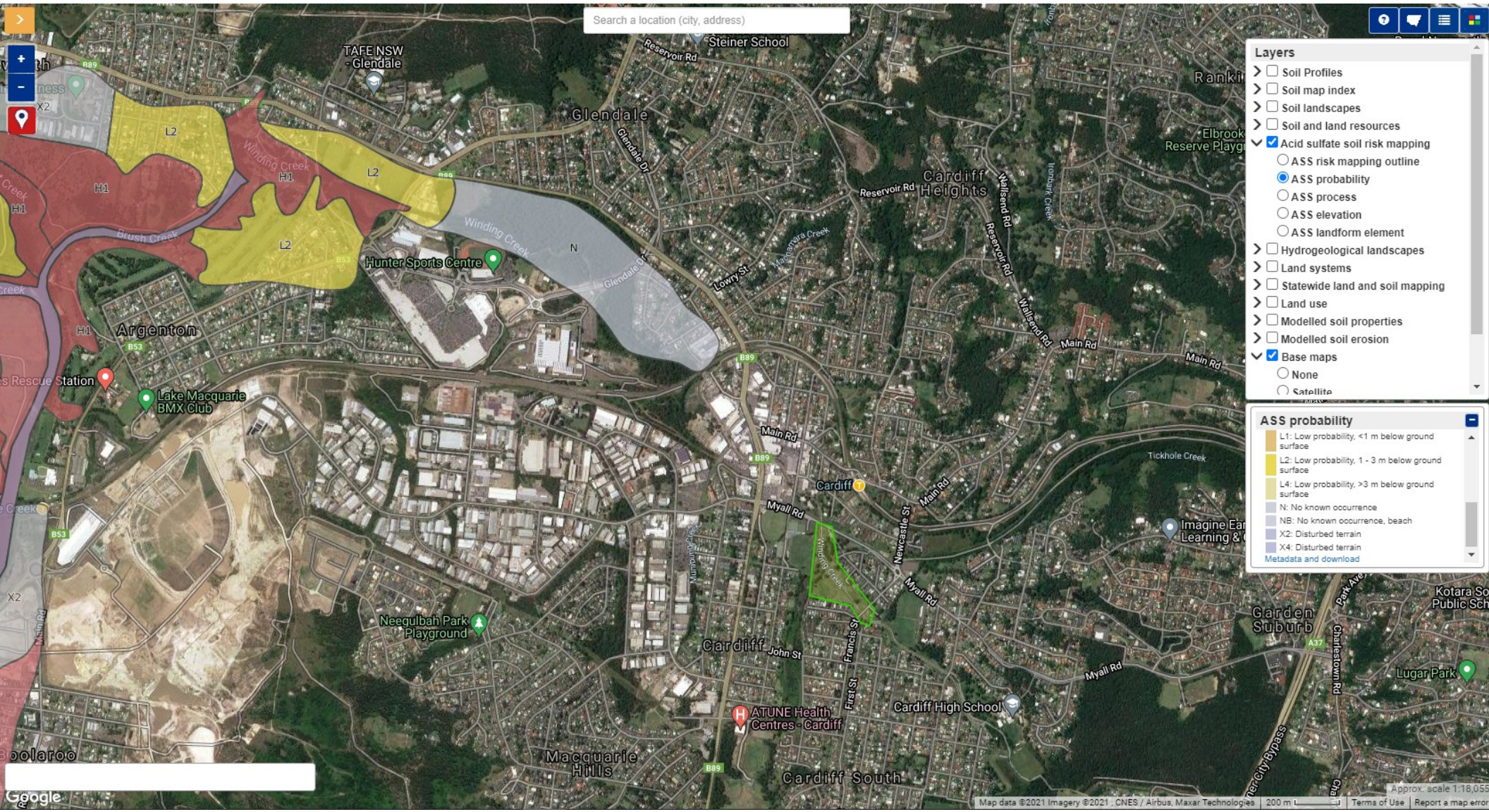
Nationally Important Wetlands

1:144,448

0 1.75 3.5 7 mi

0 2.75 5.5 11 km

Map produced by the Department of Agriculture, Water and the Environment.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Soil landscapes
Soil and land resources
Acid sulfate soil risk mapping
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ASS probability
ASS process
ASS elevation
ASS landform element
Hydrogeological landscapes
Land systems
Statewide land and soil mapping
Land use
Modelled soil properties
Modelled soil erosion
Base maps
None
Satellite
ASS probability
L1: Low probability, <1 m below ground surface
L2: Low probability, 1 - 3 m below ground surface
L4: Low probability, >3 m below ground surface
N: No known occurrence
NB: No known occurrence, beach
X2: Disturbed terrain
X4: Disturbed terrain
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TAFE NSW - Glendale
Steiner School
Glendale
Cardiff Heights
Hunter Sports Centre
Argenton
Lake Macquarie BMX Club
Neegulbah Park Playground
Cardiff
ATUNE Health Centres - Cardiff
Cardiff High School
Macquarie Hills
Cardiff South
Garden Suburb
Lugar Park
Reservoir Rd
Glendale Dr
Winding Creek
Brush Creek
Lowry St
Wallsend Rd
Main Rd
Myall Rd
John St
First St
Newcastle St
Tickhole Creek
Charlestown Rd
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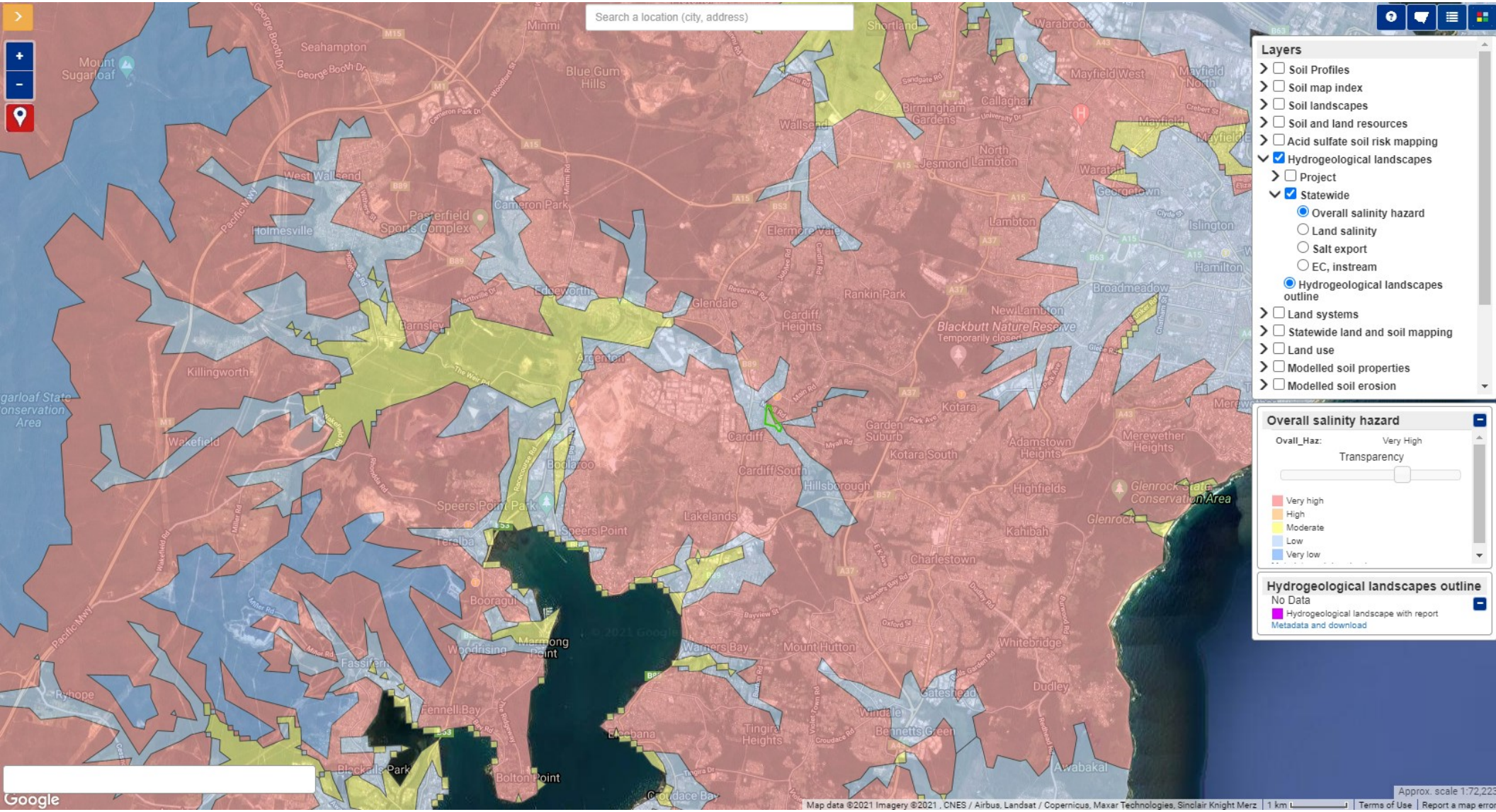
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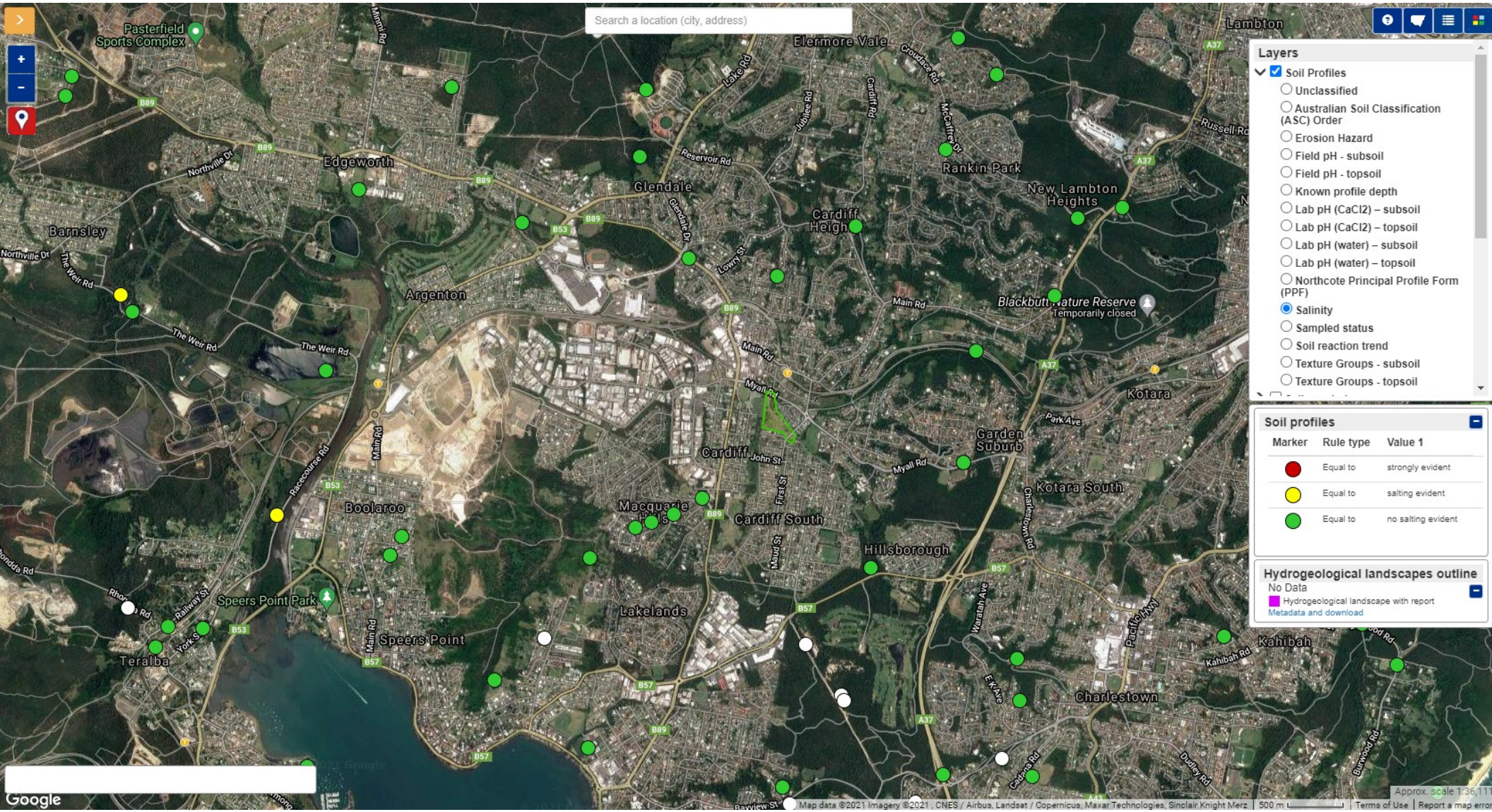
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Field pH - topsoil
Known profile depth
Lab pH (CaCl2) – subsoil
Lab pH (CaCl2) – topsoil
Lab pH (water) – subsoil
Lab pH (water) – topsoil
Northcote Principal Profile Form (PPF)
Salinity
Sampled status
Soil reaction trend
Texture Groups - subsoil
Texture Groups - topsoil
Soil profiles
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Lambton
Edgeworth
Glendale
Rankin Park
New Lambton Heights
Cardiff Heigh
Barnsley
Argenton
Blackbutt Nature Reserve
Temporarily closed
Kotara
Garden Suburb
Cardiff
Kotara South
Boolaroo
Macquarie Hills
Cardiff South
Hillsborough
Speers Point Park
Lakelands
Speers Point
Teralba
Kahibah
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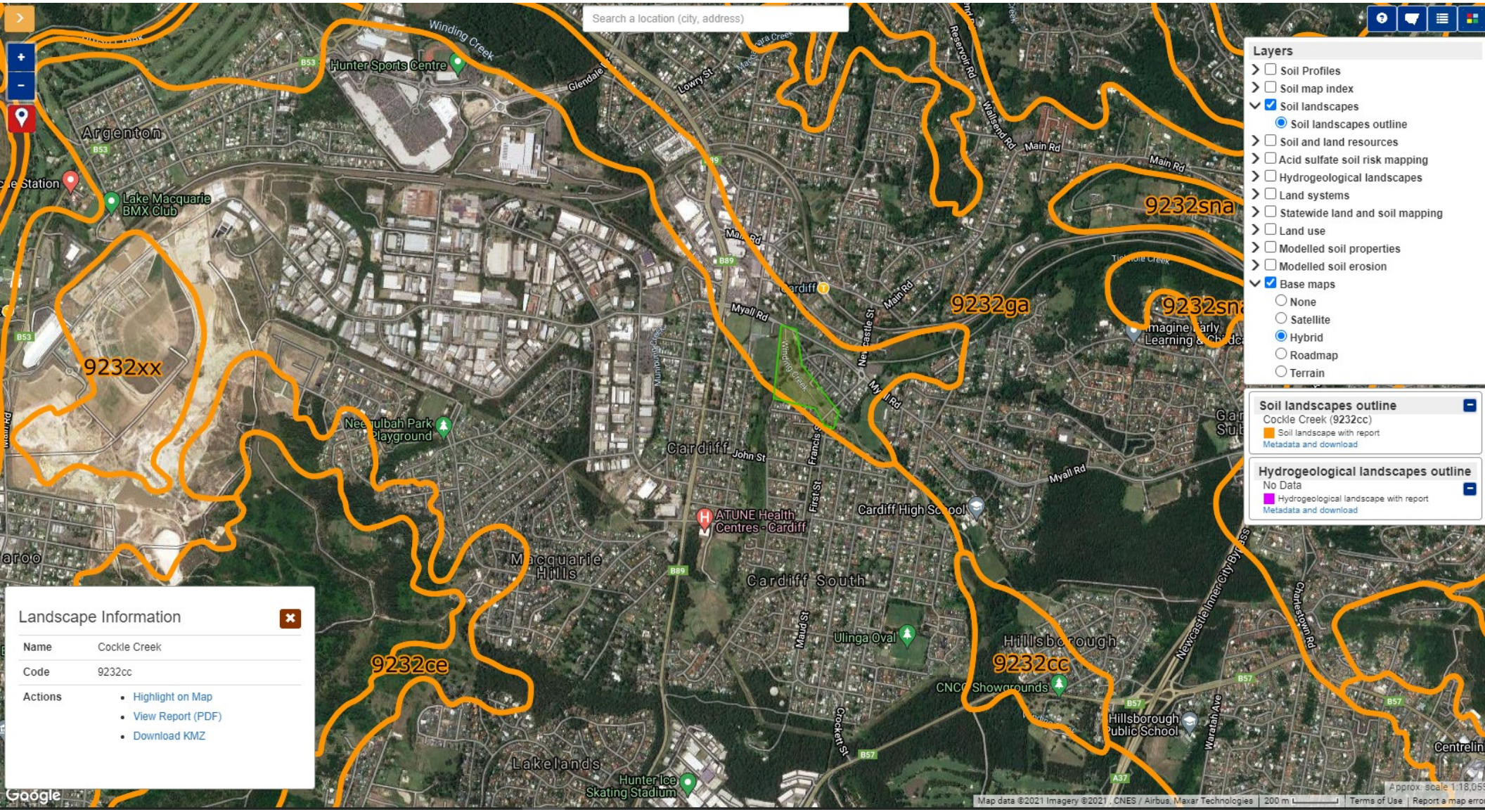
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Landscape Information
Name
Cockle Creek
Code
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Cardiff
Cardiff South
Macquarie Hills
Lakelands
Hillsborough
Hunter Sports Centre
Lake Macquarie BMX Club
Neetulbah Park Playground
ATUNE Health Centres - Cardiff
Cardiff High School
Ulinga Oval
CNC Showgrounds
Hillsborough Public School
Hunter Ice Skating Stadium
Winding Creek
Lowry St
Glendale
Reservoir Rd
Wallsend Rd
Main Rd
Myall Rd
Newcastle St
John St
First St
Maud St
Crockett St
Charlestown Rd
Newcastle Inner City Bypass
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cc COCKLE CREEK

Landscape—narrow floodplains, alluvial fan deposits and broad delta deposits in the Awaba Hills. Slope gradients are 0–2%, elevation is <1–50 m, local relief is <1 m. Cleared open-forest.

Soils—deep (>200 cm), imperfectly to poorly drained yellow Soloths (Dy3.41) and Yellow Podzolic Soils (Dy3.11) on floodplains; deep (>200 cm), moderately well to poorly drained Yellow Earths (Gn2.64), and Grey Earths (Gn2.83) on delta and fan deposits, with deep (>200 cm) imperfectly drained, to well-drained Yellow Podzolic Soils (Dy3.11, Dy2.11, Dy3.51).

Limitations—flood hazard, water erosion hazard, permanently high watertables (localised), periodic to permanent waterlogging (localised), high run-on, acid, infertile sodic/dispersible soils of low wet strength.

LOCATION

Alluvial flats of Cockle Creek and its tributaries in the far south of the area in the Awaba Hills region. Examples include Barnsley, O'Donnelltown and Diega Flat. Type location is at Barnsley (Area reference 3 **68*****E, 63 **55*****N).

LANDSCAPE

Geology and Regolith

Quaternary alluvial sediment derived from sandstone, siltstone, conglomerate, shale and tuff of the upper catchment.

Topography

Alluvial flats, alluvial fans and drainage plains. Slope gradients are 0–2% on floodplains, <5% on alluvial fans and drainage plains. Elevation ranges from <1–50 m, local relief is <1 m. Landform ranges from moderately broad (<500 m) alluvial flats to broad (up to 1 000 m) deltaic deposits on lower Cockle Creek, with some relict terrace and levee deposits and point bar deposits (local relief up to 3 m, 5–10 m in width). Alluvial fan deposits (<500 m) occur in upper Cockle Creek and its tributaries.

Vegetation

Three main associations occur. On lower Cockle Creek a predominantly cleared woodland of *Angophora costata* (smooth-barked apple), *Angophora floribunda* (rough-barked apple) and *Eucalyptus gummifera* (red bloodwood) occurs. *E. piperita* (sydney peppermint) and may also be present and *Casuarina glauca* (swamp oak) is common along drainage channels.

In upper Cockle Creek an uncleared open-forest predominates. Common species include *Eucalyptus robusta* (swamp mahogany), *E. umbra* (bastard mahogany), *E. amplifolia* (cabbage gum) and *E. deanei* (mountain blue gum) with an understorey of *Glochidion ferdinandi* (cheese tree), *Acacia parramattensis* (sydney green wattle) and *Rapanea variabilis* (muttonwood).

Melaleuca spp. (paperbark) occurs as understorey on poorly drained floodplain deposits.

Land Use

This landscape has been cleared, in part, for grazing around the lower reaches of Cockle Creek, west of Holmesville and around O'Donnelltown. Some industrial development occurs around Argenton and Boolaroo where the sewage treatment works are located. Parts of the West Wallsend Colliery occupy this landscape. The remainder is uncleared bushland.

Existing Land Degradation

On floodplains and drainage plains, moderate sheet erosion occurs where vegetation has been cleared. These areas are also prone to structural degradation when wet, through stock trampling and vehicle tracks. Stream bank erosion commonly occurs in the upper reaches of Cockle Creek. Exposed batters are prone to slumping and tunnel erosion.

Included Soil Landscapes

Small areas of Fullerton Cove **(fc)** soil landscape have been included at the fringe of the Cockle Creek soil landscape where Cockle Creek enters Lake Macquarie.

SOILS

Dominant Soil Materials

cc1—Brownish black sandy loam (topsoil—A_1 horizon)

Colour	brownish black (10YR 3/3, 10YR 2/2)
Texture	sandy loam to silty clay loam
Structure	weak, 10–20 mm sub-angular blocky or occasionally platy
Fabric	rough ped
Field pH	moderately to slightly acid (pH 5.5–6.0)
Coarse fragments	few to common rounded quartz pebbles
Roots	few to many, in-ped, fine, branched
Permeability	highly permeable
Exposed condition	weakly pedal when moderately moist, generally hardsetting when dry, but occasionally soft
Type location	Barnsley, weir over Cockle Creek on James Street (Grid Ref. 3 **69**0**E, 63 **54**6**N). Lake Macquarie Catchment Soil Survey Soil Data System card 50, 0–18 cm

cc2— Hardsetting bleached sandy clay loam (topsoil—A_2 horizon)

Colour	dull yellowish brown (10YR 4/3) when moist, dull yellow orange (10YR 7/2) when dry
Texture	light sandy clay loam to silty clay loam
Structure	massive
Fabric	earthy
Field pH	slightly acid (pH 6.0)
Coarse fragments	occasionally common to many rounded pebbles may be present
Roots	few to common, fine
Permeability	moderate
Exposed condition	massive, hardsetting, may be poached due to trampling by livestock on the wet surface
Type location	Barnsley, weir over Cockle Creek on James Street (Grid Ref. 3 **69**0**E, 63 **54**6**N). Lake Macquarie Catchment Soil Survey Soil Data System card 50, 18–32 cm

cc3— Dull yellowish brown pedal clay (subsoil—B_2 horizon)

Colour	dull yellowish brown (10YR 5/4)
Texture	silty to medium clay
Structure	moderate to strong, 10–20 mm angular blocky peds
Fabric	smooth ped, dense
Field pH	moderately to slightly acid (pH 5.5–6.0)
Coarse fragments	absent
Roots	few, in-ped, fine
Permeability	slow
Exposed condition	rarely exposed
Type location	500 m north of Killingworth on Killingworth Road (Grid Ref. 3 **65**0**E, 63 **55**3**N). Lake Macquarie Catchment Soil Survey Soil Data System card 47, 27–>200 cm

cc4—Earthy mottled sandy clay (subsoil—B_2, D horizon)

Colour	dull yellowish brown (10YR 5/3, 10YR 5/4), bright yellowish brown (10YR 6/6), greyish yellow brown (10YR 4/2, 10YR 5/2), or occasionally dull yellow orange (10YR 6/3). Orange and grey mottles are common to abundant, often increasing with depth
Texture	sandy clay
Structure	massive or weak, 20–50 mm prismatic or sub-angular blocky peds may occur
Fabric	earthy, rarely rough ped
Field pH	strongly to moderately acid (pH 4.5–5.5)
Coarse fragments	few charcoal fragments, rounded pebbles may occur. Common rounded ironstone fragments may occur
Roots	absent to many, fine to moderate
Permeability	moderate
Exposed condition	massive; occasionally this material may be indurated when dry with a moderately strong dry consistence and a crumbly, weak moist consistence
Type location	Barnsley, weir over Cockle Creek on James Street (Grid Ref. 3 **69**0**E, 63 **54**6**N). Lake Macquarie Catchment Soil Survey Soil Data System card 50, 32–>200 cm

Associated Soil Materials

Pale loose sand. This is a dull yellowish brown or brownish grey sand to loamy sand which is bleached light grey when dry. Structure is loose and single-grained when moist, but may be hardsetting when dry and moderately indurated in parts. It occurs at the edges of drainage channels.

Occurrence and Relationships

Floodplains and drainage plains. Up to 30 cm brownish black sandy loam **(cc1)** overlies up to 20 cm hardsetting bleached sandy clay loam **(cc2)** and >60 cm dull yellowish brown pedal clay **(cc3).** Boundaries are abrupt [imperfectly to poorly drained yellow Soloths (Dy3.41)]. Occasionally, **cc2** is absent and **cc1** directly overlies **cc3.** Boundaries are abrupt [imperfectly to poorly drained Yellow Podzolic Soils (Dy3.11)]. Total soil depth >200 cm.

Delta deposits and alluvial fans. 20–65 cm **cc1** overlies >260 cm earthy mottled sandy clay **(cc4).** Boundaries are gradual [moderately well to poorly drained Yellow Earths (Gn2.64), Grey Earths (Gn2.83)], or clear to abrupt [imperfectly drained to well-drained Yellow Podzolic Soils (Dy3.11, Dy2.11, Dy3.51)]. Occasionally, up to 14 cm **cc2** occurs between **cc1** and **cc4.** Boundaries are clear to abrupt [imperfectly to poorly drained yellow Soloths (Dy3.41)]. Total soil depth >200 cm.

At the edges of channels. Up to 35 cm **cc1** overlies >155 cm pale loose sand. Boundaries are gradual [poorly drained Earthy Sands (Uc5.21, Uc5.23)]. Total soil depth >200 cm. More than 80 cm pale loose sand may occur in drainage channels [poorly drained Alluvial Soils (Uc1.21)].

QUALITIES AND LIMITATIONS

Landscape Limitations

Flooding hazard
Waterlogging (localised, deltas and floodplains)
Permanently high watertables (localised, deltas)
Seasonal waterlogging
Water erosion hazard
Acid sulphate potential (localised, within 1.5 m AHD)
High run-on
Foundation hazard
Mine Subsidence District

Soil Limitations

cc1 High erodibility
Hardsetting surfaces

cc2 Low wet bearing strength
Hardsetting surface
Very strong acidity
High potential aluminium toxicity
Low fertility
Stoniness (localised)

cc3 High plasticity
Low wet bearing strength
Sodicity/dispersion
Low permeability
Very strong acidity
Potential aluminium toxicity
Acid sulphate potential (localised)

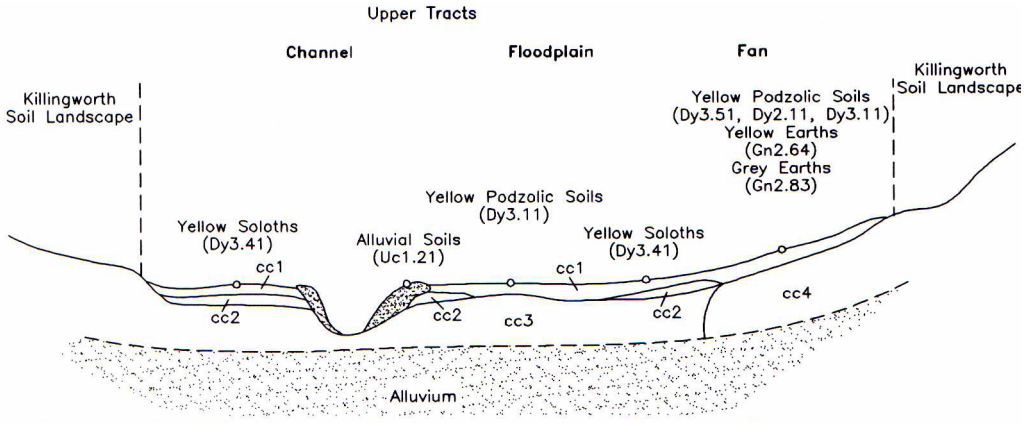
cc4 Extreme acidity
Very high potential aluminium toxicity
Acid sulphate potential (localised)
Very low fertility

Fertility

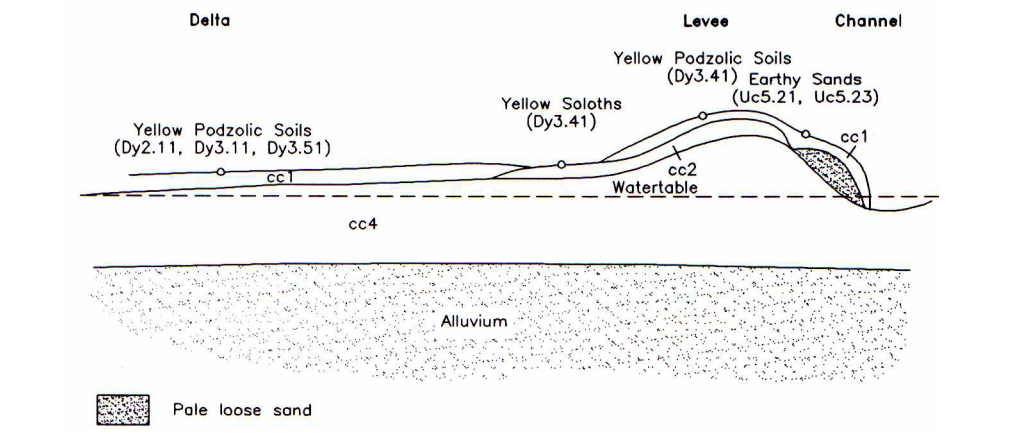
Soil Materials as Plant Growth Media. Soil material suitability for use as plant growth media is moderate **(cc1)** to low. Topsoil **cc1** has very high organic matter content, moderate available phosphorus and exchangeable cations, but low nutrient storage capacity. Soil materials **cc2**, **cc3**, and **cc4** are very strongly to extremely acid, with high potential aluminium toxicity.

Soil Profile Fertility. Soil profile suitability as a growth medium is low. The soil landscape is poorly drained and prone to seasonal waterlogging. Soil volumes available for root penetration are restricted due to high watertables.

Well-drained Yellow Podzolic Soils on alluvial fan deposits are moderately suitable.



■ *Schematic cross-section of Cockle Creek soil landscape (upper tracts) illustrating the occurrence and relationship of the dominant soil materials.*



■ *Schematic cross-section of Cockle Creek soil landscape (lower tracts) illustrating the occurrence and relationship of the dominant soil materials.*

Erodibility

	K factor	Non-concentrated flows	Concentrated flows*	Wind
cc1	0.000	very low	high	low
cc2	0.032	moderate	moderate	low
cc3	0.026	moderate	high	low
cc4	0.026	moderate	high	low

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
grazing	low	moderate	slight
cultivation	moderate	high	slight
urban	moderate	moderate	slight

*Concentrated flows include channelled flows and wave erosion hazard in this soil landscape.

Foundation Hazard

High foundation hazard due low wet strength soils, high watertables and localised potential acid sulphate soils. Localised low hazard on well-drained alluvial fans. Topsoil depth is 20–50 cm. Total soil depth is >200 cm.

Urban Capability

High to severe limitations for urban development due to flood hazard.

Rural Capability

Moderate limitations for cultivation and low limitations for grazing.

Sustainable Land Management Recommendations

Ground cover should be maintained at 75% or greater to ensure that **cc1** is not lost to erosion. In particular, the clearing of undergrowth on floodplains and drainage plains leads to topsoil loss. Organic matter incorporation may help to improve soil structure. Drainage should not be undertaken until site investigations have been carried out for potential acid sulphate soils.

Soil Conservation Earthworks

Moderate limitations for earthworks, including high watertables, saturated soil materials and potential acid sulphate soils. Soils tested have earthworks categories J for **cc1** and B for **cc2**, **cc3** and **cc4**.

APPENDIX E

Flood Impact Assessment

Technical Memo

To:	Shaun Murphy Hunter Water	**From:**	Peter Gillam Aurecon
CC:		**Date:**	13/07/2022

Subject:	Flood Impact Assessment: Proposed stormwater amenity works for Winding Creek, Cardiff (Final)		
Author	Shae Jelly	Reviewer	Peter Gillam

1 Introduction

This memo outlines the methodology and outcomes of the flood impact assessment for the proposed stormwater amenity works on a section of Hunter Water's stormwater channel known as Winding Creek, Cardiff.

The proposed works area extends upstream of Myall Road, Cardiff as part of the Hunter Water (HW) Stormwater Amenity works program for completion by June 2024. Detailed designs have been prepared of the proposed works. The extent of the final works is subject to final costing and construction budgets and the final extent of works may be reduced.

A flooding investigation has been carried out using a new two-dimensional hydraulic model (*TUFLOW*) to determine:

- Whether the proposed detailed design of amenity works at Winding Creek are likely to cause any adverse impacts to existing flood conditions for a range of flows
- Whether hydraulic conditions along the works area would change flood behaviour downstream
- Typical velocities and bed shear stresses along the works area to inform the stabilisation techniques and sizing of rock rip rap.

2 Proposed Amenity Works

The proposed works include planting and creek naturalisation works on both east and west banks as shown in Figure 2-1 and Figure 2-2. Works are within Hunter Water lands, Council land and the Myall Road reserve.

The proposed works include:

- Saw cutting and removing sections of vertical concrete channel walls
- Laying back the creek banks at a 1V:2H gradient
- Placing interlocking sandstone rock riprap over the creek banks
- Planting within the rip rap and on overbank areas
- Planting in pockets on the downstream extent of the works area
- Planting where the proposed design was <1.8m from the proposed shared path alignment.

Increases in floodplain roughness associated with planting and bank works (increase in Manning's *n* coefficient) has been offset by increasing the cross-sectional area of the channel to minimise flood afflux.

Hydraulic design (Manning's formula) was undertaken during concept designs development. Detailed flood modelling using a TUFLOW 2D hydraulic model was undertaken to confirm the expected flood impacts of the detailed design.

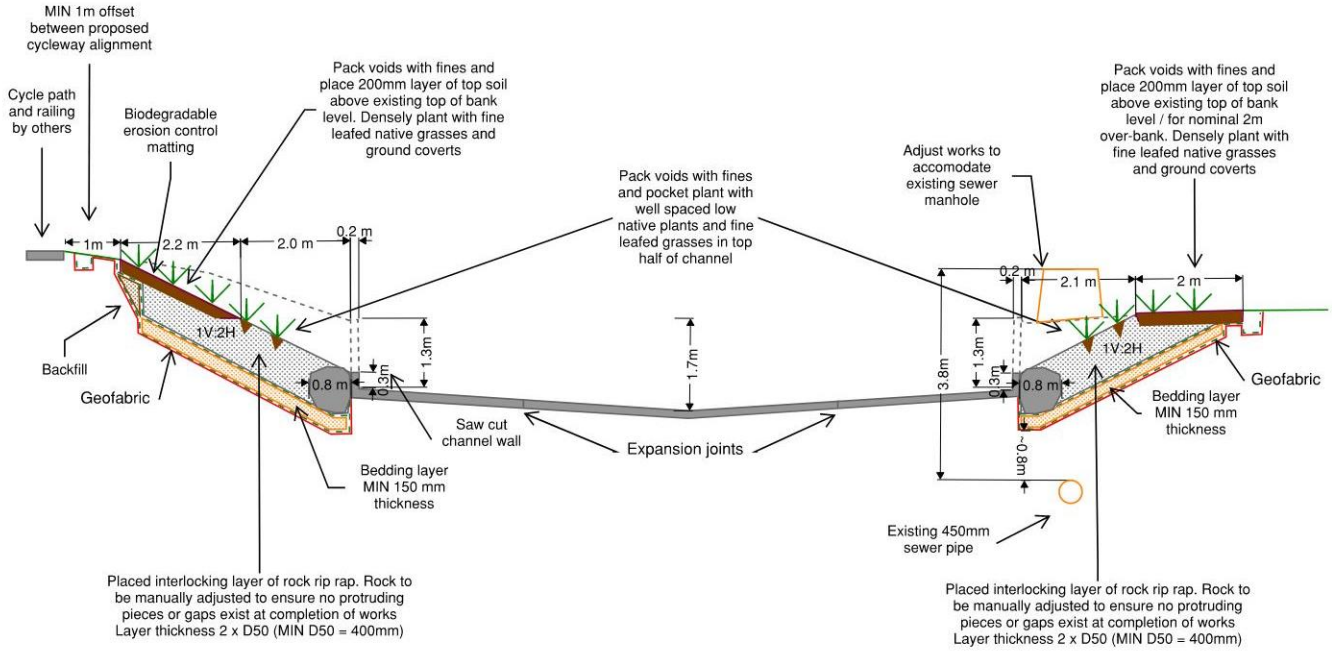


Figure 2-1 Concept design section of creek naturalisation works at Winding Creek, Myall Road, Cardiff

The extent of the final works is subject to final costing, construction budgets or constraints found on site which may reduce the final extent of rock batter slopes shown below in Figure 2-2.

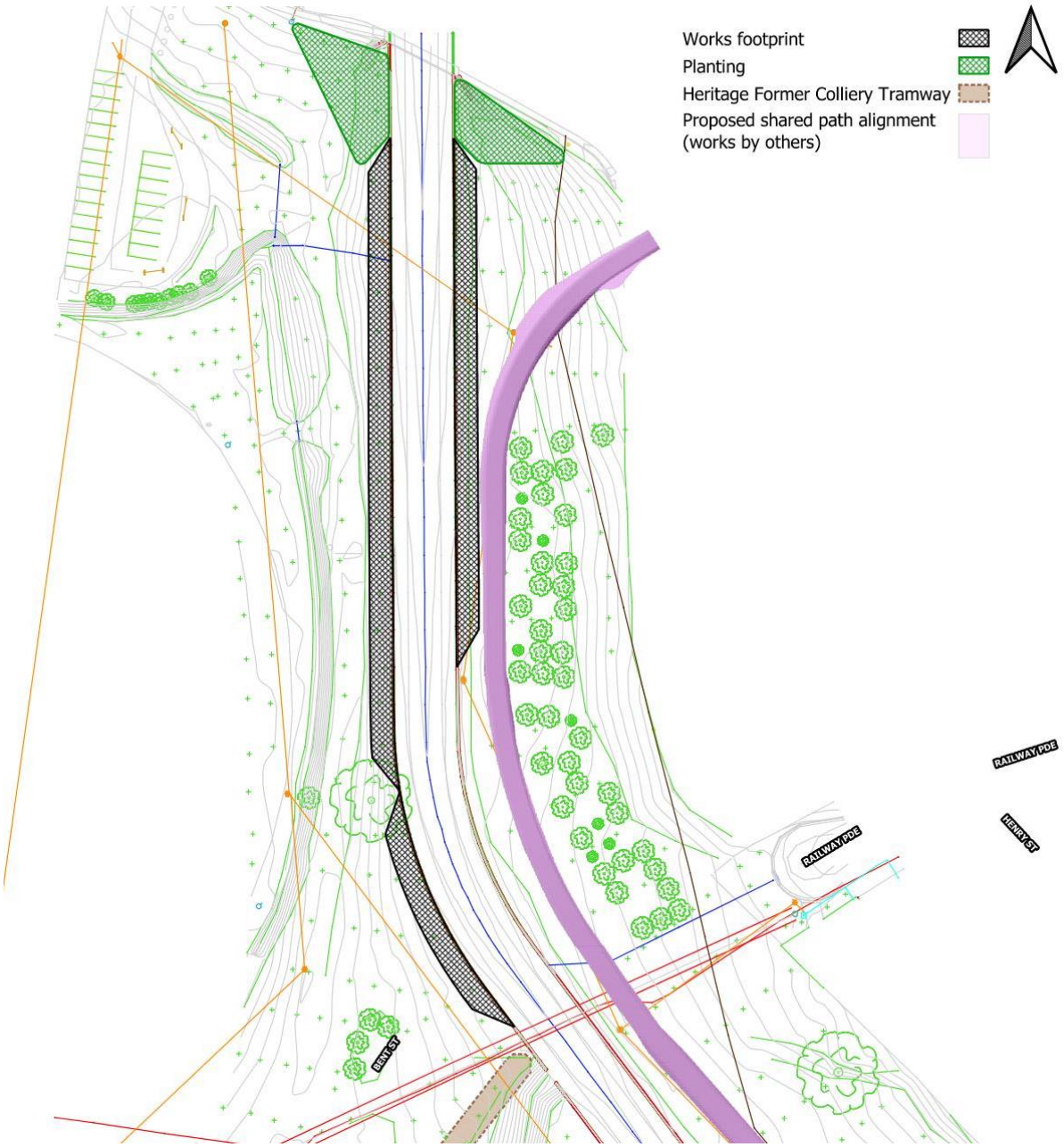


Figure 2-2 Concept design plan of creek naturalisation works at Winding Creek, Myall Road, Cardiff

3 Existing flood modelling data sets held by Council

Flood modelling has previously been undertaken by WMA Water on behalf of Lake Macquarie City Council (LMCC) for the Winding Creek and Lower Cockle Creek Flood Study (2017) and Winding Creek and Lower Cockle Creek Floodplain Risk Management Study and Plan (FRMSP) (2017).

This LMCC TUFLOW model was made available and was run to extract results for this flood impact assessment. The LMCC TUFLOW model results are also used to compare and benchmark model results produced by the new TUFLOW model of the works area.

The LMCC TUFLOW model represents concrete lined channels as 1D elements nested within the overbank floodplain area which was modelled as 2D grid using a 4m grid size. A WBNM hydrological

model was used by WMA to produce inflow hydrographs to the TUFLOW model. The studies used the Australian Rainfall and Runoff 1987 approach (AR&R87). The LMCC Winding Creek model is calibrated to the June 2007 historical flood event and verified with the February 1990 historical flood event. Flood markers for these events were not available.

A review of the LMCC Winding Creek TUFLOW model determined that a 4m grid would be too coarse to appropriately model the resolution of the proposed creek naturalisation works. However, the LMCC Winding Creek model was considered a suitable basis for the schematisation of a new model (herein referred to as the HW TUFLOW model) and to extract design hydrographs to reflect the flood levels modelled in these past studies.

4 Aurecon modelling methodology

A new model has been established specific for testing the hydraulic design. The model is intended to test the impacts of the detailed design on a range of flow events. The flows selected represent a range of typical flood events of interest as follows:

- Bank full discharge - the design should not affect the level of service provided by the channel
- 10% AEP – the design must have an acceptable impact on local drainage patterns and not worsen the frequency of nuisance flooding
- 1% AEP event flow – the design must not increase flooding on roads or private property or reduce flood immunity for this event and must have an acceptable impact on public lands and roads
- PMF event flows – the design should have an acceptable impact on PMF flood levels

Detailed parameters associated with HW TUFLOW modelling approach and set up of the model are outlined in the following sections.

4.1 Design inflows

The 10% and 1% AEP event and the PMF event were adopted as the design events for this flooding investigation. The hydrographs for these events were extracted directly from the LMCC Winding Creek model plot outputs at each of the inflow locations of the HW Winding Creek model.

At the site, the critical duration for the 10% and 1% events was found to be 9 hours, while the PMF was found to have a critical duration of 2 hours. Only these critical durations were modelled in the HW Winding Creek model.

The bank-full flow was also considered, which was generated by first running the 10% event and extracting the flow that results in bank-full flow in the HW Winding Creek model. This flow was put into the model using a synthetic hydrograph of constant flow.

4.2 Hydraulic model parameters

A summary of the hydraulic model and parameters is provided in Table 4-1. The HW Winding Creek TUFLOW model developed for the site was reduced to the area of interest and is shown in Figure 4-3. The model extent starts approximately 245m upstream of the proposed works at Newcastle Street and extends past the Myall Road bridge at the downstream end.

Table 4-1 Hydraulic model parameters

Parameter	Hunter Water Winding Creek TUFLOW Model
Completion date	April 2022
Events/durations assessed	Bank-full flow 10% 540min 1% 540min PMF 120min
Hydrologic modelling	Hydrographs extracted directly from LMCC Winding Creek TUFLOW model (based on hydrology from WBNM model of ARR1987 hydrology)
Hydraulic model software	TUFLOW quadtree model with version 2020-10-AB-iSP-w64
Grid size	2m base cell size with 0.5m nested mesh refinement over the extent of site works
DEM	Refer Figure 4-1 for data coverage. • 1m LiDAR – NSW Government LiDAR data set September 2014 • Survey data collected by Aurecon in 2021 • Design terrain modelling
Roughness	Refer to section 4.2.2 Previously agreed
Model boundaries	Refer to section 4.2.5
Timesteps	Automatic adaptive time step
Sensitivity case	Refer to section 5.3

4.2.1 Terrain

The base terrain data used for this project was the NSW Government 1m LiDAR data from September 2014, and this was then supplemented with site survey. A design TIN has also been created for the creek naturalisation structural works and was read into the TUFLOW model in the proposed scenario. The coverage of these datasets can be seen in Figure 4-1.

Several terrain modifications were made to better represent the hydraulic conveyance in the base model. The terrain was also modified to reinforce the channel under the Myall Road bridge as the road was modelled as a flow constriction. A terrain modification was also input to smooth the in-channel transition between the LiDAR and survey data at the upstream end.

Representation of both the floodplain and channel in the 2D domain is a significant difference from the existing modelling carried out by WMA. This modelling approach may yield different hydraulic outcomes. However, given the approach of this modelling is to determine the extent of velocities, bed shear stresses and potential for flood afflux, a 2D modelling approach is preferred to representing the channel works as a nested 1D channel.

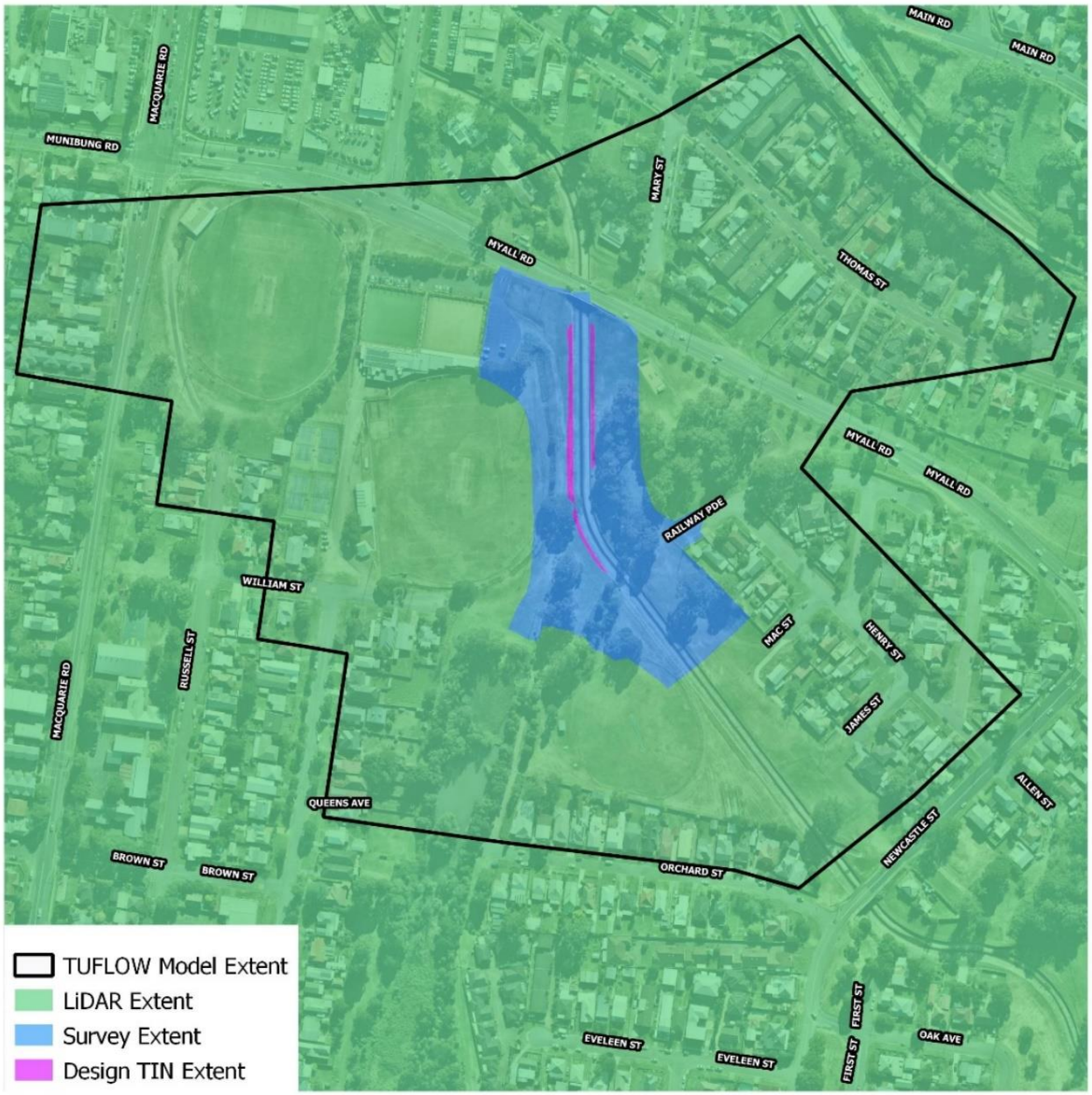


Figure 4-1 Topographic data coverage

4.2.2 Roughness

The Manning's *n* roughness coefficients from the LMCC Winding Creek model were used as a basis but were further refined and adjusted where appropriate.

The HW Winding Creek model adopts consistently lower Manning's n values for the baseline event, which was done to ensure that changes in roughness were associated with the works were appropriately captured in the hydraulic modelling roughness parameters. These values adopted for the baseline are consistent with modelling at other Hunter Water works sites. Adopted roughness parameters have been agreed with Council during earlier correspondence.

The adopted Manning's coefficients are shown in Table 4-2 and the layout of these categories is shown in Figure 4-2.

Table 4-2 Roughness values

Material	Manning's *n*	
	LMCC Model	HW Model Base Model Setup
Concrete channel	0.02	0.018
Riprap and pocket planting * (1 - 2 plants/m^2)	-	0.04
Moderate vegetated banks with fine leafed sedges and creepers * (5 plants/m^2)	-	0.045
Thick existing vegetation	-	0.06
Fence / Fenced lot	0.06 (lots)	0.1
Default floodplain	0.05	0.03
Roads	0.02	0.02
Buildings	3.0	3.0

* Denotes proposed works and planting

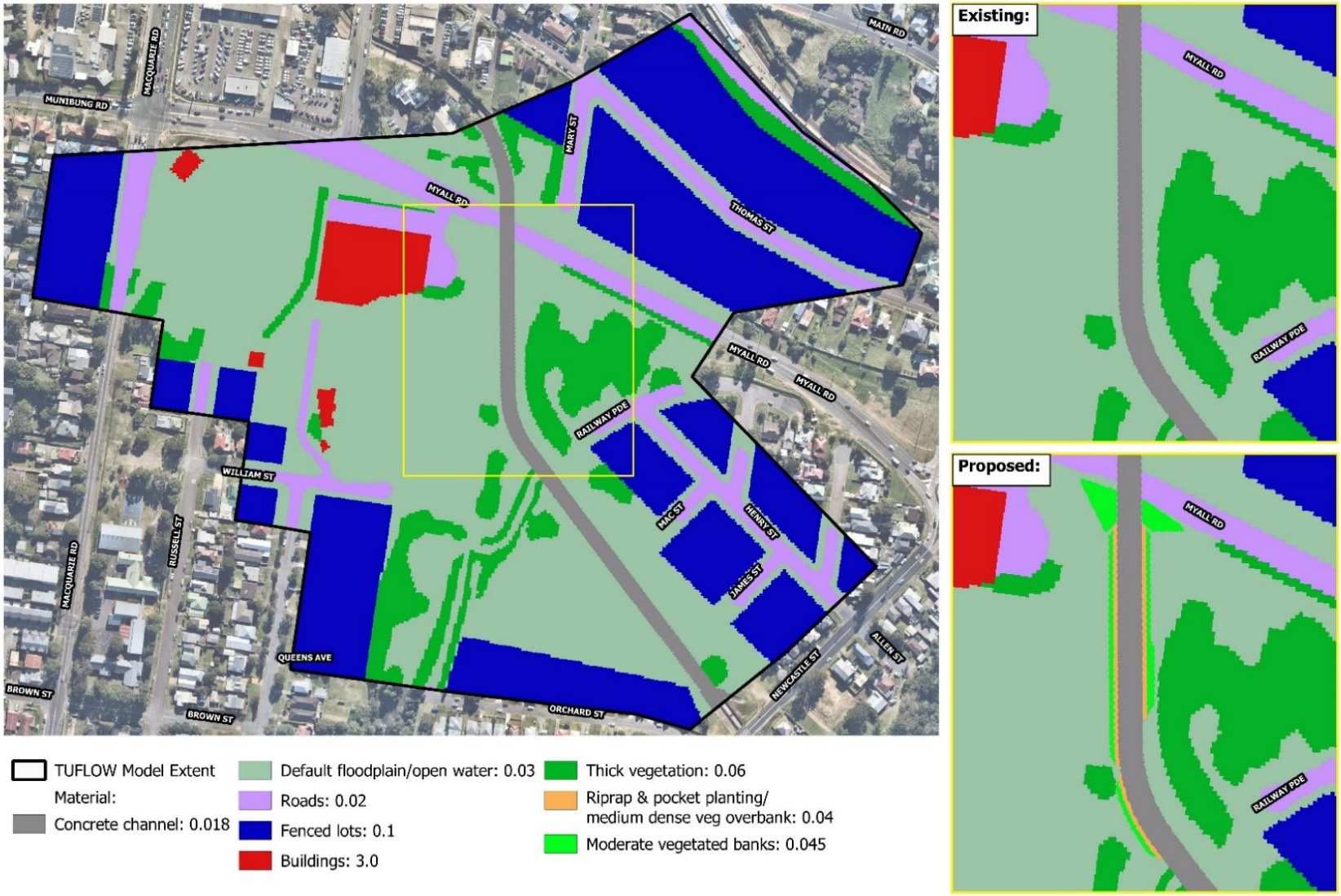


Figure 4-2 Manning's n coefficients for existing and proposed scenarios

4.2.3 Structures

The Myall Road bridge is modelled as a 1D bridge-weir in the LMCC Winding Creek model with a 1 m bridge deck thickness and a form loss coefficient of 0 under the deck and 1.56 for the deck. As the HW Winding Creek TUFLOW model has been developed only for the 2D domain, it was appropriate to model the Myall Road bridge as a 2D layered flow constriction. The deck surface level was taken from LiDAR and the same deck thickness and form loss coefficients were adopted from the LMCC Winding Creek model. The bridge was modelled with a width of 13 m.

4.2.4 Initial water level

The default initial water level in the LMCC Winding Creek model is 1.23 m AHD, which is much lower than the elevation within the HW Winding Creek model extent. As such, a static initial water level was not applied to the whole domain. However, an initial water level of 13.5 m AHD was applied to the sports field on William street in the LMCC Winding Creek model, and this was also applied to the HW Winding Creek TUFLOW model as shown in Figure 4-3.

4.2.5 Boundary conditions

The TUFLOW inflow and outflow boundaries are shown in Figure 4-3.

As previously discussed, the inflow hydrographs were extracted from LMCC Winding Creek model plot outputs taken at the same locations as the HW Winding Creek model inflow boundaries.

As the default initial water level in the LMCC Winding Creek model (1.23 m AHD) is much lower than the elevation within the HW Winding Creek model extent, this suggests that there is no tailwater level influence this high in Winding Creek catchment. As such, the model outflows have been modelled using conveyance boundaries. Flow through conveyance boundaries is dependent on a pre-defined height-discharge relationship generated in TUFLOW. The downstream slope at these boundaries is labelled in m/m on Figure 4-3.

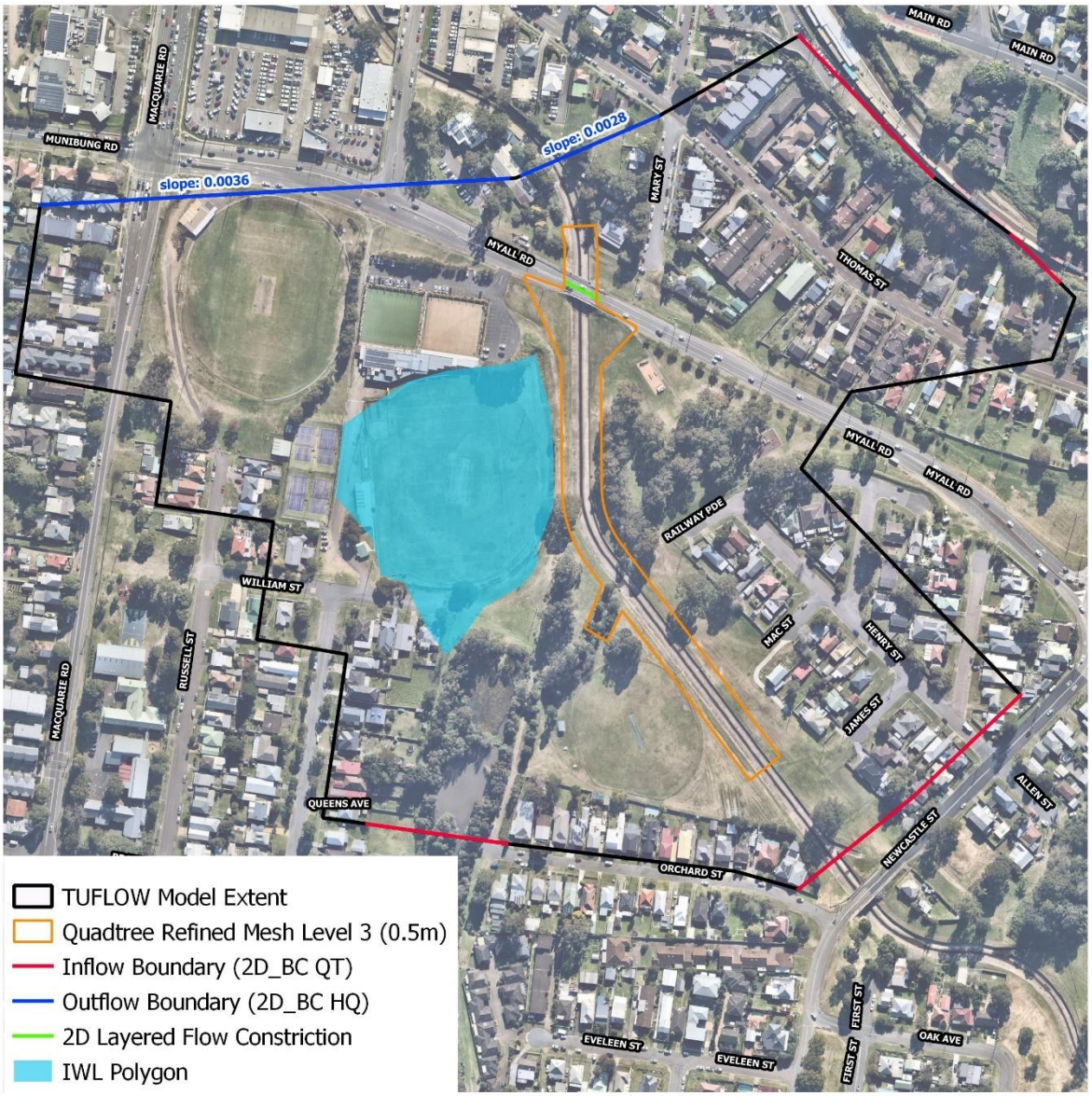


Figure 4-3 TUFLOW Model Setup

5 Hydraulic Model Results

A comparison between flood conditions was undertaken for the site with and without the proposed stormwater amenity works.

Flow velocities and bed-shear-stresses were determined along the proposed works area to inform the design of stabilisation works.

The 1% AEP model performance was also compared to the existing mapping provided by LMCC and is provided below in Section 6.

5.1 Hydraulic impacts

A flood impact assessment has been undertaken to determine the potential impact of the proposed creek naturalisation works on flood behaviour. The flood impact maps for the bank-full flow, 10% AEP, 1% AEP and PMF flow events are presented in Appendix A Figures A1 to A4.

These impacts represent the extent of works shown in Figure 2-2 however it is noted that the extent of the final works is subject to final costing, construction budgets or constraints found on site which may reduce the final extent of channel and rock works.

Flood level impact maps of the modelled works show that there is potential for some localised changes in flood levels along the extent of structural works.

Along the upper extent of works, the model results show a decrease in flood levels associated with bank-full flow, 10% AEP and 1% AEP flow events. The model suggests that despite the increased channel bank roughness, there is an overall increase in flow conveyance along this section of works.

Along the lower half of the works area, the model results show an increase in flood levels associated with a combination of overbank roughness and increased timing of flows arriving at the culvert.

The variation in flood afflux, reduced along the upper extent of works, and increased along the lower extent of works also suggests that the channel hydraulics are highly dynamic.

In all flow events there is no impact to flood levels affecting private property. There is no overtopping of the Myall Road up to and including the 1% AEP event.

In the PMF event, the proposed extent of new planting adjacent to the road corridor has the effect of increasing flood depths in this location.

For the PMF event, this results in a small increase in existing flooding to the eastern extent over Myall Road (35m^2). It is noted that the PMF event inundates a significant extent to the west.

5.1.1 Hydraulic Impacts if Extent of Construction Works Are Reduced

If the extent of the proposed channel works are reduced, it is unlikely that there would be an impact to flood levels affecting private property or Myall Road.

If there is an extension of the western channel re-vegetation works between Myall Road and the incoming side channel, there is a potential for localised and minor increases in flood levels adjacent to the works however it is unlikely that there would be an impact to flood levels affecting private property or Myall Road.

5.2 Design velocity

Flood velocity has also been reviewed for the proposed design case to ensure the proposed riprap is sized correctly and will not be subject to scour or uplift. The design peak velocity maps are presented in Figures A5 to A8.

These maps show that the velocities over the rock riprap can exceed 3 m/s for the 10% AEP event and greater in some localised areas. The rock riprap will be sized to accommodate these velocities.

Velocity sensitivity testing was also undertaken to determine the absolute range of velocities that may be experienced within the works area.

5.3 Sensitivity Testing of Roughness

A sensitivity test of Manning's *n* coefficients was undertaken to determine the sensitivity of hydraulic behaviour to material roughness.

Manning's coefficients listed in Table 4-2 above were halved, resulting in a lower surface roughness reflecting less planting.

The effect of reduced manning's roughness on 1% AEP velocities is shown in Figure 5-1. It can be seen in the proposed scenario that velocities exceeding 3 m/s may be expected over the new 1V:2H banks. However, the sensitivity test shows that if the Manning's *n* values are reduced, these velocities may even exceed 4.5 m/s in some localised areas. The expected velocity over the proposed 1V:2H banks is an important consideration in the sizing of the rock riprap.

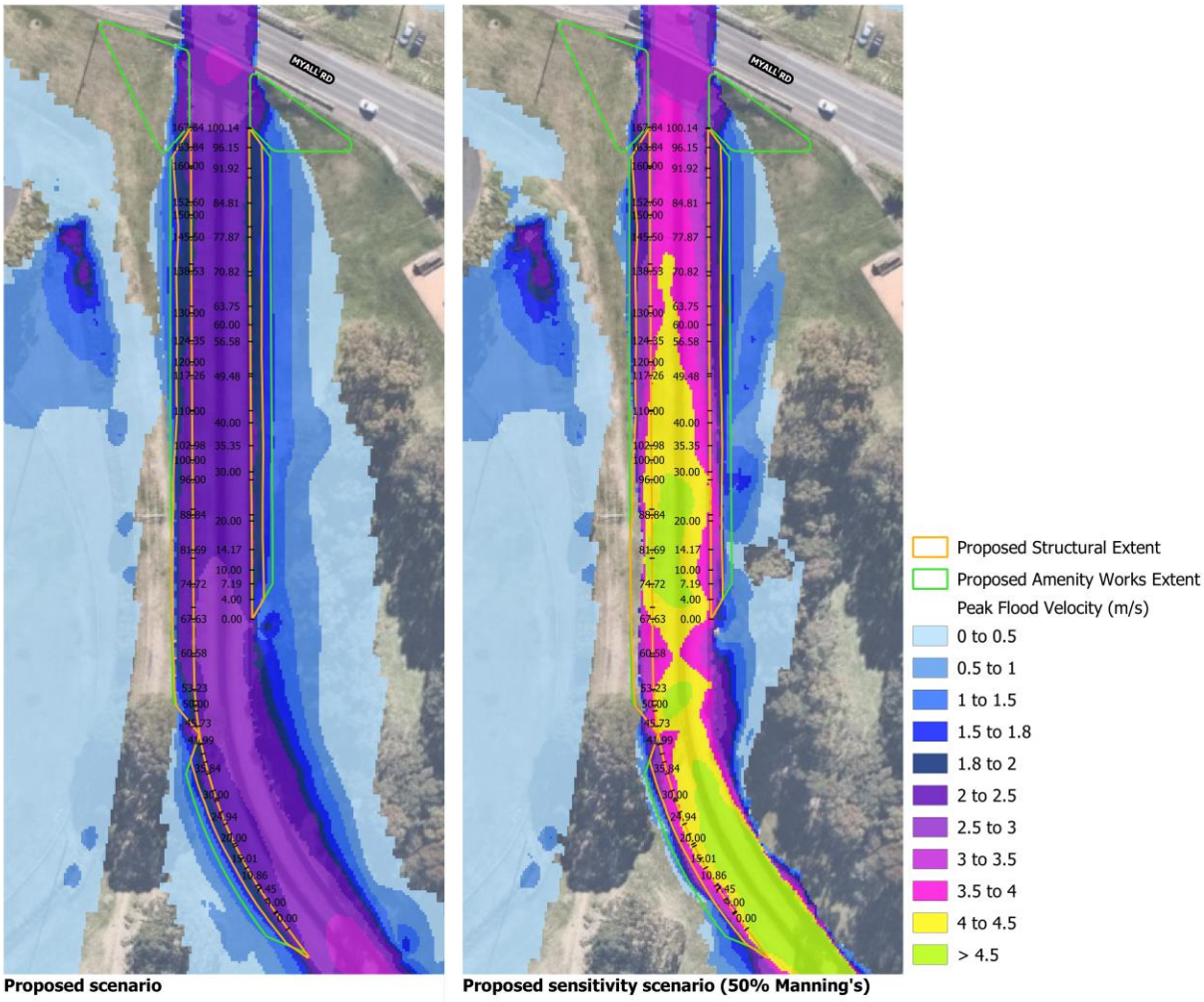


Figure 5-1 1% AEP sensitivity test velocity comparison

6 Model checks

Several model checks have been undertaken to review the model health and hydraulic behaviour of the model results. These model checks are discussed in the following sections.

6.1 Model health

The cumulative mass error output is a good indicator for model health, where a healthy model is considered to have a cumulative mass error of +/-1%.

Table 6-1 shows the CME outputs for each of the simulations.

Table 6-1 HW Winding Creek TUFLOW model health

Simulation	Final Cumulative Mass Error (CME) %
Bank full Existing	0.00
10% AEP 540min Existing	-0.01
1% AEP 540min Existing	-0.00
PMF 120min Existing	-0.00
Bank full Proposed	0.00
10% AEP 540min Proposed	-0.01
1% AEP 540min Proposed	-0.00
PMF 120min Proposed	-0.00

6.2 Hydrograph checks

A check of the flow hydrographs upstream and downstream of the project works for both existing case and proposed design scenario runs were compared to determine whether the design altered the flow regime. Combined flow plot output from the tributary and main channel immediately upstream of the works was summed and compared to the flow passing under Myall Bridge. These plot comparisons for the 10% AEP event and 1% AEP event are shown in Figure 6-1 and Figure 6-2 respectively.

These comparisons show that the flow behaviour between existing and proposed scenarios are effectively the same, and this behaviour remains similar both upstream and downstream of the proposed works. This indicates that while there does appear to be local flood impacts (in both an increase and decrease in levels) over the site works, the flow behaviour and floodplain storage remains effectively unchanged.

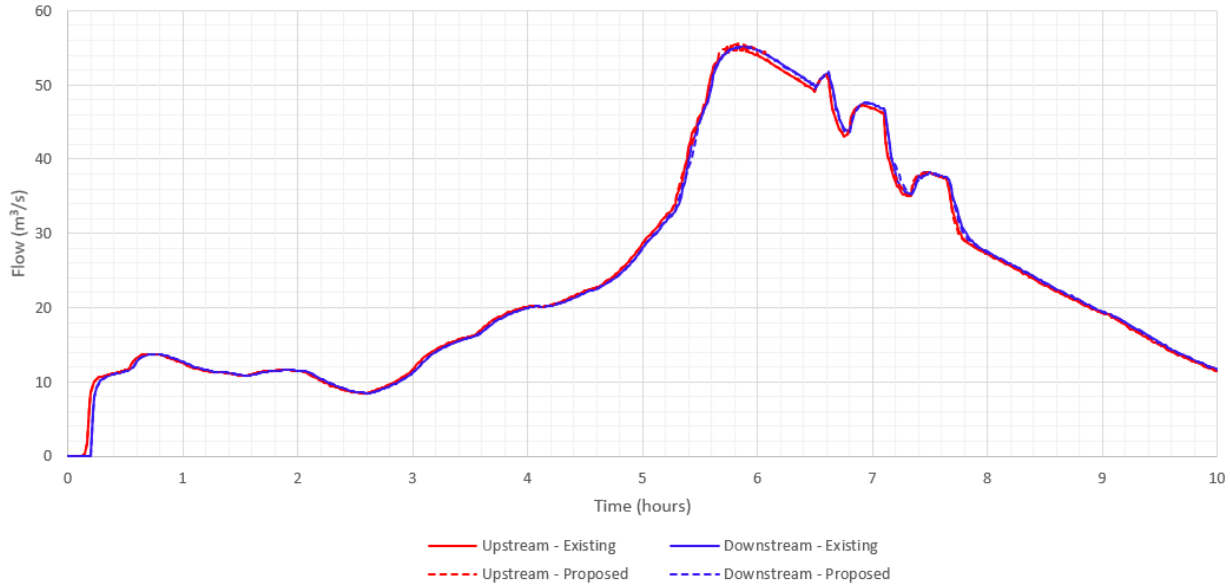


Figure 6-1 10% AEP flow plot comparisons upstream and downstream of the proposed works

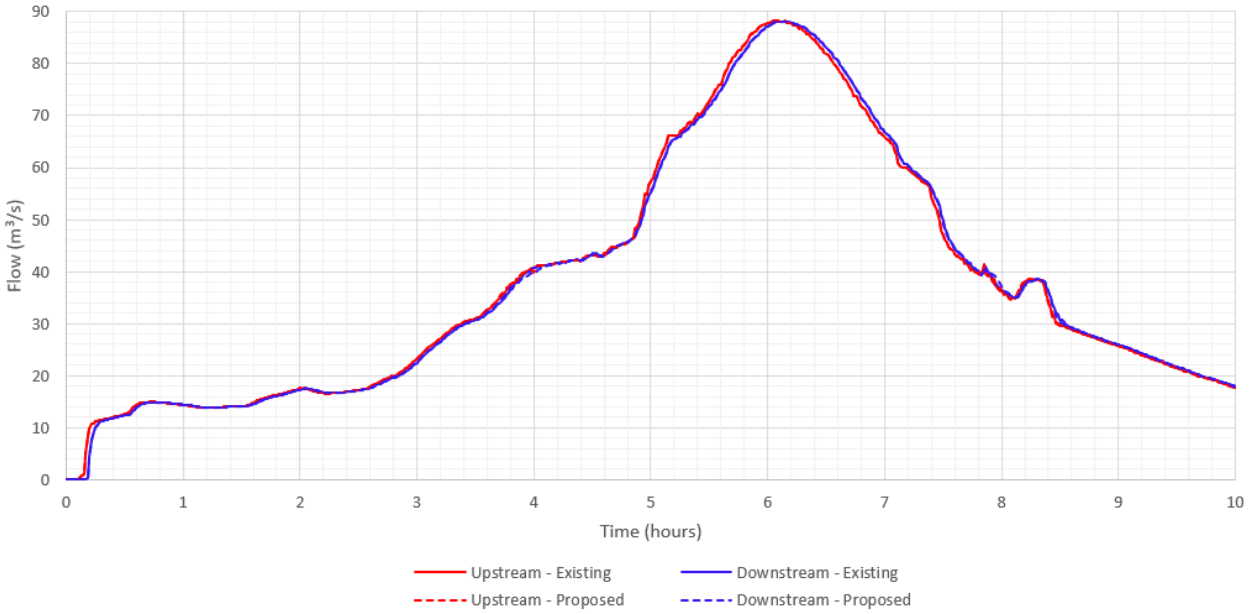


Figure 6-2 1% AEP flow plot comparisons upstream and downstream of the proposed works

6.3 Comparison to Council Flood Mapping

A comparison of the model peak flood extents between the LMCC and HW Winding Creek model for the 10% AEP, 1% AEP and PMF events (critical durations) is compared below in Figure 6-3, Figure 6-4 and Figure 6-5 respectively.

These figures show that for the 10% and 1% AEP events, the HW Winding Creek model produces a slightly larger flood extent especially along the main channel line at the upstream end of the model.

This is not unexpected when converting a 2D model with 1D nested elements into a solely 2D model, in addition to reducing the grid size and employing quadtree refined mesh. However, comparison between 1% AEP flood levels produced by LMCC and HW Winding Creek models shows the HW model predicts flood levels approximately 500mm higher than the LMCC model for the same 1% AEP flow and similar Manning's n values.

Detailed reviews of the HW model performance cannot explain such differences in modelling performance, however given the HW TUFLOW model has been build using local survey data, uses a range of flow rates adopted by Council which correspond to a range of design events, represents the floodplain in higher detail and has been verified using independent calculations, the HW TUFLOW model is considered suitable for this flood impact assessment. Given that the modelling is proposed as a design tool, and is not for establishing or revising flood planning levels, the variation between the HW and LMCC models is acceptable. As the modelling adopts a range of flow conditions for assessment, the model findings are considered to be valid for a range of hydraulic conditions resulting in minor and major flooding conditions.

6.4 Validation of Flood Model

Given the differences between the LMCC and HW models, further validation of the HW modelling was undertaken.

Comparison with Manning's formula calculations was carried out to verify the predicted HW flood levels in three locations. Culvert master software was used with inputs from surveyed floodplain geometry, surveyed channel grades, Manning's roughness and the same peak flows as adopted in both LMCC and HW TUFLOW models. Given the simple one-dimensional hydraulic nature of the channel and floodplain, comparison to a Manning's calculation is appropriate.

The manning's calculations predict flood levels to within 200mm of the HW TUFLOW flood model. The manning's calculations predict higher flood levels than both TUFLOW models. It is noted that the Manning's calculations are also significantly higher than the LMCC model, but this has not been further explored. Given that the HW model results sit within the range predicted by the LMCC model and Manning's calculations, the HW model is considered to be an appropriate design tool for testing the incremental impacts of works in the floodplain.

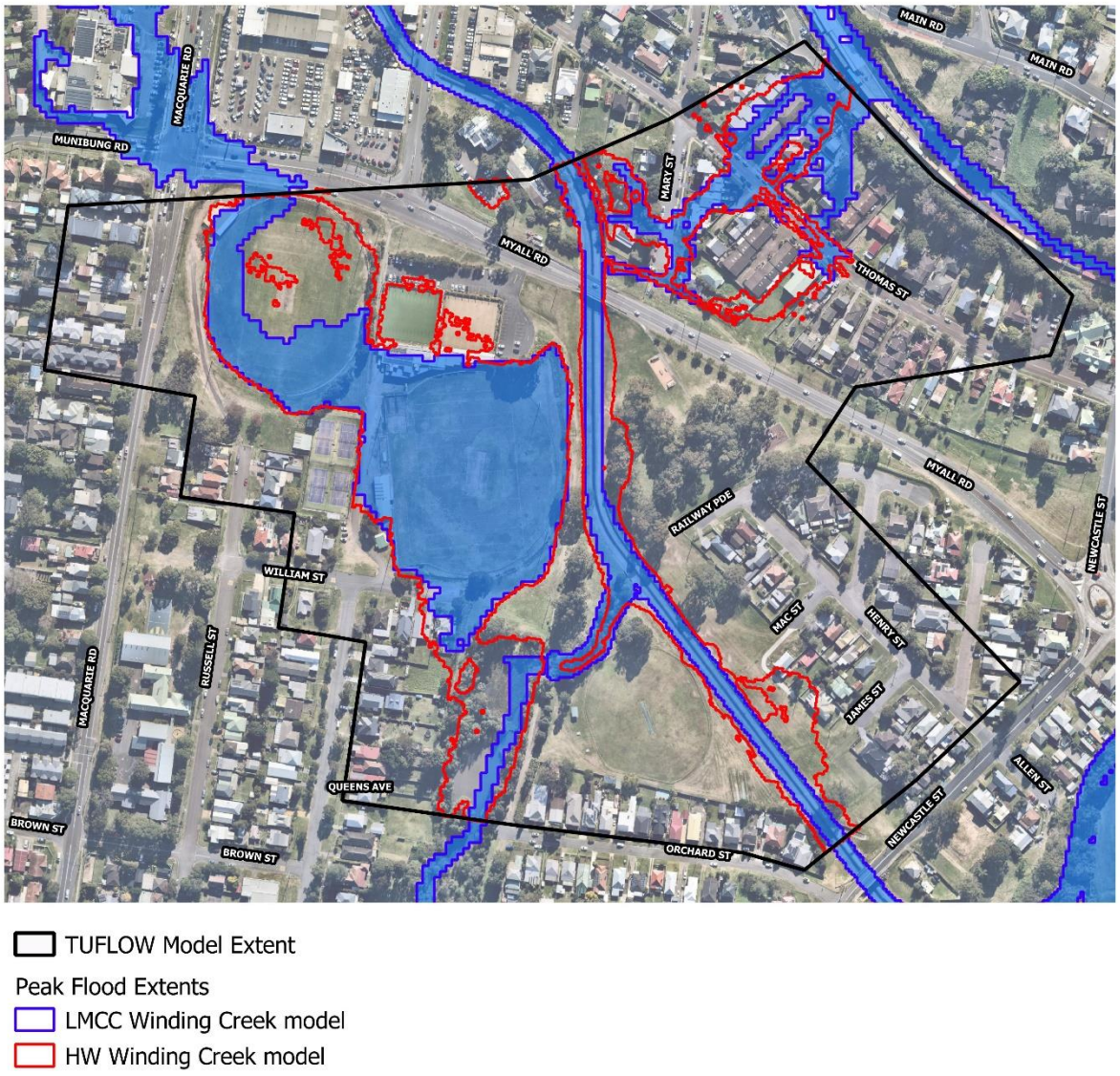


Figure 6-3 Comparison of model peak flood level extents for the 10% AEP 540min duration

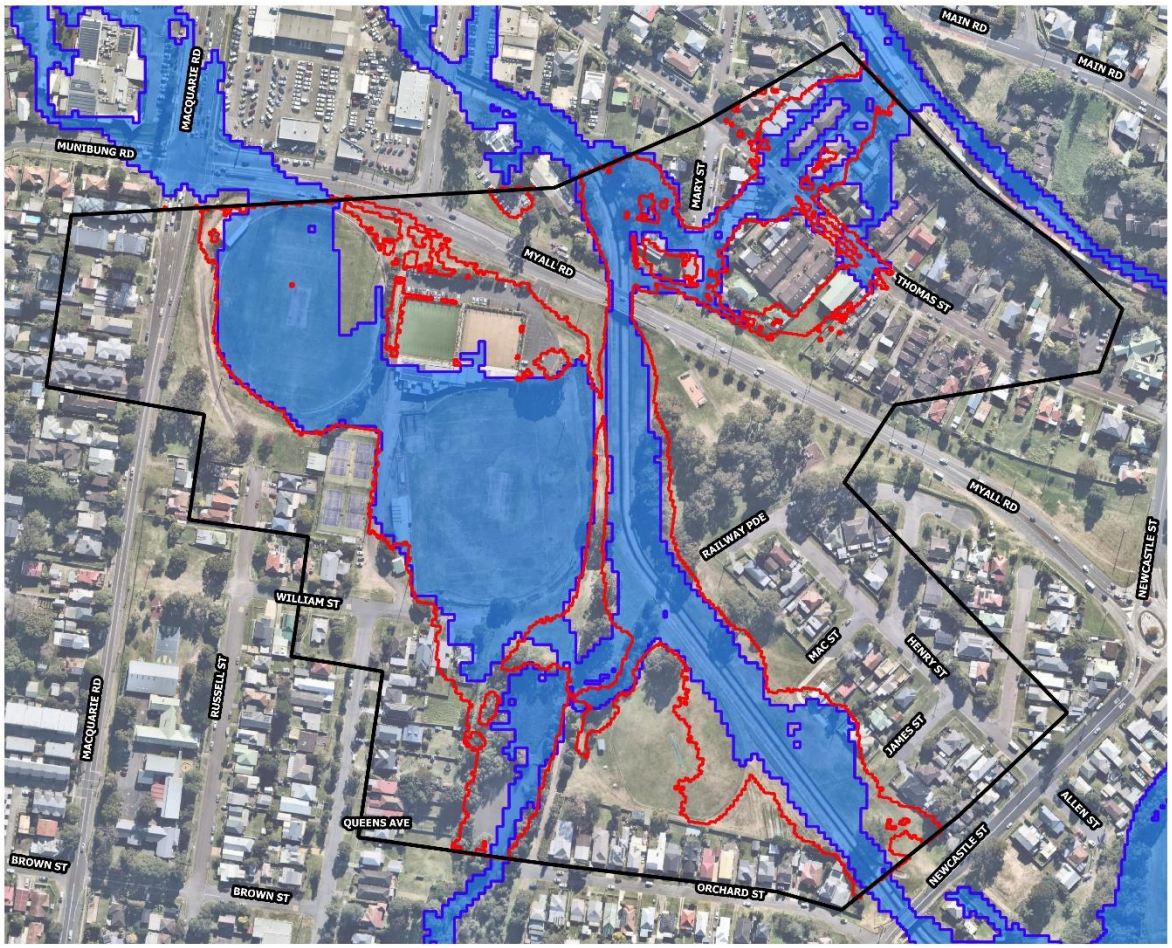


Figure 6-4 Comparison of model peak flood level extents for the 1% AEP 540min duration

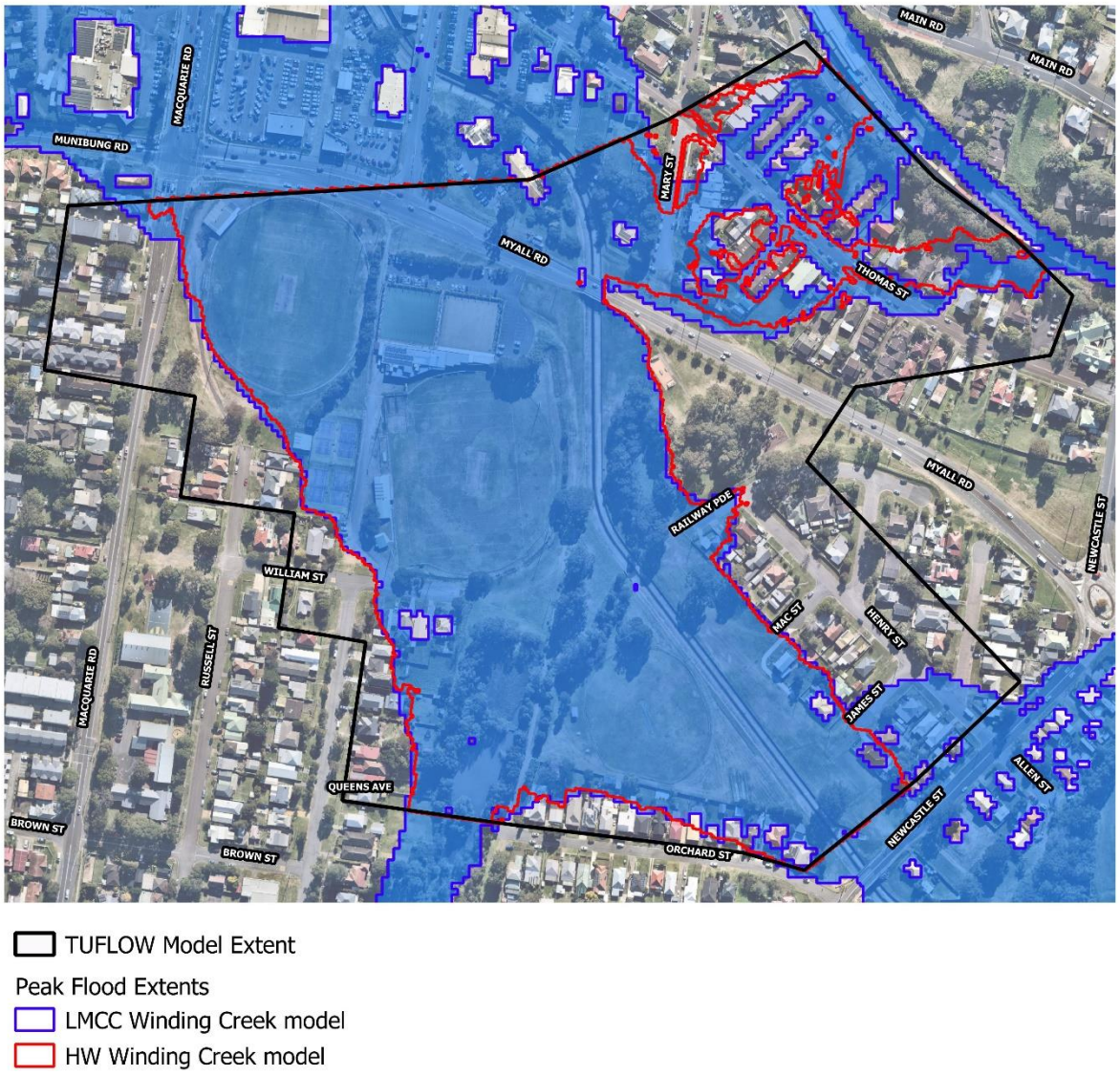


Figure 6-5 Comparison of model peak flood level extents for the PMF 120min duration

7 Conclusions

The proposed works are located within flood prone land in the Winding Creek floodplain. A flood impact assessment was undertaken where the bank-full flow, 10% Annual Exceedance Probability (AEP), 1% AEP and probable maximum flood (PMF) flows were modelled using a new two-dimensional hydraulic model (TUFLOW).

Model Development

The model uses a range of specific detailed site survey, locally specific Manning's values. Bridge data and a range of design flows were extracted from LMCC Winding Creek model. Flows were extracted as TUFLOW plot output lines taken at the same locations as the HW Winding Creek model inflow boundaries. The model uses a 2D grid to represent the channel.

Model Validation

Base case model results of the existing floodplain were compared with the 1% AEP LMCC model results. Flood levels do not compare well for the 1% AEP event results; with the HW 1% AEP flood levels approximately 500mm higher than the LMCC model results. Further checks on the model performance show no mass errors or loss of mass across the model domain. Hydrograph boundaries at the downstream model show conservation of mass and no loss of floodplain storage.

Despite the discrepancy between model results, further validation of the new HW flood models was made by comparing results against hydraulic calculations. The model results compared well with the Manning's calculations.

Given that the HW model results sit within the range predicted by the LMCC model and Manning's calculations, the HW model is considered to be an appropriate design tool for testing the incremental impacts of works in the floodplain.

Likely Flood Level Impacts

The proposed works area that was documented in June 2022 was incorporated into flood models for testing. A comparison between flood conditions was undertaken for the site with and without the proposed stormwater amenity works. Flow velocities and bed-shear-stresses were determined along the proposed works area to inform the design of stabilisation works.

The flood impact assessment indicates there is potential for localised increases in flood levels within the park and along the downstream end of the structural works for a range of flow events. 1% AEP flood levels are likely to increase by 50mm towards Myall Road and within the park adjacent to the Bowls Club and skate park. A small area of 150mm of flood increase may occur immediately upstream of Myall Road in a 1% AEP event. No increase in 1% AEP flooding affects existing buildings, infrastructure, roads or private property. The works are likely to result in an extensive area of decreased flood levels on land adjacent to dwellings on Mac St and Henry St.

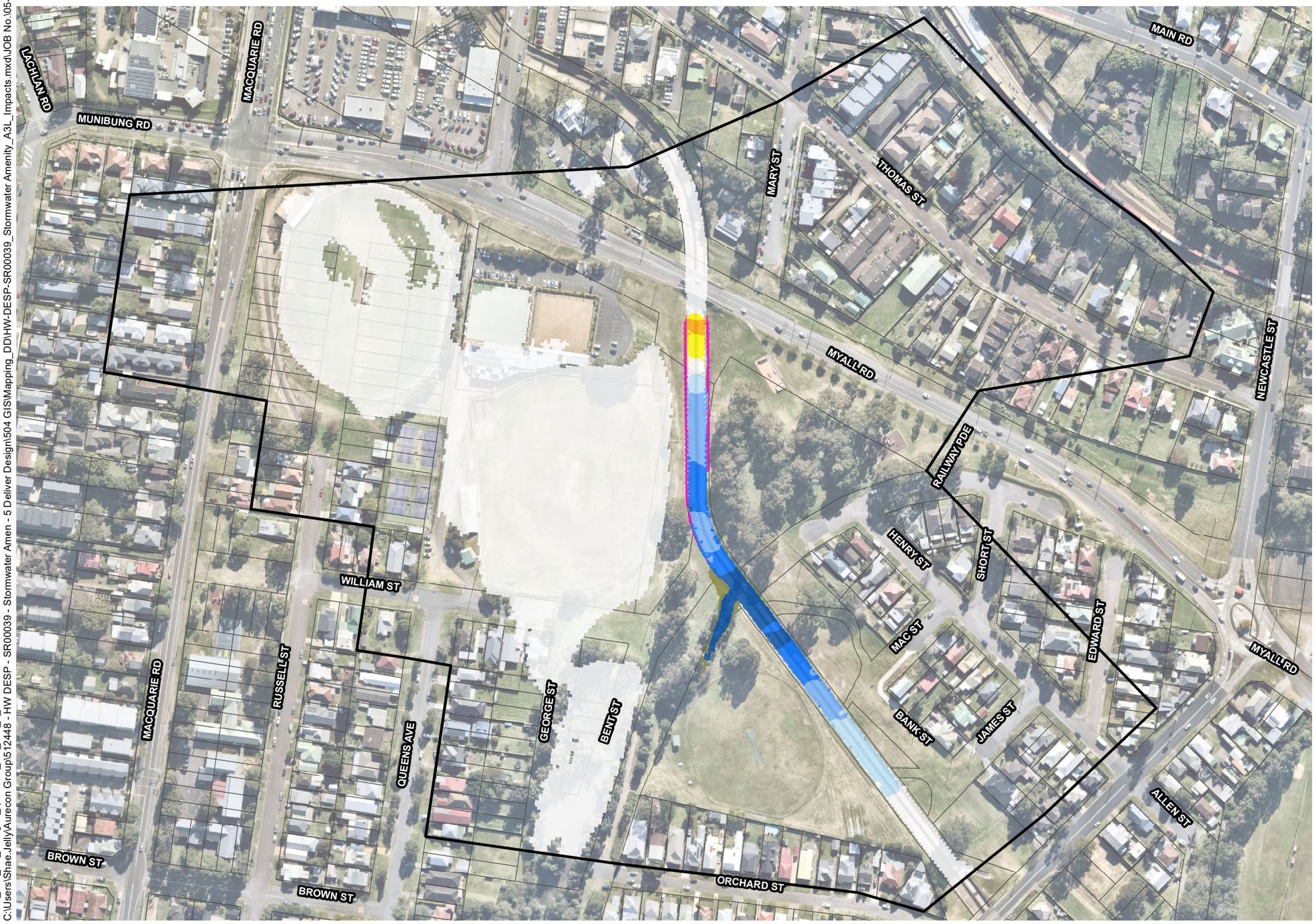
Where vegetation works are undertaken without channel works, there is likely to be a small increase in flood levels but this is unlikely to impact on private properties where works are carried out between Myall Road and Railway parade due to set backs to private property. It is recommended that vegetation works should not be undertaken further south of Railway Pde without additional flood modelling to demonstrate flood impacts.

Velocity and Scour Protection

The stormwater amenity improvement works will experience flooding and associated scour forces in a range of flows. Sensitivity testing of Manning's values provides the possible range of velocities that would be experienced by works area.

Model results demonstrate the expected scour velocities can be managed through a combination of placed rock and erosion control matting, such that no damage is likely to occur to works during flood events once all works are complete and stabilisation planting has been established.

Flood mapping



Legend

- TUFLOW Model Extent
- Cadastre

Flood Level Impact (m)

- Area no longer inundated
- < -0.25
- -0.25 to -0.15
- -0.15 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.15
- 0.15 to 0.25
- > 0.25
- New area of inundation

Source: Aurecon, Hunter H2O, Hunter Water, DPIE, Nearmap, ESRI

1:2,613

0 25 50 75m

Projection: GDA 1994 MGA Zone 56

Stormwater Amenity

FIGURE A1: Change in Peak Flood Level (Proposed vs. Existing) - Bank-full Flow

SWA_L03_BF_Ex_quadtree_2m_002_h_Max
SWA_L03_BF_Design2_quadtree_2m_002_h_Max
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Legend

- TUFLOW Model Extent
- Cadastre

Flood Level Impact (m)

- Area no longer inundated
- < -0.25
- -0.25 to -0.15
- -0.15 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.15
- 0.15 to 0.25
- > 0.25
- New area of inundation

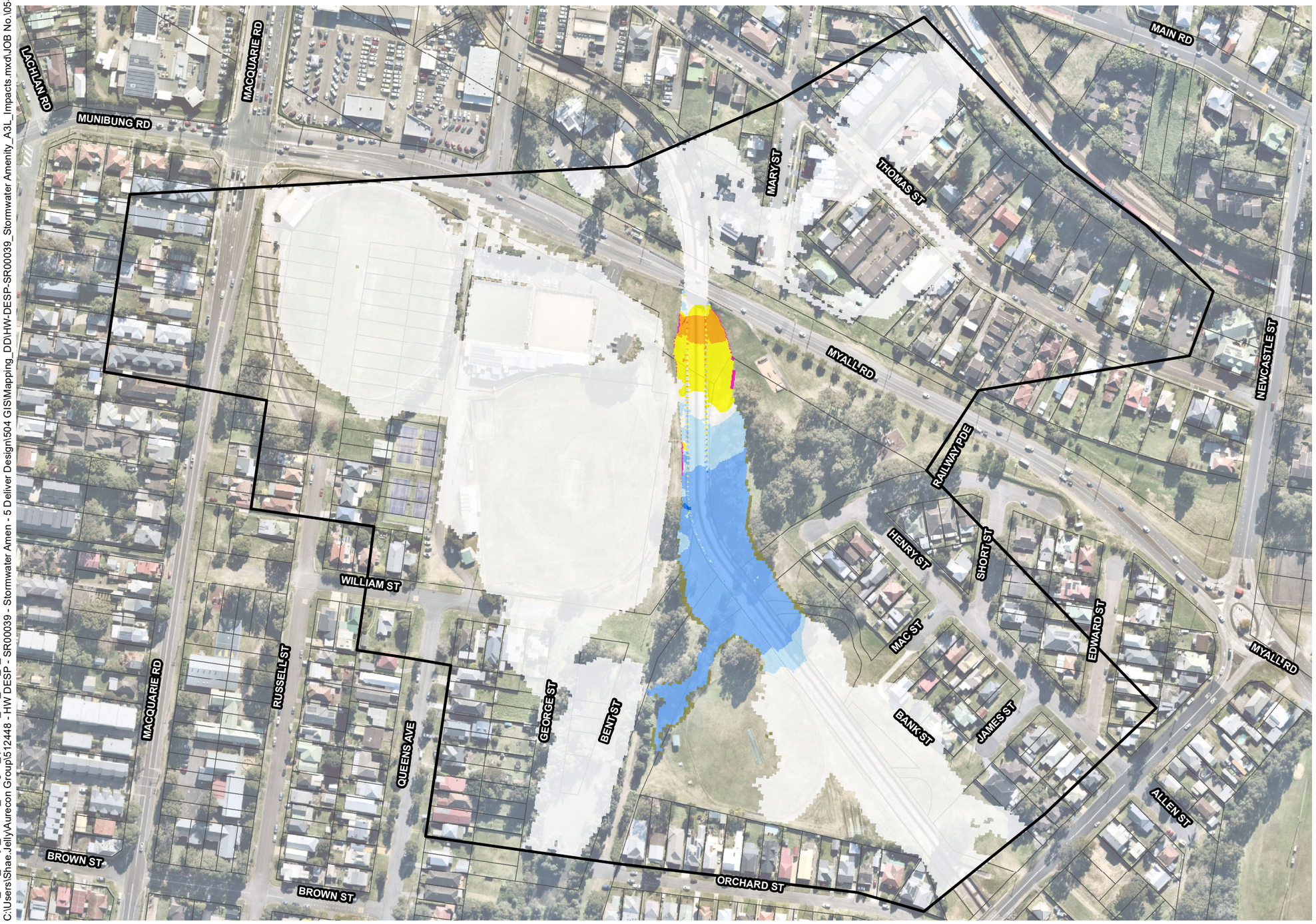
Source: Aurecon, Hunter H2O, Hunter Water, DPIE, Nearmap, ESRI

1:2,613
0 25 50 75m

Projection: GDA 1994 MGA Zone 56

Stormwater Amenity

FIGURE A2: Change in Peak Flood Level (Proposed vs. Existing) - 10% AEP



Legend

- TUFLOW Model Extent
- Cadastre

Flood Level Impact (m)

- Area no longer inundated
- < -0.25
- -0.25 to -0.15
- -0.15 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.15
- 0.15 to 0.25
- > 0.25
- New area of inundation

Source: Aurecon, Hunter H2O, Hunter Water, DPIE, Nearmap, ESRI

1:2,613
0 25 50 75m

Projection: GDA 1994 MGA Zone 56

Stormwater Amenity

FIGURE A3: Change in Peak Flood Level (Proposed vs. Existing) - 1% AEP

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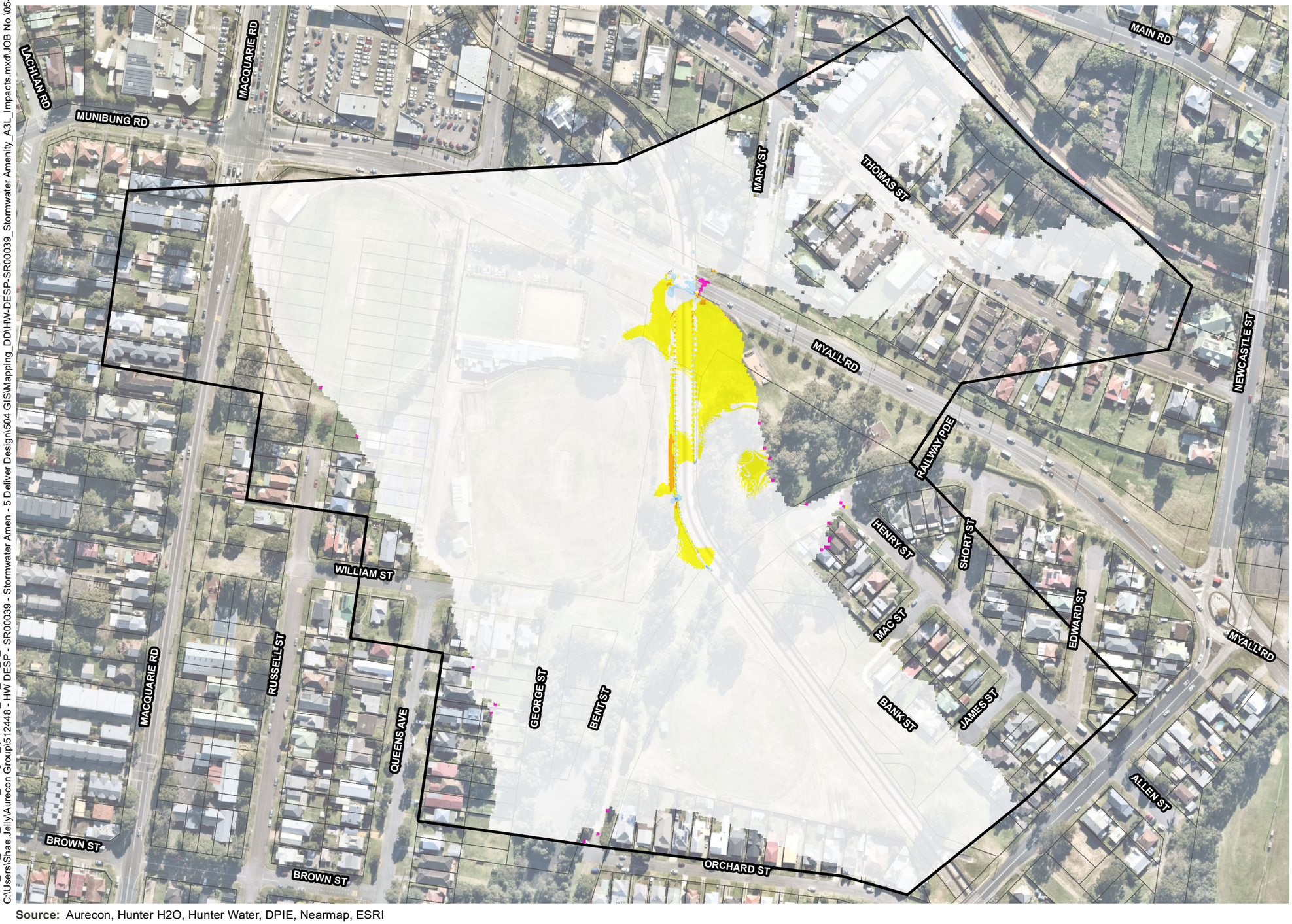
SWA_L03_100yr_540min_Design2_quadtree_2m_002_h_Max
SWA_L03_100yr_540min_Ex_quadtree_2m_002_h_Max

hunterh2o aurecon

Together...



Legend

- TUFLOW Model Extent
- Cadastre

Flood Level Impact (m)

- Area no longer inundated
- < -0.25
- -0.25 to -0.15
- -0.15 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.15
- 0.15 to 0.25
- > 0.25
- New area of inundation

Source: Aurecon, Hunter H2O, Hunter Water, DPIE, Nearmap, ESRI

1:2,613

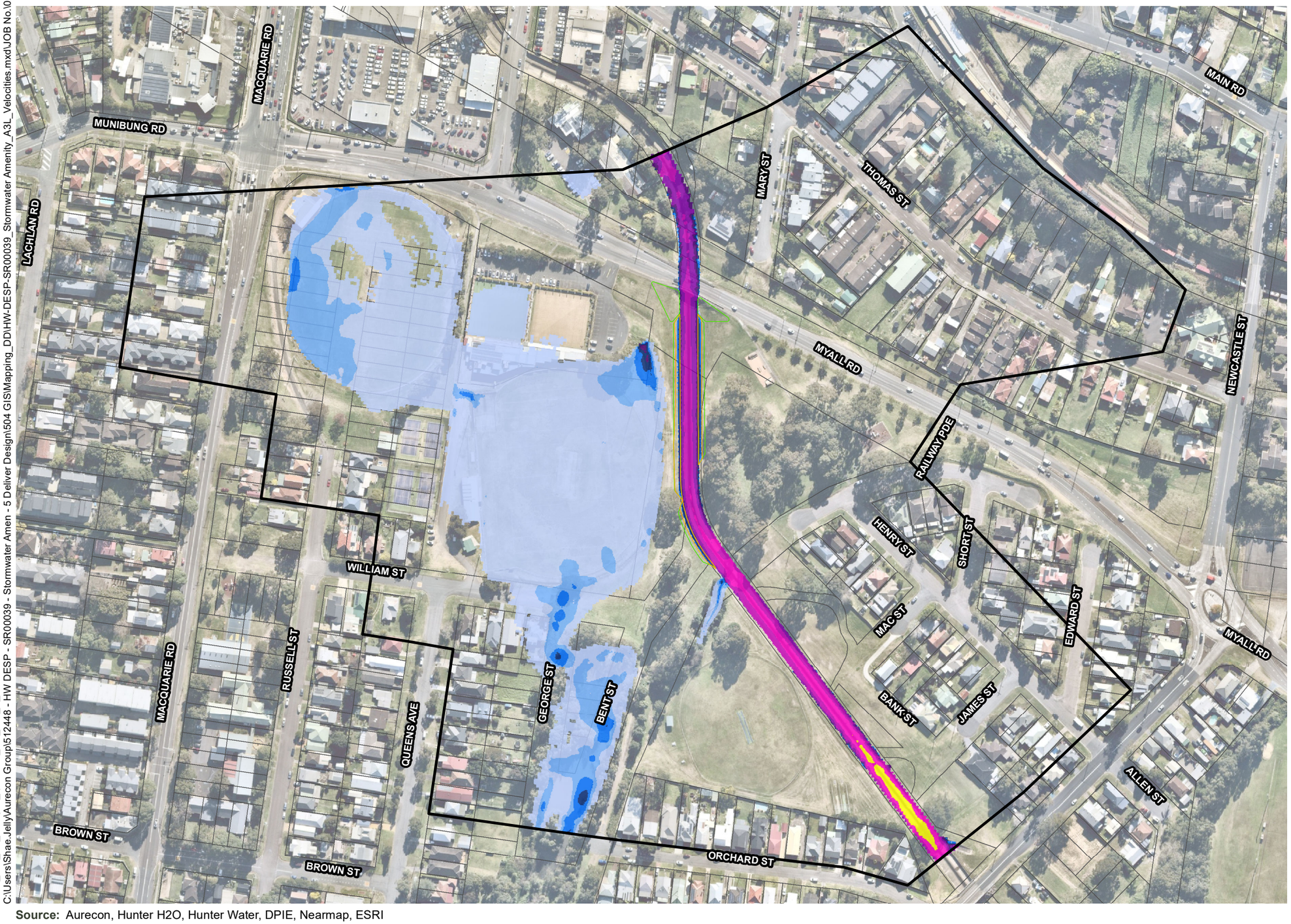
0 25 50 75m

Projection: GDA 1994 MGA Zone 56

Stormwater Amenity

FIGURE A4: Change in Peak Flood Level (Proposed vs. Existing) - PMF

SWA_L03_PMF_120min_Ex_quadtree_2m_002_h_Max
SWA_L03_PMF_120min_Design2_quadtree_2m_002_h_Max
C:\Users\Shae.Jelly\Aurecon Group\512448 - HW DESP - SR00039 - Stormwater Amen - 5 Deliver Design\504 GIS\Mapping_DD\HW-DESP-SR00039_Stormwater Amenity_A3L_Impacts.mxd\JOB No.\05-05-22\Shae.Jelly\Rev 0



Legend

- TUFLOW Model Extent
- Cadastre
- Proposed Amenity Works Extent
- Proposed Structural Extent

Peak Flood Velocity (m/s)

- 0 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 3.5
- 3.5 to 4
- 4 to 4.5
- > 4.5

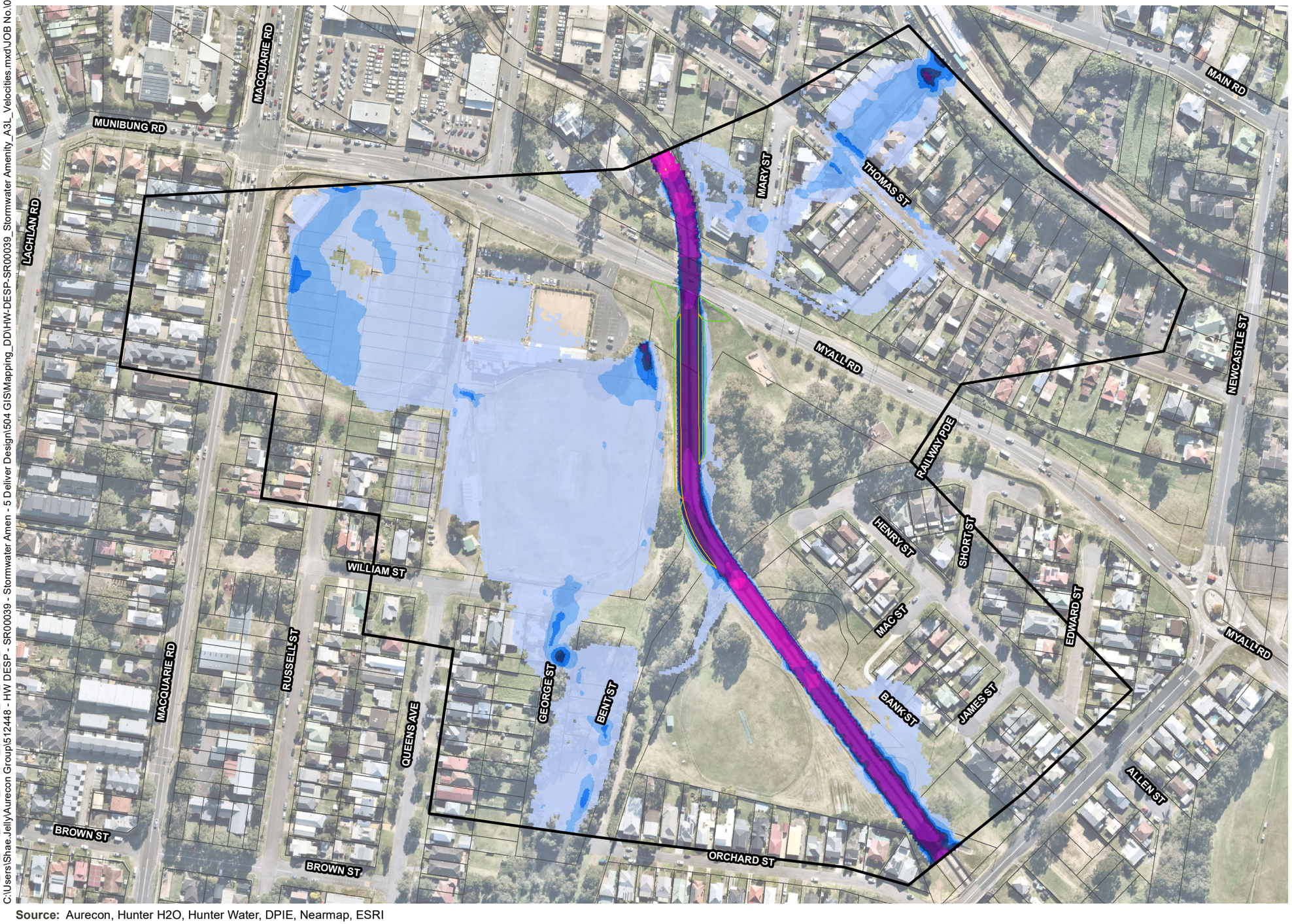
Source: Aurecon, Hunter H2O, Hunter Water, DPIE, Nearmap, ESRI

1:2,667
0 25 50 75 m

Projection: GDA 1994 MGA Zone 56

Stormwater Amenity

FIGURE A5: Proposed Peak Flood Velocity - Bank-full Flow

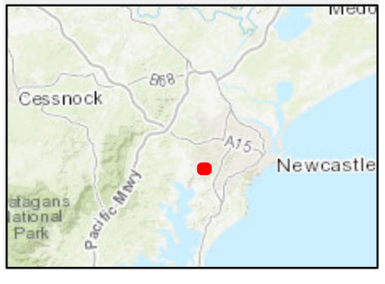


Legend

- TUFLOW Model Extent
- Cadastre
- Proposed Amenity Works Extent
- Proposed Structural Extent

Peak Flood Velocity (m/s)

- 0 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 3.5
- 3.5 to 4
- 4 to 4.5
- > 4.5



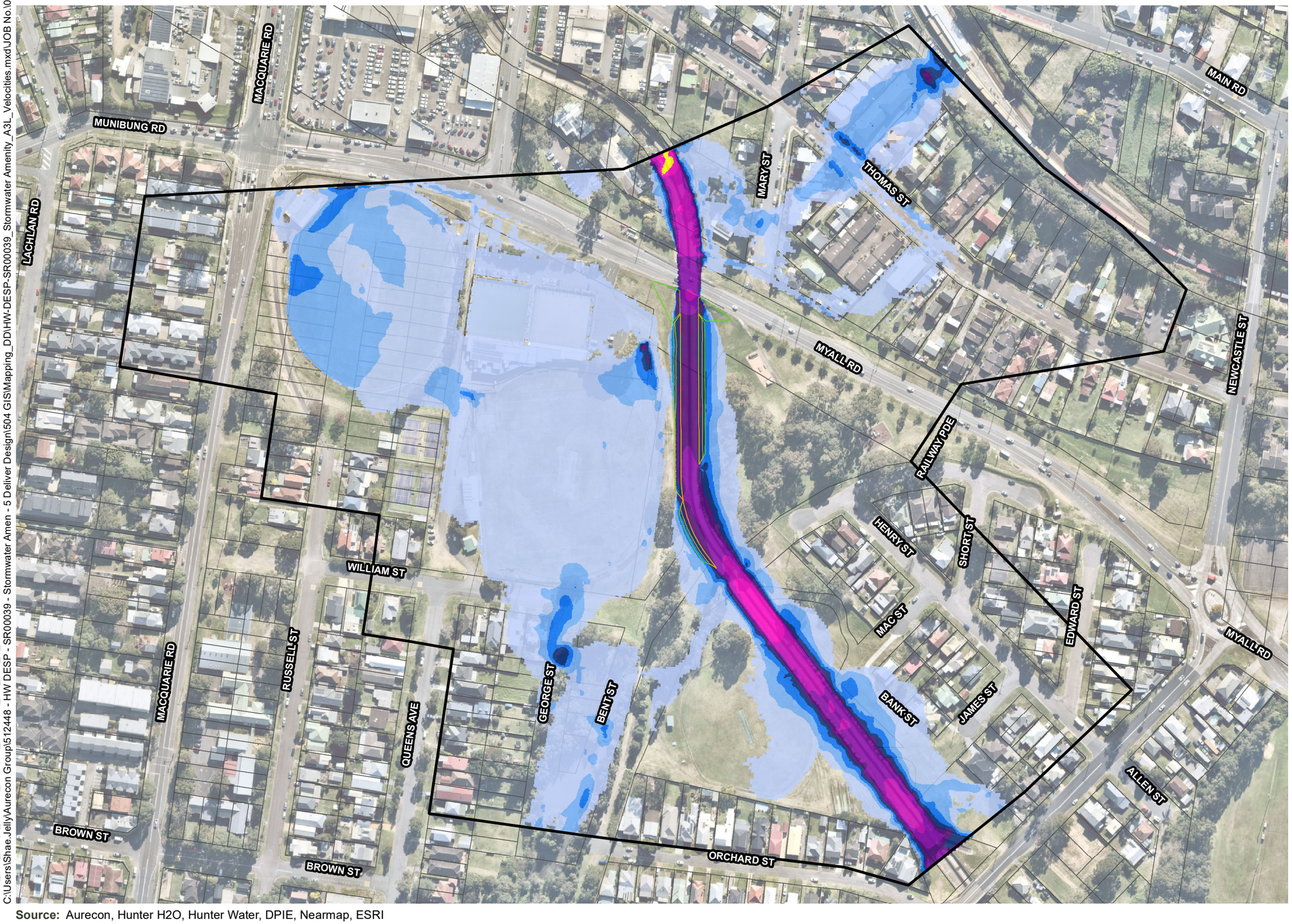
Source: Aurecon, Hunter H2O, Hunter Water, DPIE, Nearmap, ESRI

1:2,667
0 25 50 75 m

Projection: GDA 1994 MGA Zone 56

Stormwater Amenity

FIGURE A6: Proposed Peak Flood Velocity - 10% AEP



Legend

- TUFLOW Model Extent
- Cadastre
- Proposed Amenity Works Extent
- Proposed Structural Extent

Peak Flood Velocity (m/s)

- 0 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 3.5
- 3.5 to 4
- 4 to 4.5
- > 4.5

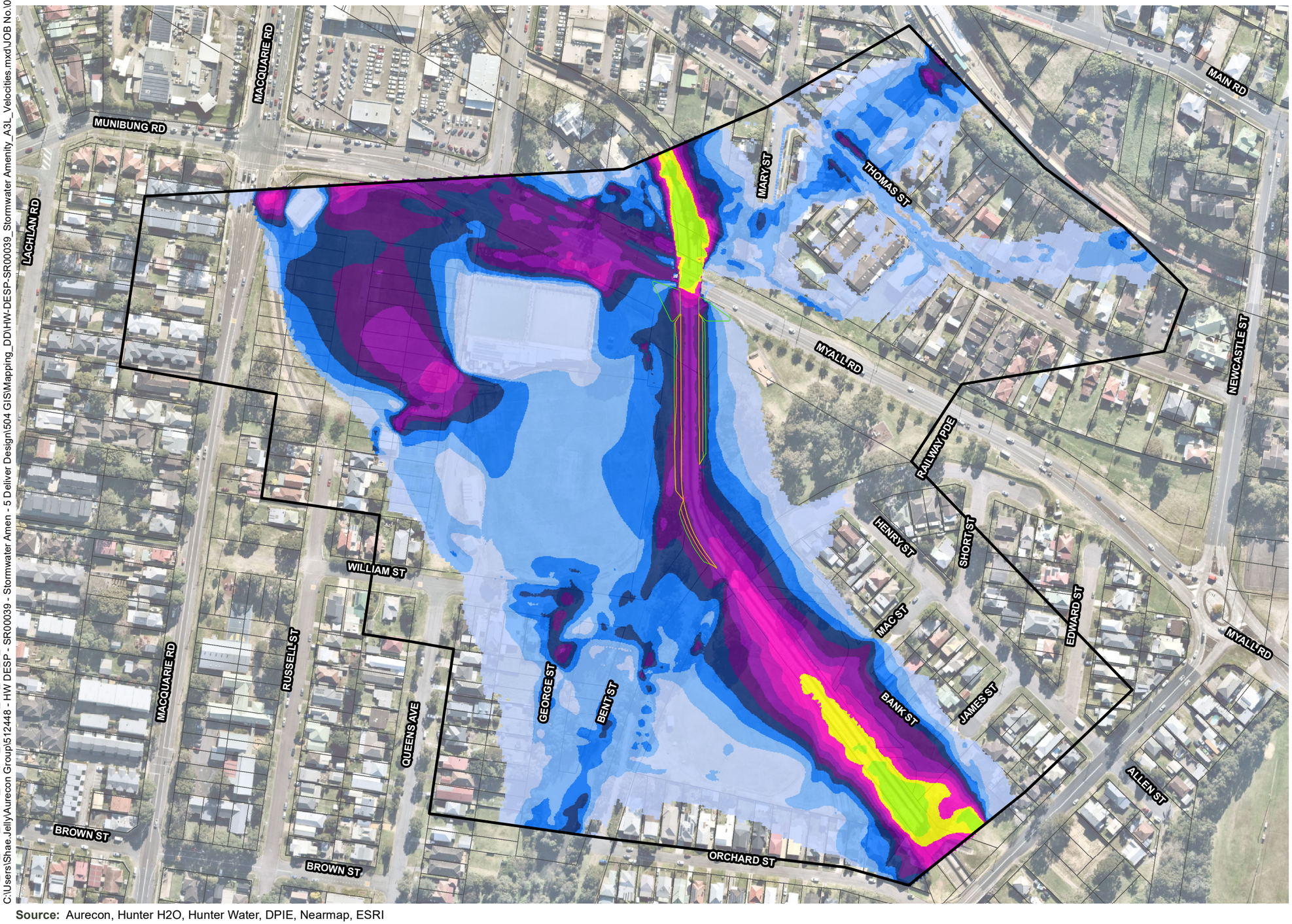
Source: Aurecon, Hunter H2O, Hunter Water, DPIE, Nearmap, ESRI

1:2,667
0 25 50 75 m

Projection: GDA 1994 MGA Zone 56

Stormwater Amenity

FIGURE A7: Proposed Peak Flood Velocity - 1% AEP



Legend

- TUFLOW Model Extent
- Cadastre
- Proposed Amenity Works Extent
- Proposed Structural Extent

Peak Flood Velocity (m/s)

- 0 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 3.5
- 3.5 to 4
- 4 to 4.5
- > 4.5

Source: Aurecon, Hunter H2O, Hunter Water, DPIE, Nearmap, ESRI

1:2,667
0 25 50 75 m

Projection: GDA 1994 MGA Zone 56

Stormwater Amenity

FIGURE A8: Proposed Peak Flood Velocity - PMF

APPENDIX F

Groundwater Dewatering Memorandum

Stormwater Amenity Improvement – Winding Creek South of Myall Road, Cardiff

Groundwater Dewatering Memorandum

JULY 2022

ABN 16 602 201 552

Report Details

Report Title	**Stormwater Amenity Improvement – Winding Creek South of Myall Road, Cardiff: Groundwater Dewatering Memorandum**
Project No.	512448
Status	Final
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Enquiries	William Legg P: (02) 4941 5000 E: info@hunterh2o.com.au

Document History and Status

Revision	Report Status	Prepared by	Reviewed by	Approved by	Issue Date
Draft	Draft for client comment	Manon Gebauer	Harry Gregg	William Legg	03/05/2022
Final	Final version	Manon Gebauer	Harry Gregg	William Legg	17/06/2022
Final rev1	Final version, revision 1	Manon Gebauer	Harry Gregg	William Legg	12/07/2022

Contents

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Appendices

1 Introduction

Hunter Water intends to construct 1,000 m of channel naturalisation works to improve the amenity of concrete lined waterways in response to various stakeholder preferences for naturalisation of Hunter Water's concrete stormwater open channels.

The majority of the naturalisation works involves removal of the concrete channel walls, battering the sides of the channel back to a 1V:2H slope, installation of rock revetment (rip-rap) on the channel sides, and planting of native species within and along the top of the rock revetment. Detailed designs have been prepared for these works at **Winding Creek South of Myall Road, Cardiff (the site).**

Based on the findings of previous geotechnical investigations at the site, carried out during concept design, it is anticipated that groundwater may be intercepted, therefore, temporary dewatering may be required during construction. Any dewatering requires a Water Supply Works (WSW) approval, (unless incidental, e.g. used for dust suppression, erosion mitigation risks). If more than 3 ML/year of groundwater is anticipated to be extracted, a Water Access License, under the *Water Management Act 2000*, must be sought through the Natural Resource Access Regulator (NRAR). To avoid potential program/timing impacts, if a Water Access License is required the application should start early in the project lifecycle, before construction commences.

This memorandum provides a dewatering assessment in relation to **Winding Creek South of Myall Road, Cardiff** (the site).

1.1 Objectives and Scope of Works

The objective of this memorandum is to assess groundwater conditions and provide advice in relation to expected dewatering volumes during construction to inform construction method, dewatering management requirements and details required for approvals with regulatory authorities (e.g. NRAR).

To meet the objective above, the following scope of works was carried out:

- Desktop review of geotechnical bore and test pit data and existing groundwater data in the project area.
- Calculation of the range of dewatering rates and estimation of total dewatering volumes.
- Comparison of dewatering volumes to legislative requirements to provide recommendations regarding the need for licencing and approvals.
- Provide recommendations regarding the need for further assessment (if required).

2 Overview of Design and Construction Activities

For the site, design details and expected hydrogeological properties were collated to form the basis of the analytical calculations.

Design details relevant to the dewatering calculations for the site illustrated in **Figure 2-1**, **Figure 2-2** and **Figure 2-3** and are summarised in **Table 2-1** below.

Table 2-1 Concept design details summary

Site Location	Excavation Length – Western Bank	Excavation Length – Eastern Bank	Total excavation length (m)	Maximum excavation depth (mBGL*)
Winding Creek, Cardiff	174	100	274	2.8

*mBGL = metres below ground level.

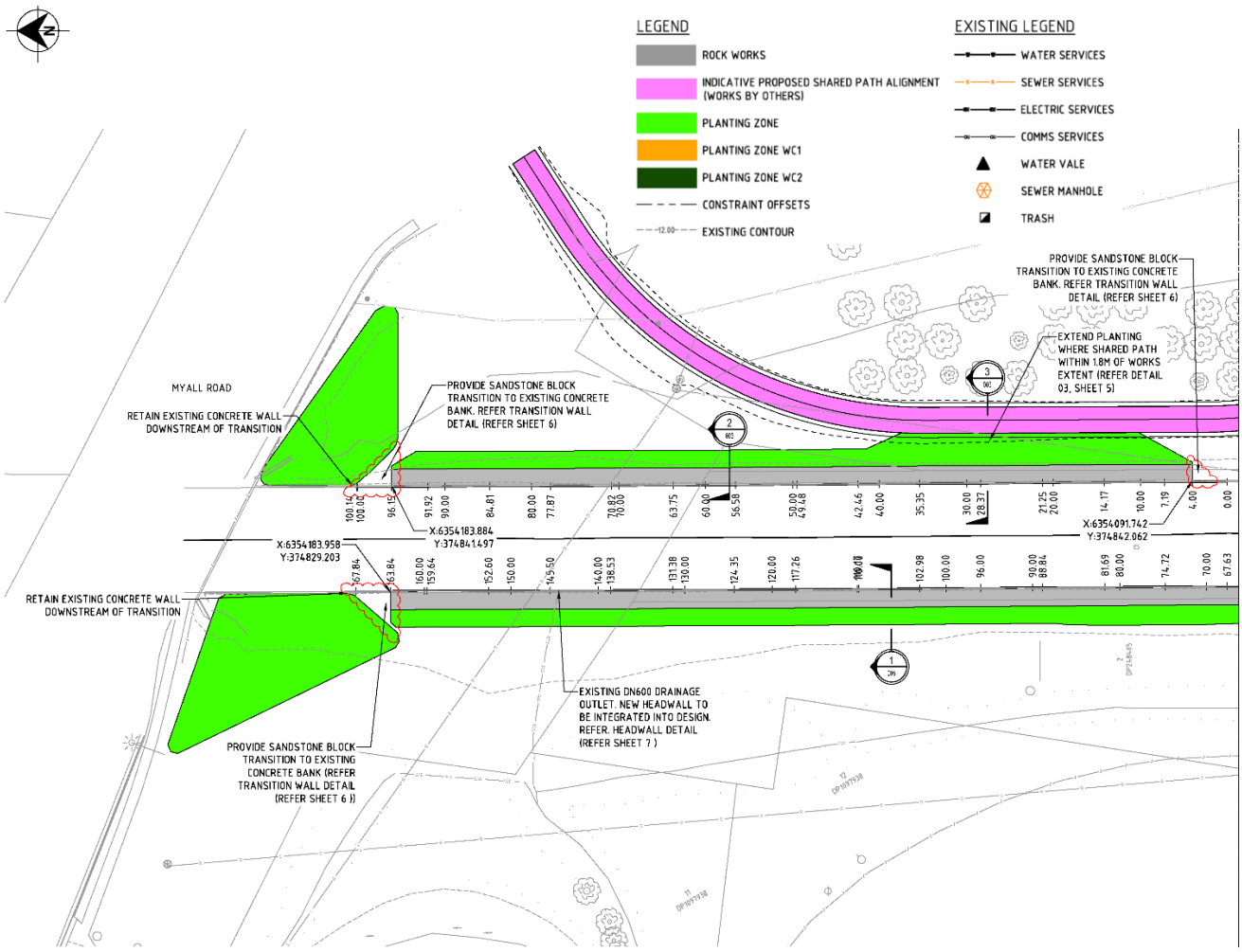


Figure 2-1 Winding Creek South of Myall Road, Cardiff: Site Overview (1 of 2)

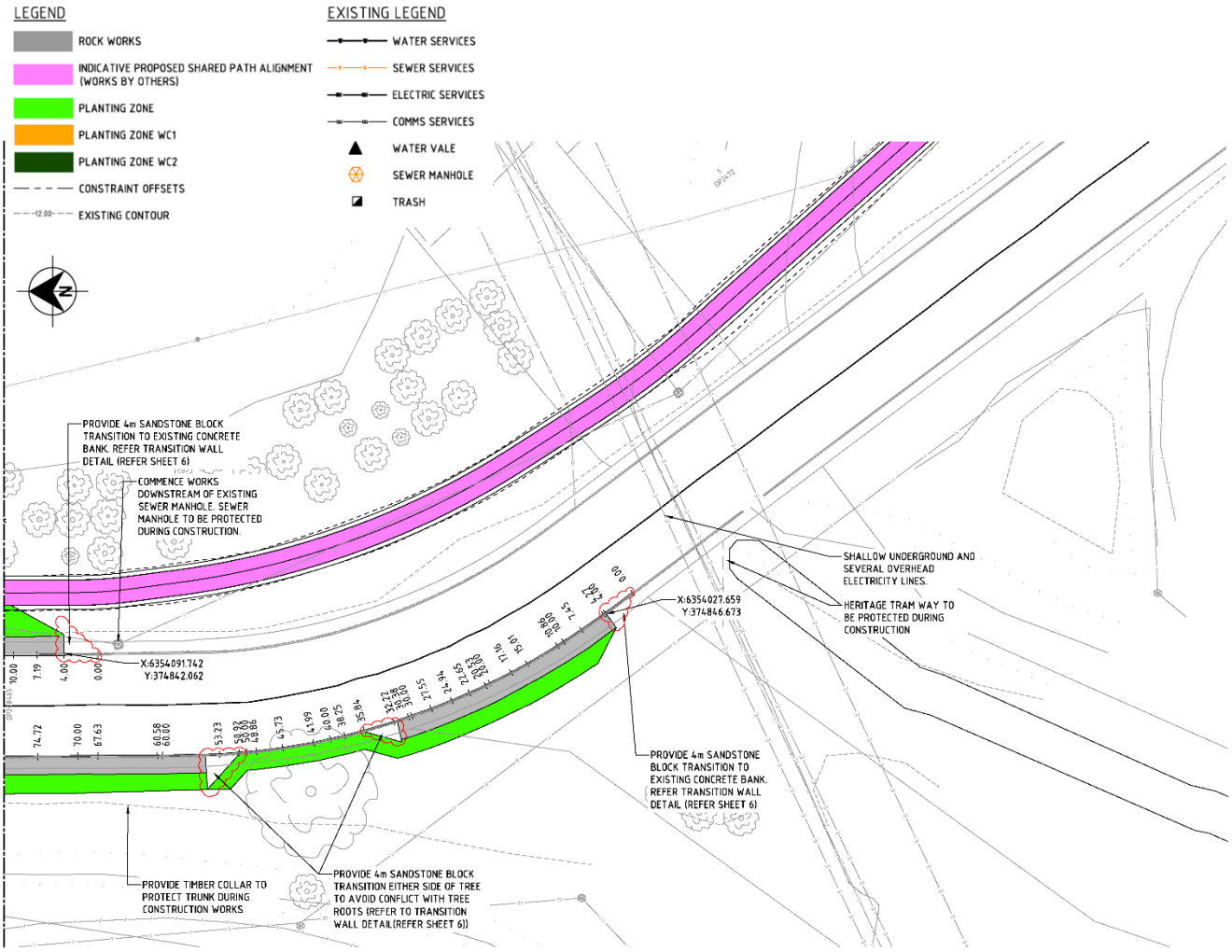
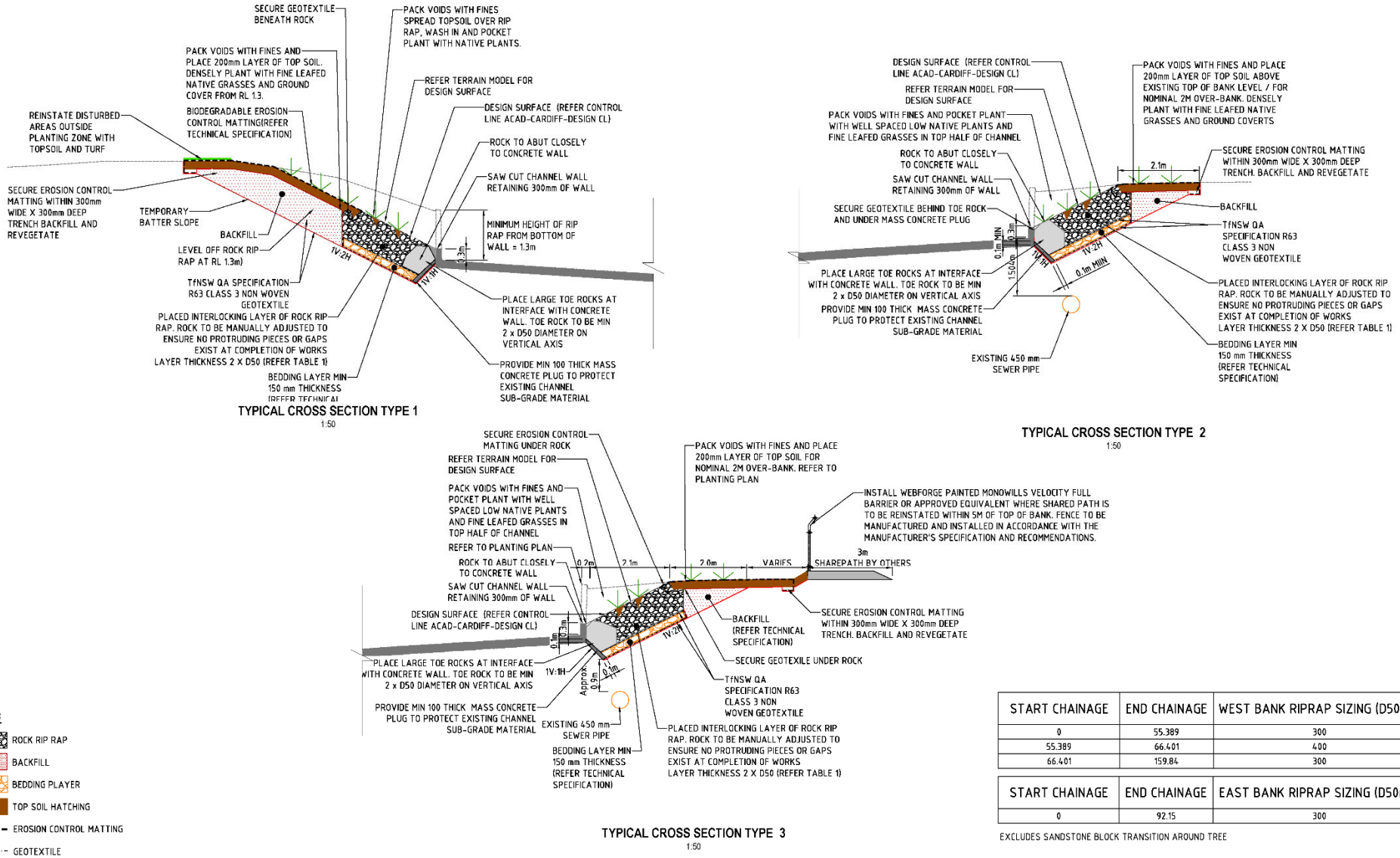


Figure 2-2 Winding Creek South of Myall Road, Cardiff: Site Overview (2 of 2)



START CHAINAGE	END CHAINAGE	WEST BANK RIPRAP SIZING (D50mm)
0	55.389	300
55.389	66.401	400
66.401	159.84	300

START CHAINAGE	END CHAINAGE	EAST BANK RIPRAP SIZING (D50mm)
0	92.15	300

EXCLUDES SANDSTONE BLOCK TRANSITION AROUND TREE

Figure 2-3 Winding Creek South of Myall Road, Cardiff: Typical Cross-Sections

2.1 Excavation and Dewatering Methodologies

Once the existing channel wall is removed and the excavations intersect the groundwater table, temporary dewatering is expected to be required. Temporary dewatering will provide a dry trench and allow for the placement of geofabric and bedding layer to the completed.

The adopted shoring system of the excavations will have significant impacts on the amount of groundwater inflows experienced. Adopting watertight trench support systems (e.g. sheet piling) would significantly reduce the amount of groundwater inflows experienced however are unlikely to be feasible at this site and for a project of this scale.

Temporary structures (e.g. sandbags or sandstone blocks) are likely to be positioned on the creek side of excavations to reduce inflows from Winding Creek into the excavation however some groundwater is likely to inflow into the excavations. Placement of fill materials would likely be undertaken within a wet environment in the lower portions of the excavations.

To provide a preliminary understanding of the dewatering rates and volumes, a conservative approach has been adopted in assuming that the adopted trench support system is unable to reduce groundwater inflows to the excavation and that dewatering would be required throughout the full duration of construction of a given trench length.

An open sump pumping technique (i.e. collector drains and a sump pump) is expected to be the most suitable dewatering method for this site. This is a cost-effective approach and suitable in stable ground conditions (i.e. relatively low permeability soils, small required drawdowns, and no immediately adjacent source of recharge) after excavation. Collector drains can be used to direct inflowing groundwater to the lowest point within the excavation, where a sump pump can be operated continuously or intermittently as required in the adopted construction schedule. If required, several sumps can be placed along the open trench to improve the drainage.

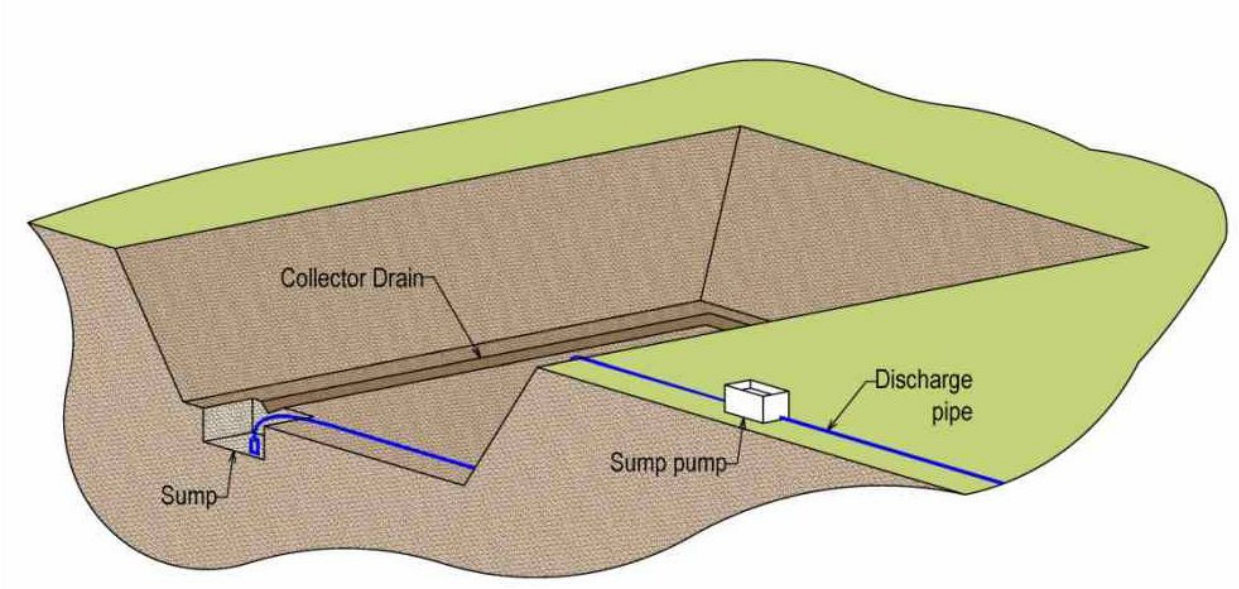


Figure 2-4 Conceptual diagram – Sump pump dewatering methodology (Image source: Gharpedia, 2022)

3 Assessment Methodology

To establish the existing baseline physical and environmental conditions pertinent to groundwater and estimate dewatering rates/volumes, the methodology outlined below was applied.

3.1 Desktop Assessment

To develop an understanding of groundwater conditions at the site, the following documents were reviewed:

- SR00039 – Stormwater Amenity: Geotechnical Report – Rev 1 (Aurecon, 2022)
- SR00039 - Stormwater Amenity Winding Creek - Cardiff: Preliminary Waste Classification Assessment (Aurecon, 2022)

In addition, publicly available information was reviewed from the following data sources:

- Surface Geology: Department of Regional NSW, 2018, NSW Seamless Geology
- Climate: Bureau of Meteorology (BoM), 2022a, Climate Data Online
- Registered groundwater bores: Bureau of Meteorology (BoM), 2022b, National Groundwater Information System (registered bores).

3.2 Geotechnical Investigations

The geotechnical scope comprised drilling of two boreholes and two test pits to a maximum depth of 5.45 m below ground level (mBGL). The boreholes were advanced using a DT1200 drilling rig using solid flight augers. The test pits were advanced using a 3T excavator. The boreholes and test pits were backfilled upon completion.

A summary of the borehole information is presented in **Table 3-1**. The approximate locations of the boreholes are shown on **Figure 3-1** and the borehole logs and explanatory notes are included in **Appendix B**.

Table 3-1 Summary of the borehole locations.

Borehole ID/ Test Pit ID	Easting (mE)	Northing (mN)	Top RL (mAHD)	Drilled Depth / Excavated Depth (mBGL)	Depth of Encountered Groundwater (mBGL)	Piezometer Installed
L03-BH01	374818	6354146	13.96	5.45	2.50	Yes
L03-BH02	374850	6354049	13.16	5.45	4.20	-
L03-TP01	374845	6354172	12.98	2.90	2.80	-
L03-TP02	374838	6354024	13.51	1.90	1.80	-

Notes:
- The approximate ground surface levels are estimated using the surveyed data.
- Easting and Northing relate to the Map Grid of Australia (MGA) coordinate system.
- mBGL = metres below ground level

Upon completion of drilling, one standpipe piezometers were installed in L03-BH01. The screened zone was installed within the bottom 3 m of each hole as detailed in Table 3-2 below.

Table 3-2 Standpipe piezometer details.

Monitoring Well ID	Total Hole Depth (m)	Backfill Levels (from Depth mbgl to Depth mbgl)	Bentonite Levels (from Depth mbgl to Depth mbgl)	Screened Section (from Depth mbgl to Depth mbgl)	Sand Levels (from Depth mbgl to Depth mbgl)
L03-BH01	5.45	0.0 – 1.0	1.0 – 1.5	1.7 – 4.7	1.5 – 5.45

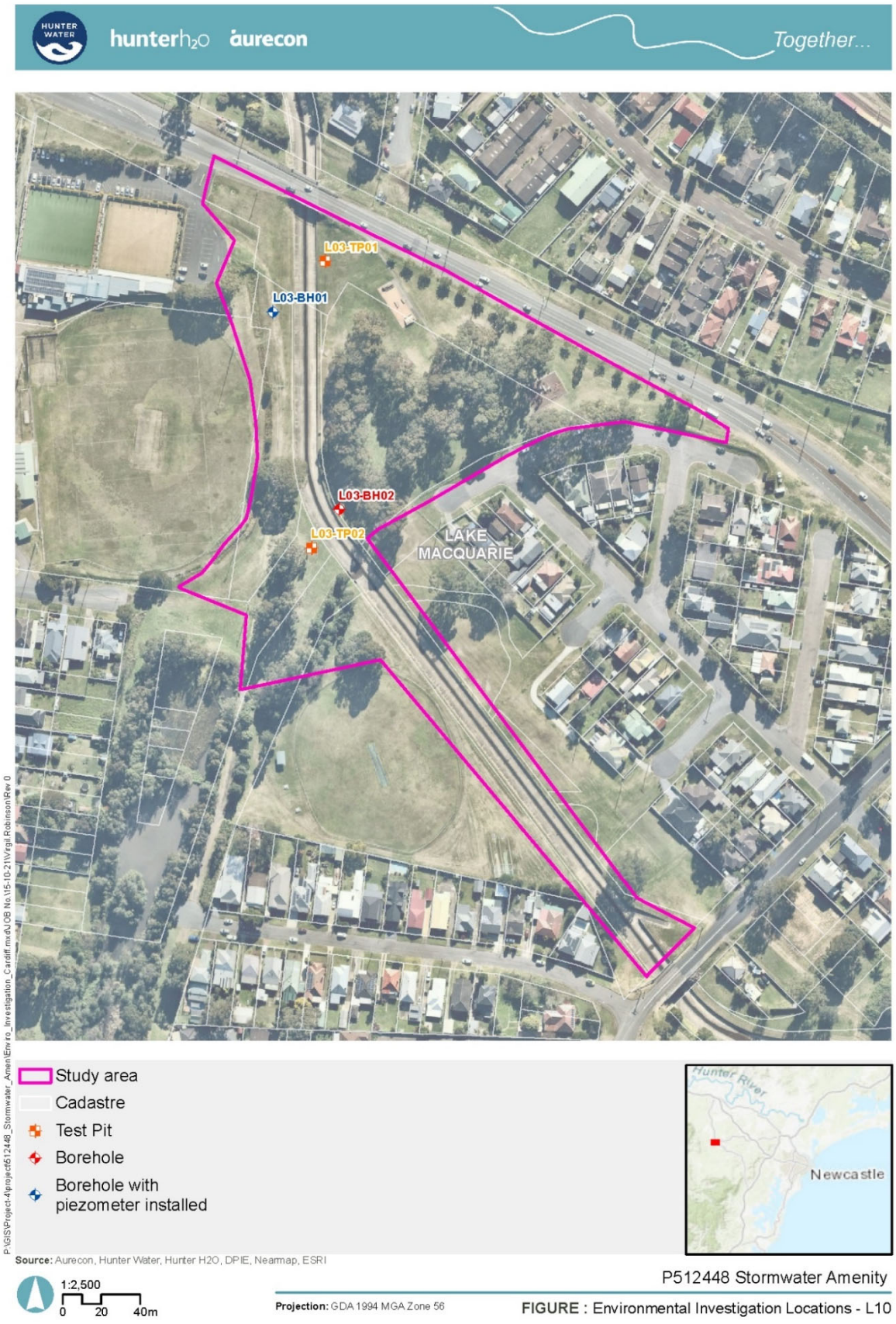


Figure 3-1 Winding Creek South of Myall Road, Cardiff: Geotechnical Investigation Locations

3.3 Analytical modelling methodology

Dewatering rate/volume calculations were carried out for the site. Design details and expected hydrogeological properties were collated to form the basis of the analytical calculations.

For the purposes of dewatering calculations, it is assumed that the duration of earthworks for the project will be 3 months. It is also assumed that each feature will be constructed using a staged approach in discrete 30 m sections.

To introduce a level of conservatism, and account for the potential variability in groundwater level at the site (due to climatic conditions), 0.5 m has been added to the groundwater elevations (presented in **Section 4.3**) when deriving required drawdown values.

3.3.1 Radius of Influence

The radius of influence (i.e. extent of induced groundwater drawdowns) was calculated using Sichardt's formula (Sichardt, 1930) for unconfined aquifers:

$$R_o = C \times s\sqrt{K}$$

Where:

R_o = Radius of influence (m)

C = Radial/linear flow conversion factor = 2000 for linear flow into trenches (dimensionless)

s = Maximum drawdown (m)

K = Hydraulic conductivity (m/d)

3.3.2 Groundwater Recharge

In addition to the dewatering rates outlined below, any groundwater recharge that occurs within the radius of influence during dewatering, will contribute to the overall dewatering rates/volumes. The main groundwater recharge mechanism in an unconfined aquifer is expected to be direct infiltration via rainfall. To account for this, the groundwater recharge volume via rainfall was estimated and added to the overall dewatering rates.

Groundwater recharge volume via rainfall was calculated via the following formula:

$$G_R = r_h \times R$$

Where:

G_R = Average annual groundwater recharge volume (m^3)

r_h = Average annual rainfall amount (m)

R = Groundwater recharge rate (%)

This provides an estimation of the volume of uniformly distributed groundwater recharge that can be expected to contribute to dewatering volumes during a year where average rainfall conditions occur.

Groundwater recharge volumes have been estimated based on average annual rainfall amounts between between 1990 to 2022 (Edgeworth WWTP - Station No. 61393 (BoM, 2022a)) and typical groundwater recharge rates for unconfined coast alluvium aquifers in NSW (CSIRO, 2010).

3.3.3 Dewatering Rates

Dewatering rates were calculated in accordance with an analytical scenario applicable to groundwater inflow into a linear trench. The adopted equation calculates the total discharge from a single row of partially penetrating well points in an unconfined aquifer midway between two equidistant and parallel line sources (Mansur & Kaufman, 1962).

$$Q = \left[\left(0.73 + 0.27 \frac{(H - h_w)}{H} \right) \frac{Kx}{R_0} (H^2 - h_w^2) \right]$$

Where:

Q = Total discharge from the well points (m^3/d)

H = Height of the water table at the radius of influence (m)

h_w = Height of the water table at well point (m)

K = Hydraulic conductivity (m/d)

x = Length of trench (m)

R_o = Radius of influence = calculated from Sichardt's formula above (m)

The assumptions have been applied in these formulas include necessary simplifications of the existing groundwater conditions and dewatering methodology. Understanding these assumptions, which are provided in **Appendix A**, is important in interpreting the results.

Worthy of note is the assumption that the analytical model is run assuming the dewatering is in equilibrium / steady state. This assumes that pumping has continued for a period where the zone of influence has intercepted sufficient recharge to equal the amount being pumped.

The progressive excavation will introduce non-steady state or transient conditions where the pumped water will be released mainly from storage. The storage capacity or specific yield of the aquifer has not been considered in the adopted analytical model. In general, for the same drawdown, low storage capacity aquifers such as fractured rocks produce less amount of water from storage with rapid propagation of drawdown compared to high storage capacity aquifers such as alluvial aquifers. Therefore, the results may underestimate the expected volume of water to be pumped.

4 Groundwater Conditions

This section provides a summary of groundwater conditions pertinent to the dewatering calculations.

4.1 Surface Geology

The Seamless NSW state surface geology GIS dataset shows the site being overlain by Alluvial valley deposits (Q_av) comprising silt, clay, (fluvially deposited) lithic to quartz-lithic sand, gravel. The approximate site location is identified in relation to the NSW state surface geology in **Figure 4-1.**

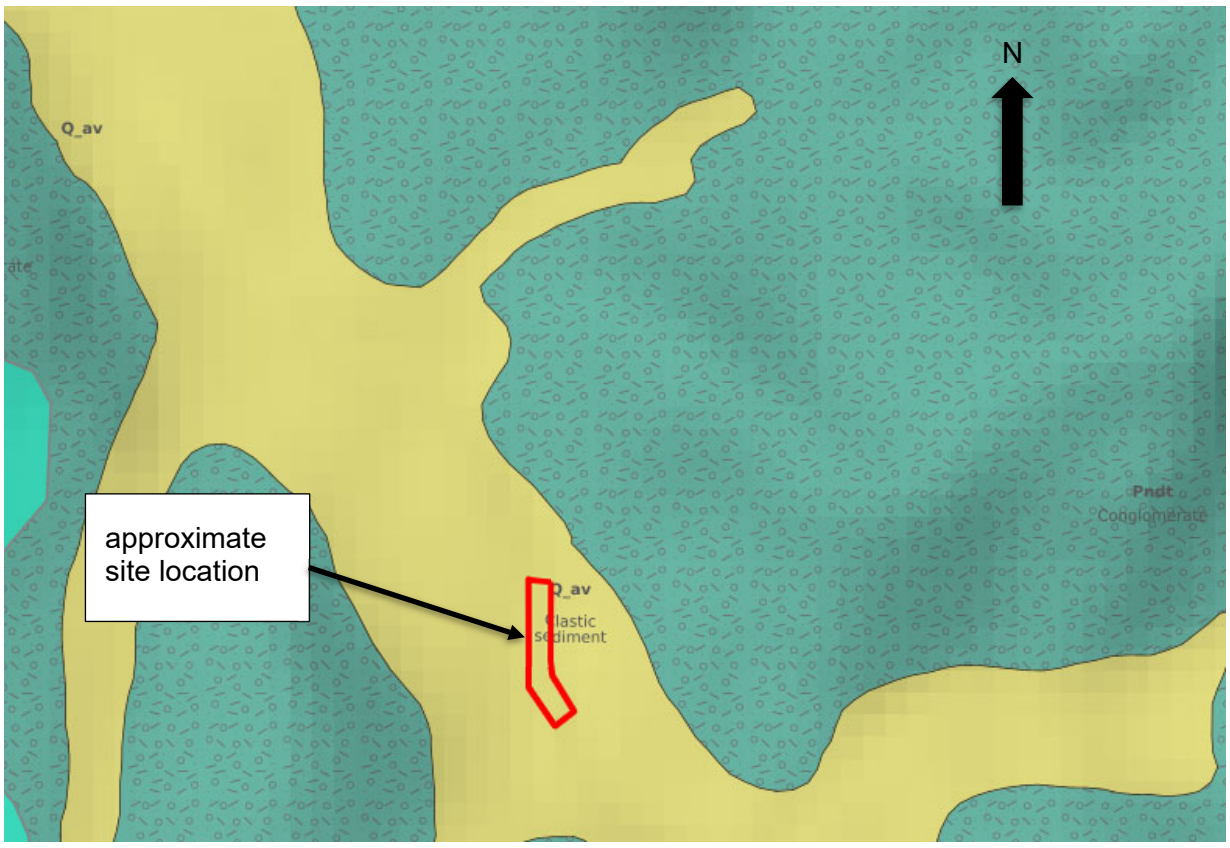


Figure 4-1 Surface geology mapping at the site (Department of Regional NSW, 2018)

4.2 Lithology

A summary of the lithology observations recorded during geotechnical investigations at the site are summarised in **Table 4-1**.

Table 4-1 Lithological observations - Summary

Parameter / Lithological Description	Bore/Test Pit ID			
	L03-BH01	L03-BH02	L03-TP01	L03-TP02
Fill	0.00 – 3.70	0.00 – 1.70	0.00 – 2.30	0.00 – 1.90
Alluvium	3.70 – 5.45	1.70 – 5.45	2.30 – 2.90	-

The fill material was typically logged as Sandy clay. The material was characterised as low or medium to high plasticity with fine to medium grained sand. The colour of this material was dark brown or grey mottle orange brown and had a moisture condition of greater than the plastic limit.

The water bearing alluvium material was generally logged as the following:

- **Clayey Sand** – Characterised as very loose with fine to medium grained sand with fine to medium grained gravel. The colour of this material was grey and had a moisture condition of wet.
- **Silty Sand** – Characterised as very medium dense with fine to medium grained sand. The colour of this material was grey and had a moisture condition of wet.

These lithological observations are generally consistent with the material descriptions outlined in the surface geological mapping discussed in **Section 4.1**.

4.3 Groundwater Levels

The water levels were recorded within the standpipe piezometers using a dipping metre on 23 September 2021 as indicated in **Table 4-2**. It is noted that no rainfall was recorded on the measurement date or in the days preceding it.

Table 4-2 Groundwater level measurement at the site

Standpipe ID	Measurement Date	Groundwater level (mBGL)	Groundwater elevation (mAHD)
N14-BH03	23/09/2021	2.50	11.43

4.4 Hydraulic Conductivity

No site-specific measurements for hydraulic conductivity are available at the sites. In the absence of site-specific measurements, literature-based values for hydraulic conductivity have been adopted, matching the lithological observations and geological material descriptions as far as practicable. The adopted soil texture class, based on the United States Department of Agriculture (USDA) soil taxonomy system and the associated hydraulic conductivity estimates are outlined in **Table 4-3** below.

Table 4-3 Adopted hydraulic conductivity values

Geological Unit Description	Lithological Material Description	Adopted USDA soil texture class	Assumed hydraulic conductivity values (Saxton and Rawls, 2006)		
			Minimum (m/s)	Geometric mean (m/s)	Maximum (m/s)
Alluvium	Clayey sand / silty sand	Sandy loam	2.82 x 10-6	7.33 x 10-6	1.91 x 10-5

5 Results

Assumptions, input values and results of the analytical modelling are presented in **Appendix A** and summarised below.

The required drawdown, based on the maximum depth of excavation (2.8 mBGL) and the measured groundwater level (2.5 mBGL) is approximately 0.3 m. To introduce a level of conservatism, and account for the potential variability in groundwater level at the site (due to climatic conditions, possible tidal influence etc), 0.5 m has been added to this value and 0.8 m has been adopted as the required drawdown value.

The full range of hydraulic conductivity values recorded at the site (presented in **Section 4.4**) were adopted in the calculations to provide a range of possible dewatering estimates. Minimum and maximum discharge rates were calculated using the minimum and maximum hydraulic conductivity values respectively. The "expected" discharge rates were calculated using the geometric mean hydraulic conductivity value.

Total dewatering volumes are dependent upon the estimated dewatering rates and the duration. Total length of the project features is approximately 274 m. Based on an estimated 3-month (92 days) construction window, approximate dewatering durations were derived for each ~30 m section as follows:

- Total length = 274 m, section length = 30 m (11%), construction duration of each section = ~10 days.

Based on these durations, total dewatering volumes were calculated, and results are summarised in **Table 5-1** below.

Table 5-1 Winding Creek South of Myall Road, Cardiff – Dewatering Estimates

Parameter	Values		
	Minimum	Expected	Maximum
Required drawdown (m)	0.8	0.8	0.8
Applied hydraulic conductivity (m/s)	2.82×10^{-6}	7.33×10^{-6}	1.91×10^{-5}
Radius of Influence (m)	2.69	4.33	6.98
Total length of trench (m)	274	274	274
Length of open section	30	30	30
Discharge rate per section (m^3/day)	0.67	2.81	11.76
Dewatering duration per section (days)	10.07	10.07	10.07
Discharge per section (m^3)	6.75	28.28	118.43
Total discharge (m^3)	61.68	258.29	1081.64

Groundwater recharge via rainfall that may occur during dewatering activities was also estimated in accordance with the methodology outlined in **Section 3.3.2**, as this will contribute to the overall dewatering volume. Calculated groundwater recharge rate is outlined in **Table 5-2** below.

Table 5-2 Groundwater recharge rates

Parameter	Value	Comment
Area of influence (m2)	1383.3	Max radius of influence buffer around total length of excavations.
Average annual rainfall (m/year)	1.155	Annual average rainfall between 1990 to 2022 (Edgeworth WWTP - Station No. 61393 (BoM, 2022a))
Average annual rainfall volume (m3)	1597.7	Calculated based on above values

Parameter	Value	Comment
Groundwater recharge rate (%)	18%	Adopted as typical value based on recharge studies from unconfined coastal alluvium aquifers in NSW (CSIRO, 2010)
Groundwater recharge rate (m^3/day)	0.8	Calculated based on above values
Total groundwater recharge volume (m^3)	72.5	Calculated based on above values and assumed total duration

The estimated groundwater recharge volume can then be added to the overall dewatering volumes, which yields the results outlined in **Table 5-3** below.

Table 5-3 Total dewatering volumes

Site / Parameter	Total Dewatering Volumes (m^3)		
	Minimum	**Expected**	**Maximum**
Total including estimated groundwater recharge	131.0	327.6	1150.9

Therefore, the estimated total volume of dewatering, including groundwater recharge during dewatering, is expected to be 327.6 m^3, or 0.33 ML.

There is a large difference between the estimated minimum and maximum dewatering rates/volume estimates. The results from the analytical calculations are sensitive to the adopted hydraulic conductivity, for which no site-specific measurements have been conducted. The results are also influenced by the depth of required drawdown, however, are less sensitive to these values in comparison to hydraulic conductivity. Therefore, hydrogeological conditions are unknown along the alignment(s) and there is a high degree of uncertainty associated with these estimates which should be considered in interpreting the modelling results.

6 Conclusions and Recommendations

Based on the analysis presented in this memorandum, the estimated total volume of dewatering for the project is expected to be approximately 0.33 ML.

Any dewatering requires a Water Supply Works (WSW) approval, (unless incidental, e.g. used for dust suppression, erosion control). If more than 3 ML/year of groundwater is anticipated to be extracted, a Water Access License, under the *Water Management Act 2000*, must be sought through the Natural Resource Access Regulator (NRAR). The estimated total volume of dewatering is below 3 ML/year; therefore, a Water Access License is not expected to be required.

There is a large difference between the estimated minimum and maximum dewatering rates/volume estimates. The results from the analytical calculations are highly sensitive to the adopted hydraulic conductivity, which has not been measured at the sites and literature values have been adopted. The results are also influenced by the depth of required drawdown, however, are less sensitive to these values in comparison to hydraulic conductivity. Therefore, hydrogeological conditions are unknown along the alignment and there is a high degree of uncertainty associated with these estimates.

It is possible that during excavation works, unexpected hydrogeological conditions may be encountered due to previously unknown heterogeneities in the subsurface or changes in the proposed scope/design that affect the underlying assumptions used in this groundwater dewatering assessment. In this instance, the contractor should revisit the evaluation and groundwater management process and decide if additional data or approvals are required. The development of a change management strategy may be required depending on the quantity and quality of the encountered groundwater.

Further approval may be required to discharge extracted groundwater to a receiving water body, stormwater collection system or sewer. The primary discharge options for extracted groundwater, to be determined by the contractor, would be managed in accordance with the *Water Management Act 2000* and the *Protection of the Environment Operations Act 1997*. The primary discharge options include:

- **Discharge to a receiving surface water body (i.e. Winding Creek).** A discharge assessment would be required to demonstrate that the groundwater quality is suitable, and that discharge will not have significant deleterious impacts to the receiving water body. Otherwise, treatment may be required prior to discharge, or a different disposal method applied.
- **Discharge to stormwater collection system.** This would require a similar level of assessment to discharging to receiving surface water body as described above.
- **Discharge to sewer via a Trade Waste Agreement (TWA)** with the wastewater system operator. Discharge to sewer is to be conducted in accordance with the TWA, which may require treatment of the water prior to discharge.
- **Land based application or reinjection / irrigation.** Feasibility of this option is dependent upon soil properties (infiltration rates, salinity etc.) at the reinjection / irrigation area. This option is generally precluded as a discharge option in areas with low permeability soils and salinity issues. However, for incidental or small volumes of extracted groundwater, this option could be considered provided the groundwater quality is suitable and other approval mechanisms are in place. Stability of nearby trenches / excavations and surrounding underground structures must be considered.
- **Offsite disposal.** Extracted groundwater could be trucked offsite and treated and/or disposed of at a licensed wastewater treatment plant or waste facility.

7 References

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8 Assumptions and Limitations

Where hydrogeologic information and design details were not available, the following assumptions have been made:

- The required drawdown, based on the maximum depth of excavation (2.8 mBGL) and the measured groundwater level (2.5 mBGL) is approximately 0.3 m. To introduce a level of conservatism, and account for the potential variability in groundwater level at the site (due to climatic conditions, possible tidal influence etc), 0.5 m has been added to this value and 0.8 m has been adopted as the required drawdown value.
- No site-specific measurements for hydraulic conductivity are available at the sites. In the absence of site-specific measurements, literature-based values for hydraulic conductivity have been adopted, matching the lithological observations and geological material descriptions as far as practicable. The adopted soil texture class, based on the United States Department of Agriculture (USDA) soil taxonomy system and the associated hydraulic conductivity (presented in Table 4-3) (Saxton and Rawls, 2006).
- For the purposes of dewatering calculations, it is assumed that the duration of earthworks for the project will be 3 months. It is also assumed that each feature will be constructed using a staged approach in discrete 30 m sections.
- Groundwater recharge volumes have been estimated based on average annual rainfall amounts between between 1990 to 2022 (Edgeworth WWTP - Station No. 61393 (BoM, 2022a)) and typical groundwater recharge rates for unconfined coast alluvium aquifers in NSW (CSIRO, 2010).

In preparing the report, Aurecon has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). The report also relies on publicly available data and the level of characterisation is dependent upon the reliability of this data and how often the various databases are updated.

Except as otherwise stated in the report, Aurecon has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Aurecon will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Aurecon.

In accordance with the scope of services, Aurecon has relied upon the data and has not conducted any environmental field monitoring or testing in the preparation of this report. The conclusions are based upon the data sources included in this report and are therefore merely indicative of the environmental condition of the site at the time of preparing the report.

Within the limitations imposed by the scope of services, the assessment of the site and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

Appendix A

Analytical Calculations

21) Radius of influence (Sichardt)

$$R_0 = Cs\sqrt{K}$$

Empirical equation based on drawdown and permeability

Essential input
Optional input
Calculated

		expected		min	max	
Drawdown in well	s	0.8	m	0.8	0.8	m
Hydraulic conductivity	K	7.33E-06	m/s	2.82E-06	1.91E-05	m/s
		0.6335	m/d	0.24384	1.64593	m/d
Factor	C	2000		3000 for radial flow 1500-2000 for line flow to trenches or wellpoints		
Radius of influence	R_0	4.33	m	2.69	6.98	m

The following assumptions apply to this equation
- the aquifer is unconfined
- the aquifer has infinite areal extent
- the aquifer is homogeneous, isotropic and of uniform thickness
- flat initial water table
- the aquifer is pumped at a constant discharge rate
- the pumping well is fully penetrating, therefore receiving water from the entire saturated thickness of the aquifer
- the flow to the well is in a steady state

Data sources (to complete an audit trail)

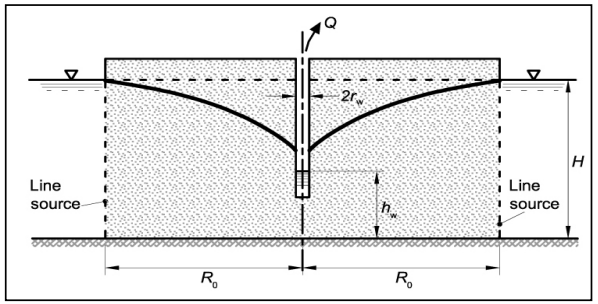
Drawdown in well	s	Depth of excavation (2.8 m) - groundwater depth (2.5 m) + 0.5
Hydraulic conductivity	K	Assumed hydraulic conductivity range (Saxton and Rawls, 200
Factor	C	Linear trench

10) Partial penetration by a single row of wellpoints of an unconfined aquifer midway between two equidistant and parallel line sources

$$Q=\left[\left(0.73+0.27\frac{(H-h_w)}{H}\right)\frac{Kx}{R_0}(H^2-h_w^2)\right]$$

Essential input
Optional input
Calculated

		expected		min	max	
Head						
Height of water table at radius of influence	H	0.8	m	0.8	0.8	m
Height of water table at well	h_w	0	m	0	0	m
Conductivity						
Hydraulic conductivity of aquifer	K	0.634	m/d	0.244	1.646	m/d
Radius						
Length of trench	*x*	30	m	30	30	m
Distance to line source, equal to radius of influence	R_0	4.33	m	2.69	6.98	m
Is R_0/H greater than or equal to 3 ?		Yes		Yes	Yes	
Total discharge from wellpoints	**Q**	2.81	m^3/d	0.67	11.76	m^3/d



(Figure adapted from Mansur & Kaufman, 1962)

The following assumptions apply to this equation

- the slot is infinite in length
- R_0/H greater than or equal to 3
- the aquifer is unconfined
- the aquifer is homogeneous, isotropic and of uniform thickness
- the Dupuit Forcheimer assumption is valid
- the aquifer has reached steady state conditions
- the initial water table is horizontal

(Mansur & Kaufman, 1962)

Data sources (to complete an audit trail)		
Height of water table at radius of influence	H	Depth of excavation (2.8 m) - groundwater depth (2.5 m) + 0.5
Height of water table at well	h_w	Water level relative to drawdown at radius of influence
Hydraulic conductivity of aquifer	K	Assumed hydraulic conductivity range (Saxton and Rawls, 20
Length of trench	*x*	Proposed length of open section (constructed in 30m sections
Radius of influence	R_0	Calculated from Sichardt method

Appendix B

Borehole Logs

Borehole No: L03-BH01

Engineering Log - Borehole

SHEET 1 OF 1

Client	Hunter Water	Project No.	512448
Project	Stormwater Amenity	Logged By	MC
Location	Cardiff	Checked By	NS

Started Drilling	23.9.21	Northing	6354146.00	Slope	90°	Equipment	DT1200
Completed Drilling	23.9.21	Easting	374818.00	Bearing	---	Ground Level	13.935 AHD

DRILLING				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
AD/T	▼	13	0		CL	FILL: Sandy CLAY: low plasticity, dark brown, medium grained sand, with coarse, subangular, black and brown gravel					FILL
			1			1.00m: As above, sand becomes fine to medium grained with trace of gravels.			SPT 2, 2, 4 N=6		SPT Recovery: 0.45 m
		12	2		CI-CH	FILL: Sandy CLAY: medium to high plasticity, grey mottled orange brown, medium grained sand, with coarse, subangular, black and brown gravel	>PL		SPT 2, 3, 4 N=7		SPT Recovery: 0.45 m
											2.5m - seepage observed
		11	3						SPT 4, 6, 7 N=13		SPT Recovery: 0.45 m
		10	4		SC	Clayey SAND: fine to medium grained, grey, with fine to medium, subangular, brown gravel	W	VL			ALLUVIUM
									SPT 1, 1, 2 N=3		SPT Recovery: 0.45 m
		9	5						SPT 1, 0, 0 N=0		SPT Recovery: 0.45 m
		8	6			Borehole L03-BH01 Terminated at 5.45 m					Borehole terminated at target depth
		7	7								
		6	8								

Remarks:

aurecon

Borehole No: L03-BH02

Engineering Log - Borehole

SHEET 1 OF 1

Client	Hunter Water	Project No.	512448
Project	Stormwater Amenity	Logged By	MC
Location	Cardiff	Checked By	NS

Started Drilling	23.9.21	Northing	6354049.00	Slope	90°	Equipment	DT1200
Completed Drilling	23.9.21	Easting	374850.00	Bearing	---	Ground Level	13.156 AHD

DRILLING				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
AD/T		13	0		CL	FILL: Sandy CLAY: low plasticity, dark brown, fine to medium grained sand	>PL				FILL
		12	1			1.00m: As above, becomes dark grey, with medium grained sand and coarse, black, brown and grey subangular gravels			SPT 3, 3, 3 N=6		SPT Recovery: 0.45 m
		11	2		CI	Silty CLAY: medium plasticity, grey mottled orange brown	<PL	F to St	SPT 3, 3, 6 N=9		ALLUVIUM SPT Recovery: 0.45 m
		10	3			3.00m: As above, becomes dark grey			SPT 2, 4, 4 N=8		SPT Recovery: 0.45 m
	▶	9	4		SM	Silty SAND: fine to medium grained, grey	W	MD	SPT 7, 7, 8 N=15		SPT Recovery: 0.45 m 4.2m - seepage observed
		8	5		CI-CH	Sandy CLAY: medium to high plasticity, grey, fine to medium grained sand	~PL	St	SPT 5, 4, 6 N=10		SPT Recovery: 0.45 m
		7	6			Borehole L03-BH02 Terminated at 5.45 m					Borehole terminated at target depth
		6	7								
			8								

Remarks:

aurecon

Test Pit No: L03-TP01

Engineering Log - Test Pit

Client	Hunter Water	Project No.	512448
Project	Stormwater Amenity	Logged By	MP
Location	Cardiff	Checked By	NS

Started Excavation	23.9.21	Northing	6354172.00	Slope	90°	Equipment	2-4t Excavator
Completed Excavation	23.9.21	Easting	374845.00	Bearing	---	Ground Level	12.983 AHD

EXCAVATION				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E		12	1		CL-CI	FILL: Silty Sandy CLAY: low to medium plasticity, dark brown, fine to medium sand, trace ironstone, sandstone and igneous gravel, traces of slag, asphalt and root fibres				E	FILL
										E	
						1.10m to 1.80m: becomes dark orange brown and grey	~PL				
										E	
		11	2			1.80m to 2.30m: becomes grey mottled orange brown				E	
					CL	Gravelly Sandy CLAY: low plasticity, yellow and grey, fine to medium sand, river gravel	>PL			E	ALLUVIUM
		10	3			Test Pit L03-TP01 Terminated at 2.90 m					2.8m - seepage observed Collapse of test pit
		9	4								
		8	5								
		7	6								
		6	7								
		5	8								

Remarks:

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aurecon	**Client** Hunter Water **Project** Stormwater Amenity **Project No.** 512448/SR00039 **Photo By:** MP	**Test Pit Photo** **L03-TP01**

Test Pit No: L03-TP02

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Hunter Water	Project No.	512448
Project	Stormwater Amenity	Logged By	MP
Location	Cardiff	Checked By	NS

Started Excavation	23.9.21	Northing	6354024.00	Slope	90°	Equipment	2-4t Excavator
Completed Excavation	23.9.21	Easting	374838.00	Bearing	---	Ground Level	13.507 AHD

EXCAVATION				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E		13	0		CL-CI	FILL: Silty Sandy CLAY: low to medium plasticity, dark brown, fine to medium grained sand, trace ironstone, sandstone and igneous gravel, traces of concrete, asphalt, slag, wood and root fibres	~PL			E	FILL
		12	1			1.20m to 1.80m: becomes orange brown				E	
	▶	11	2		GC	FILL: Clayey GRAVEL: fine to medium grained, dark brown, trace fine to medium grained sand, boulders	D			E	1.8m - seepage observed
		10	3			Test Pit L03-TP02 Terminated at 1.90 m					Refusal on boulders and collapse of test pit
		9	4								
		8	5								
		7	6								
		6	7								
			8								

Remarks:

aurecon

aurecon	**Client** Hunter Water **Project** Stormwater Amenity **Project No.** 512448/SR00039 **Photo By:** MP	**Test Pit Photo** **L03-TP02**

APPENDIX G

Arboricultural Impact Assessment and Tree Protection Plan

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Arboricultural Impact Appraisal and Method Statement

173B Myall Road
Cardiff, NSW

Prepared for
Hunter Water

---

4 July 2022

by Andrew Scales
Dip. Horticulture / Dip. Arboriculture AQF5

PO Box 5085, Elanora Heights NSW 2101
E: info@naturallytrees.com.au M: 0417 250 420

Summary

The proposed works include improvements to the existing stormwater amenity that are to be undertaken along the existing concrete-lined stormwater channel. I have inspected all the trees that could be affected and list their details in Appendix 2. Based on this information, I provided guidance to project architect on the constraints these trees impose on the use of the site.

The proposed changes may adversely affect two high category trees if appropriate protective measures are not taken. However, if adequate precautions to protect the retained trees are specified and implemented through the arboricultural method statement included in this report, the development proposal will have no adverse impact on the contribution of trees to local amenity or character.

Table of Contents

Appendices

1. INTRODUCTION

1.1 **Instruction:** I am instructed by Aurecon Group to inspect the tree population at 173B Myall Road, Cardiff and to provide an arboricultural report to accompany a development application. This report investigates the impact of the proposed development on trees and provides the following guidelines for appropriate tree management and protective measures:

- a schedule of the relevant trees to include basic data and a condition assessment;
- an appraisal of the impact of the proposal on trees and any resulting impact that has on local character and amenity;
- a preliminary arboricultural method statement setting out appropriate protective measures and management for trees to be retained

1.2 **Purpose of this report**: This report provides an analysis of the impact of the development proposal on trees with additional guidance on appropriate management and protective measures. Its primary purpose is for Hunter Water to review the tree information as part of the planning phase and use as the basis for tree management. Within this planning phase, it will be available for inspection by people other than tree experts, so the information is presented to be helpful to those without a detailed knowledge of the subject.

1.3 **Qualifications and experience:** I have based this report on my site observations and the provided information, and I have come to conclusions in the light of my experience. I have experience and qualifications in arboriculture and include a summary in Appendix 1.

1.4 **Documents and information provided:** Aurecon Group provided me with copies of the following documents:

- Stormwater Amenity Plans, Dwg No. 85223-16267-001 to 85223-16267-008 (Revision 01), by Hunter Water dated 25 May 2022.

1.5 **Scope of this report:** This report is only concerned with two individual trees, plus a stand of similar trees, within the site precinct. It takes no account of other trees, shrubs or groundcovers within the site unless stated otherwise. It includes a preliminary assessment based on the site visit and the documents provided, listed in 1.4 above.

2. THE LAYOUT DESIGN

2.1 **Tree AZ method of tree assessment:** The TreeAZ assessment method determines the worthiness of trees in the planning process. TreeAZ is based on a systematic method of assessing whether individual trees are important and how much weight they should be given in management considerations. Simplistically, trees assessed as potentially important are categorised as '**A**' and those assessed as less important are categorised as '**Z**'. Further explanation of TreeAZ can be found in Appendix 3.

In the context of new development, all the Z trees are discounted as a material constraint in layout design. All the A trees are potentially important and they dictate the design constraints. This relatively simple constraints information is suitable for use by the architect to optimise the retention of the best trees in the context of other material considerations.

2.2 Site visit and collection of data

2.2.1 **Site visit:** I carried out an unaccompanied site visit on 27 June 2022. All my observations were from ground level and I estimated all dimensions unless otherwise indicated. Aerial inspections, root or soil analysis, exploratory root trenching and internal diagnostic testing was not undertaken as part of this assessment. The weather at the time of inspection was clear and dry with good visibility.

2.2.2 **Brief site description:** 173B Myall Road is located in the residential suburb of Cardiff (refer figure 1). The site is on the southern side of the road and surrounded by residential and commercial development. The site consists of Wilkinson Park which has a variety of indigenous trees scattered throughout the site and around the site boundaries.

Figure 1: The location of the subject site (www.googlemaps.com).

2.2.3 **Collection of basic data:** I inspected each tree and have collected information on species, height, diameter, maturity and potential for contribution to amenity in a development context. I have recorded this information in the tree schedule included, with explanatory notes, in Appendix 2. Each tree was then allocated to one of four categories (**AA**, **A**, **Z** or **ZZ**), which reflected its suitability as a material constraint on development.

2.2.4 **Identification and location of the trees:** I have illustrated the locations of the significant trees on the Tree Management Plan (Plan TMP01) included as Appendix 8. This plan is for illustrative purposes only and it should not be used for directly scaling measurements.

2.2.5 **Advanced interpretation of data:** Australian Standard *Protection of trees on development sites* (AS4970-2009), recommends that the trunk diameter measurement for each tree is used to calculate the tree protection zone (TPZ), which can then be interpreted to identify the design constraints and, once a layout has been consented, the exclusion zone is to be protected by barriers.

2.3 **The use of the tree information in layout design:** Following my inspection of the trees, the information listed in Appendix 2 was used to provide constraints guidance based on the locations of all the A trees. All the Z trees were discounted because they were not considered worthy of being a material constraint. This guidance identified two zones of constraint based on the following considerations:

- **The tree protection zone** (TPZ) is an area where ground disturbance must be carefully controlled. The TPZ was established according to the recommendations set out in AS4970-2009 and is the radial offset distance of twelve (x12) times the trunk diameter. In principle, a maximum encroachment of 10% is acceptable within the TPZ and a high level of care is needed during any activities that are authorised within it if important trees are to be successfully retained.

- **The structural root zone** (SRZ) is a radial distance from the centre of a tree's trunk, where it is likely that structural, woody roots would be encountered. The distance is calculated on trunk flare diameter at ground level. The SRZ may also be influenced by natural or built structures, such as rocks and footings. The SRZ only needs to be calculated when major encroachment (>10%) into a TPZ is proposed.

3. ARBORICULTURAL IMPACT APPRAISAL

3.1 **Summary of the impact on trees:** I have assessed the impact of the proposal on trees by the extent of disturbance in TPZs and the encroachment of structures into the SRZ (as set out briefly in 2.3 above and more extensively in Appendix 2). All the trees that may be affected by the development proposal are listed in Table 1

Table 1: Summary of existing trees and trees that may be affected by development

Impact	Reason	Important trees		Unimportant trees	
		AA	A	Z	ZZ
Retained trees that may be affected through disturbance to TPZs	Removal of existing surfacing/structures/ landscaping and/or installation of new surfacing/structures/ landscaping	1	A		1a

3.2 **Detailed impact appraisal**

3.2.1 **Category AA and A trees that could potentially be adversely affected through TPZ disturbance:** Two category A and AA trees (Trees 1 and A) could potentially be adversely affected through disturbance to their TPZs as follows:

- Tree 1: This is a very important tree with an existing stormwater channel near it. The current proposal is to modify the existing stormwater channel which will occupy 16% of its TPZ. These works will exceed recommendations set out in AS4970-2009.

  If it is intended to retain this tree, design and/or siting modification would be required to be considered to accommodate setbacks as prescribed by the Australian Standard AS4970-2009 *Protection of trees on development sites*. Specifically, the proposed works should be limited to the outer edges of the TPZ to avoid severance of roots.

  If these modifications are implemented, this tree could be successfully retained without any adverse effects if appropriate protective measures are properly specified and controlled through a detailed arboricultural method statement.

- Tree A: This is an important stand of trees. The proposal channel works remains outside their TPZ, and the shared pathway will be constructed at the edge of their TPZ. I have reviewed the situation carefully and my experience is that this tree could be successfully retained without any adverse effects if appropriate protective measures are properly specified and controlled through a detailed arboricultural method statement.

3.2.2 **Low category tree to be retained:** Tree 1a is completely dead and remains outside the works zone. The canopy of this tree has been reduced to prevent risk of falling limbs. Protective measures do not apply near this tree however no excavation is permitted within 3m from its trunk.

3.3 Proposals to mitigate any impact

3.3.1 **Protection of retained trees:** The successful retention of trees within the site will depend on the quality of the protection and the administrative procedures to ensure protective measures remain in place throughout the development. An effective way of doing this is through an arboricultural method statement that can be specifically referred to in the planning condition. An arboricultural method statement for this site is set out in detail in Section 4.

3.3.2 **Summary of the impact on local amenity:** The proposed changes may adversely affect two high category trees if appropriate protective measures are not taken. However, if adequate precautions to protect the retained trees are specified and implemented through the arboricultural method statement included in this report, the development proposal will have no adverse impact on the contribution of trees to local amenity or character.

4. ARBORICULTURAL METHOD STATEMENT

4.1 Introduction

4.1.1 **Terms of reference:** The impact appraisal in Section 3 identified the potential impacts on trees caused by proposed development. Section 4 is an arboricultural method statement setting out management and protection details that must be implemented to secure successful tree retention. It has evolved from Australian Standard AS4970-2009 *Protection of trees on development sites*.

4.1.2 **Plan TMP01:** Plan TMP01 in Appendix 8 is illustrative and based entirely on provided information. This plan should only be used for dealing with the tree issues and all scaled measurements must be checked against the original submission documents. The precise location of all protective measures must be confirmed at the pre-commencement meeting before any demolition or construction activity starts. Its base is the existing land survey, which has the proposed layout superimposed so the two can be easily compared. It shows the existing trees numbered, with high categories (A) highlighted in green triangles and low categories (Z) highlighted in blue rectangles. It also shows the locations of the proposed protective measures.

4.2 Tree protection with fencing and ground protection

4.2.1 **Protection fencing:** Tree protection fencing must comply with AS4970 (section 4.3) recommendations. An illustrative guide is included as Appendix 4. The approximate location of the barriers and the TPZs is illustrated on plan TMP01. The precise location of the fencing must be agreed with the project Arborist before any development activity starts.

4.2.2 **Ground protection:** Any TPZs outside the protective fencing must be covered in ground protection based on AS4970 recommendations until there is no risk of damage from the demolition and construction activity. An illustrative specification for this ground protection is included as Appendix 5. On this site, it must be installed near Tree 1 as illustrated on plan TMP01 before any demolition and construction starts.

4.3 **Precautions when working in TPZs:** Any work in TPZs must be done with care as set out in Appendix 6. On this site, special precautions must be taken near Trees 1 and A as illustrated on plan TMP01 and summarised below:

- **Removal of existing surfacing/structures and replacement with new surfacing/structures:** Trees 1 and A may be adversely affected by the demolition and construction works or the installation of a small area of new surfacing. Any adverse impact must be minimised by following the guidance set out in Appendix 6.

- **Installation of new soft landscaping:** All landscaping activity within TPZs has the potential to cause severe damage and any adverse impact must be minimised by following the guidance set out in Section 7 of Appendix 6.

- **Installation of new services or upgrading of existing services:** It is often difficult to clearly establish the detail of services until the construction is in progress. Where possible, it is proposed to use the existing services into the site and keep all new services outside TPZs. However, where existing services within TPZs require upgrading or new services have to be installed in TPZs, great care must be taken to minimise any disturbance. Trenchless installation should be the preferred option but if that is not feasible, any excavation must be carried out by hand according to the guidelines set out in Section 6 of Appendix 6. If services do need to be installed within TPZs, consultation must be obtained from the project Arborist and/or council before any works are carried out.

4.4 Other tree related works

4.4.1 **Site storage, cement mixing and washing points:** All site storage areas, cement mixing and washing points for equipment and vehicles must be outside TPZs unless otherwise agreed with the project Arborist and/or council. Where there is a risk of polluted water run off into TPZs, heavy-duty plastic sheeting and sandbags must be used to contain spillages and prevent contamination.

4.4.2 **Pruning:** Any pruning that is required to accommodate hoardings, scaffolding or to accommodate the unloading/loading of vehicles and has been approved by Council shall be carried out by a qualified Arborist (AQF3) and must be in accordance with AS4373 Australian Standards 'Pruning of Amenity Trees'.

4.5 Programme of tree protection and supervision

4.5.1 **Site management:** It is the developer's responsibility to ensure that the details of this arboricultural method statement and any agreed amendments are known and understood by all site personnel. Copies of the agreed documents must be kept on site at all times and the site manager must brief all personnel who could have an impact on trees on the specific tree protection requirements. This must be a part of the site induction procedures and written into appropriate site management documents.

5. HOW TO USE THIS REPORT

5.1 **Limitations:** It is common that the detail of logistical issues such as site storage and the build programme are not finalised until after consent is issued. As this report has been prepared in advance of consent, some of its content may need to be updated as more detailed information becomes available once the post-consent project management starts. Although this document will remain the primary reference in the event of any disputes, some of its content may be superseded by authorised post-consent amendments.

5.2 **Suggestions for the effective use of this report:** Section 4 of this report, including the relevant appendices, is designed as an enforcement reference. It is constructed so the council can directly reference the detail in a planning condition. Referencing the report by name and relating conditions to specific subsections is an effective means of reducing confusion and facilitating enforcement in the event of problems during implementation. More specifically, the following issues should be directly referenced in the conditions for this site:

1.	Pre-commencement meeting	4.5
2.	Protection fence	4.2.1 and Appendix 4
3.	Ground protection	4.2.2 and Appendix 5
4.	Removal of surfacing/structures	4.3 and Appendix 6 (Section 4)
5.	Installation of surfacing/structures	4.3 and Appendices 6 (Section 5)
6.	Services	4.3 and Appendix 6 (Section 6)
7.	Landscaping	4.3 and Appendix 6 (Section 7)
8.	Programming of tree protection	4.5 and Appendix 7

Each of the above matters shall be certified by the project arborist, where applicable. The last column of the table in Appendix 7 is to be used so that the various supervision issues can be recorded as they are confirmed by supervision letters. It is intended to act as a summary quick reference to help keep track of the progress of the supervision.

6. OTHER CONSIDERATIONS

6.1 **Trees subject to statutory controls:** The subject trees are legally protected under Lake Macquarie City Council's Tree Preservation Order, it will be necessary to consult the council before any pruning or removal works other than certain exemptions can be carried out. The works specified above are necessary for reasonable management and should be acceptable to the council.

7. BIBLIOGRAPHY

7.1 **List of references:**

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8. DISCLAIMER

8.1 Limitations on use of this report:

This report is to be utilized in its entirety only. Any written or verbal submission, report or presentation that includes statements taken from the findings, discussions, conclusions or recommendations made in this report, may only be used where the whole of the original report (or a copy) is referenced in, and directly attached to that submission, report or presentation.

ASSUMPTIONS

Care has been taken to obtain all information from reliable sources. All data has been verified insofar as possible: however, Naturally Trees can neither guarantee nor be responsible for the accuracy of information provided by others.

Unless stated otherwise:

- *Information contained in this report covers only those trees that were examined and reflects the condition of those trees at time of inspection: and*
- *The inspection was limited to visual examination of the subject trees without dissection, excavation, probing or coring. There is no warranty or guarantee, expressed or implied, that problems or deficiencies of the subject trees may not arise in the future.*

Yours sincerely

Andrew Scales
Dip. Horticulture
Dip. Arboriculture AQF5

APPENDIX 1

Brief qualifications and experience of Andrew Scales

1. Qualifications:

Associate Diploma Horticulture	Northern Sydney Institute of TAFE	1998
Certificate in Tree Surgery	Northern Sydney Institute of TAFE	1998
Diploma of Horticulture (Arboriculture)	Northern Sydney Institute of TAFE	2006
Diploma of Arboriculture AQF5	Northern Sydney Institute of TAFE	2019

2. Practical experience: Being involved in the arboricultural/horticultural industry for in excess of 20 years, I have developed skills and expertise recognized in the industry. Involvement in the construction industry and tertiary studies has provided me with a good knowledge of tree requirements within construction sites.

As director of Naturally Trees, in this year alone I have undertaken hundreds of arboricultural consultancy projects and have been engaged by a range of clients to undertake tree assessments. I have gained a wide range of practical tree knowledge through tree removal and pruning works.

3. Continuing professional development:

Visual Tree Assessment (Prof. Dr. Claus Mattheck)	Northern Sydney Institute of TAFE 2001
Wood Decay in Trees (F.W.M.R.Schwarze)	Northern Sydney Institute of TAFE 2004
Visual Tree Assessment (Prof. Dr. Claus Mattheck)	Carlton Hotel, Parramatta NSW 2004
Tree A-Z / Report Writing (Jeremy Barrell)	Northern Sydney Institute of TAFE 2006
Up by Roots – Healthy Soils and Trees in the Built Environment (James Urban)	The Sebel Parramatta NSW 2008
Tree Injection for Insect Control (Statement of Attainment)	Northern Sydney Institute of TAFE 2008
Quantified Tree Risk Assessment (QTRA) Registered Licensee #1655	South Western Sydney Institute TAFE 2011
Practitioners Guide to Visual Tree Assessment	South Western Sydney Institute TAFE 2011
Quantified Tree Risk Assessment (QTRA) Registered Licensee #1655	Richmond College NSW TAFE 2014
VALID Approach to Likelihood of Failure (David Evans)	Centennial Park NSW 2017

APPENDIX 2
Tree schedule

NOTE: Colour annotation is AA & A trees with green background; Z & ZZ trees with blue background; trees to be removed in red text.

No.	Genus species	Height	Spread	DBH	TPZ	Foliage %	Age class	Defects | Comment	Location	Services	Significance	Tree AZ
1	*Eucalyptus microcorys*	28	26	1100	**13.2**	80%	M	Nil	Grass	Nil	H	**AA1**
1a	*Eucalyptus sp.*	16	14	1000	**12.0**	0%	O	Dead tree	Grass	Nil	H	**ZZ4**
A	Stand of similar *Eucalyptus tereticornis*	14	9	350	**4.2**	80%	M	Stand of similar trees	Grass	Nil	H	**A1**

Explanatory Notes

- **Measurements/estimates:** All dimensions are estimates unless otherwise indicated. Measurements taken with a tape or clinometer are indicated with a '*'. Less reliable estimated dimensions are indicated with a '?'.
- **Species:** The species identification is based on visual observations and the botanical name. In some instances, it may be difficult to quickly and accurately identify a particular tree without further detailed investigations. Where there is some doubt of the precise species of tree, it is indicated with a '?' after the name in order to avoid delay in the production of the report. The botanical name is followed by the abbreviation sp if only the genus is known. The species listed for groups and hedges represent the main component and there may be other minor species not listed.
- **Tree number:** relates to the reference number used on site diagram/report.
- **Height:** Height is estimated to the nearest metre.
- **Spread:** The average crown spread is visually estimated to the nearest metre from the outermost tips of the live lateral branches.
- **DBH:** These figures relate to 1.4m above ground level and are recorded in millimetres. If appropriate, diameter is measured with a diameter tape. 'M' indicates trees or shrubs with multiple stems.
- **Foliage Cover:** Percent of estimated live foliage cover for particular species range.
- **Age class:**

Y	Young = recently planted
S	Semi-mature (<20% of life expectancy)
M	Mature (20-80% of life expectancy)
O	Over-mature (>80% of life expectancy)

- **TPZ:** The Tree Protection Zone (TPZ) is the radial offset distance of twelve times the trunk diameter in meters.
- **Tree AZ:** See reference for Tree AZ categories in Appendix 3.
- **Significance:** A tree's significance/value in the landscape takes into account its prominence from a wide range of perspectives. This includes, but is not limited to neighbour hood perspective, local perspective and site perspective. The significance of the subject trees has been categorized into three groups, such as: High, Moderate or Low significance.

APPENDIX 3

TreeAZ Categories (Version 10.04-ANZ)

Z Category Z: Unimportant trees not worthy of being a material constraint

Local policy exemptions: Trees that are unsuitable for legal protection for local policy reasons including size, proximity and species

Z1	Young or insignificant small trees, i.e. below the local size threshold for legal protection, etc
Z2	Too close to a building, i.e. exempt from legal protection because of proximity, etc
Z3	Species that cannot be protected for other reasons, i.e. scheduled noxious weeds, out of character in a setting of acknowledged importance, etc

High risk of death or failure: Trees that are likely to be removed within 10 years because of acute health issues or severe structural failure

Z4	Dead, dying, diseased or declining
Z5	Severe damage and/or structural defects where a high risk of failure cannot be satisfactorily reduced by reasonable remedial care, i.e. cavities, decay, included bark, wounds, excessive imbalance, overgrown and vulnerable to adverse weather conditions, etc
Z6	Instability, i.e. poor anchorage, increased exposure, etc

Excessive nuisance: Trees that are likely to be removed within 10 years because of unacceptable impact on people

Z7	Excessive, severe and intolerable inconvenience to the extent that a locally recognised court or tribunal would be likely to authorise removal, i.e. dominance, debris, interference, etc
Z8	Excessive, severe and intolerable damage to property to the extent that a locally recognised court or tribunal would be likely to authorise removal, i.e. severe structural damage to surfacing and buildings, etc

Good management: Trees that are likely to be removed within 10 years through responsible management of the tree population

Z9	Severe damage and/or structural defects where a high risk of failure can be temporarily reduced by reasonable remedial care, i.e. cavities, decay, included bark, wounds, excessive imbalance, vulnerable to adverse weather conditions, etc
Z10	Poor condition or location with a low potential for recovery or improvement, i.e. dominated by adjacent trees or buildings, poor architectural framework, etc
Z11	Removal would benefit better adjacent trees, i.e. relieve physical interference, suppression, etc
Z12	Unacceptably expensive to retain, i.e. severe defects requiring excessive levels of maintenance, etc

NOTE: Z trees with a high risk of death/failure (Z4, Z5 & Z6) or causing severe inconvenience (Z7 & Z8) at the time of assessment and need an urgent risk assessment can be designated as ZZ. ZZ trees are likely to be unsuitable for retention and at the bottom of the categorisation hierarchy. In contrast, although Z trees are not worthy of influencing new designs, urgent removal is not essential and they could be retained in the short term, if appropriate.

A Category A: Important trees suitable for retention for more than 10 years and worthy of being a material constraint

A1	No significant defects and could be retained with minimal remedial care
A2	Minor defects that could be addressed by remedial care and/or work to adjacent trees
A3	Special significance for historical, cultural, commemorative or rarity reasons that would warrant extraordinary efforts to retain for more than 10 years
A4	Trees that may be worthy of legal protection for ecological reasons (Advisory requiring specialist assessment)

NOTE: Category A1 trees that are already large and exceptional, or have the potential to become so with minimal maintenance, can be designated as AA at the discretion of the assessor. Although all A and AA trees are sufficiently important to be material constraints, AA trees are at the top of the categorisation hierarchy and should be given the most weight in any selection process.

TreeAZ is designed by Barrell Tree Consultancy (www.treeaz.com/tree_az/)

APPENDIX 4

Tree protection fencing and signs - Illustrative specification

Protective fencing: Protective 1.8m high fencing should be installed at the location illustrated on the Tree Management Plan before any site works start. All uprights should be fixed in position for the duration of the development activity. The fixings must be able to withstand the pressures of everyday site work.

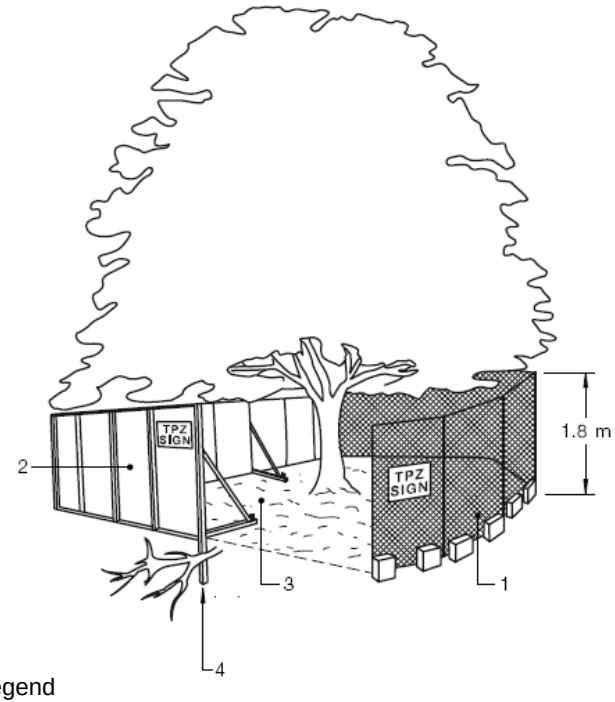
Inside the protective fencing, the following rules must be strictly observed:

- **No vehicular access without adequate ground protection**
- **No storage of excavated debris, building materials or fuels**
- **No excessive cultivation for landscape planting**
- **No fires**
- **No mixing of cement**
- **No service installation or excavation**

Once erected, protective fencing must not be removed or altered without consulting first with the project Arborist.

Shade cloth or similar should be attached to reduce the transport of dust, other particulate matter and liquids into the protected area and signage must be attached to outside of fencing.

Signage: All signs are to provide clear and readily accessible information to indicate that a TPZ has been established. Signage identifying the TPZ must be attached to outside of fencing and be visible from within the development site.



Signage example:

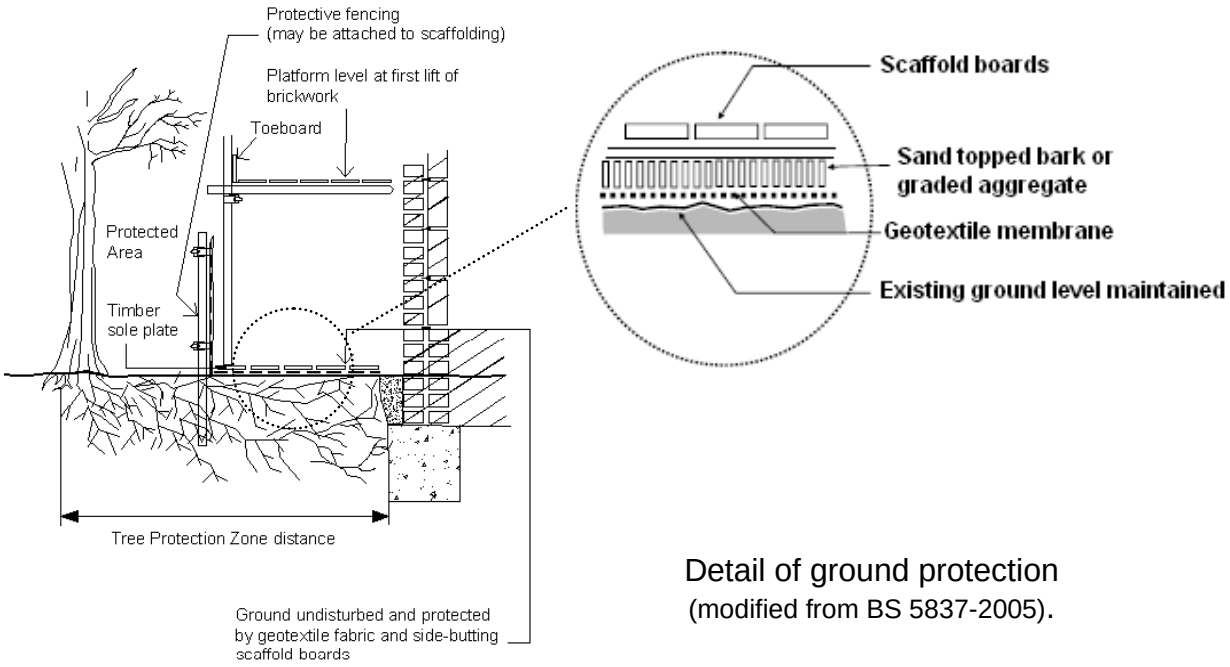
Legend

1. Chain wire mesh panels with shade cloth (if required) attached, held in place with concrete feet.
2. Alternative plywood or wooden paling fence panels. This fencing material also prevents building materials or soil entering the TPZ.
3. Mulch installation across surface of TPZ (at the discretion of the project arborist). No excavation, construction activity, grade changes, surface treatment or storage of materials of any kind is permitted within the TPZ.
4. Bracing is permissible within the TPZ. Installation of supports should avoid damaging roots.

APPENDIX 5

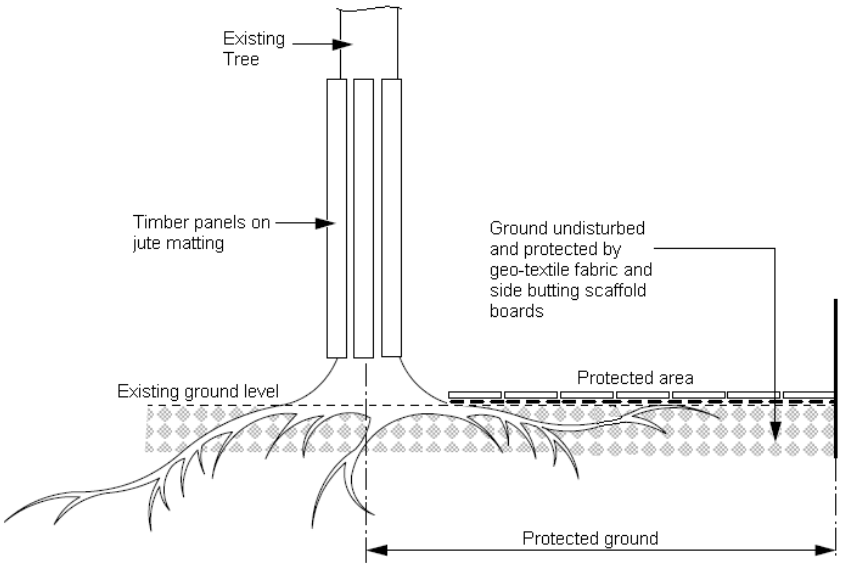
Root zone and trunk protection - Illustrative specification

Root zone protection: Where necessary, access through the TPZ can be achieved by laying aggregate and timber boards (or similar) over the root zone to protect roots. The ground beneath the boarding should be left undisturbed and should be protected with a porous geo-textile fabric covered with sand or mulch.



Detail of ground protection
(modified from BS 5837-2005).

Trunk protection: Where fencing cannot be installed, the vertical trunk of exposed trees shall be protected by the placement of 3.6m lengths of 50 x 100mm hardwood timbers, spaced vertically, at 150mm centres and secured by 2mm wire at 300mm wide spacing over suitable protective padding material e.g. Jute Matting. The trunk protection shall be maintained intact until the completion of all work on site.



Detail of trunk protection.

APPENDIX 6

General guidance for working in TPZ

1 PURPOSE OF THIS GUIDANCE

This guidance sets out the general principles that must be followed when working within a TPZ. Where more detail is required, it will be supplemented by illustrative specifications in other appendices in this document (refer Appendix 4 and 5).

This guidance is based on the Australian Standards (2009) AS4970: *Protection of Trees on Construction Sites*.

Once the site works start, this guidance is specifically for the site personnel to help them understand what has been agreed and explain what is required to fully meet their obligations to protect trees. All personnel working in TPZs must be properly briefed about their responsibilities towards important trees based on this guidance.

This guidance should always be read in conjunction with the Tree Management Plan (TMP01) illustrating the areas where specific precautions are necessary. Each area where precautions are required is explained on the plan as identified on the legend. All protective measures should be installed according to the prevailing site conditions and agreed as satisfactory by the Project Arborist before any demolition or construction work starts.

2 TREE PROTECTION

2.1 Tree Protection Zone (TPZ)

The TPZ is a radial setback, extending outwards from the centre of the trunk, where disturbance must be minimised if important trees are to be successfully retained. The TPZ area is illustrated on the Tree Management Plan (TMP01) accompanying this guidance.

- The TPZ is a radial setback extending outwards from the centre of the trunk equal to the DBH x 12.
- This area shall be protected by tree protective fencing (refer Appendix 4).
- Any part of the TPZ outside of the tree protective fencing area must be isolated from the work operations by protective barriers and/or root zone protection for the duration of the work (refer Appendix 5).
- The Project Arborist shall approve the extent of the TPZ prior to commencement of works.
- The TPZ shall be mulched to a depth of 90mm with approved organic mulch e.g. leaf and wood chip where possible.
- Supplementary watering shall be provided in dry periods to reduce water or construction stress, particularly to those trees which may incur minor root disturbance.

The following activities shall be excluded within the TPZ:

- Excavation, compaction or disturbance of the existing soil.
- The movement or storage of materials, waste or fill.
- Soil level changes
- Disposal/runoff of waste materials and chemicals including paint, solvents, cement slurry, fuel, oil and other toxic liquids
- Movement or storage of plant, machinery, equipment or vehicles.
- Any activity likely to damage the trunk, crown or root system.

2.2 Arboricultural supervision

Any work within TPZs requires a high level of care. Qualified arboricultural supervision is essential to minimise the risk of misunderstanding and misinterpretation. Site personnel must be properly briefed before any work starts. Ongoing work must be inspected regularly and, on completion, the work must be signed off by the Project Arborist to confirm compliance by the contractor.

2.3 Tree protection fencing, root zone and trunk protection

Prior to site establishment, tree protection fencing and root zone and trunk protection shall be installed to establish the TPZ for trees to be retained in accordance with site conditions. These protective barriers shall be maintained entire for the duration of the construction program (refer Appendix 4 and 5).

Tree protection fencing and trunk and root zone protection shall be removed following completion of construction. The mulch layer in the TPZ shall be retained and replenished where required to maintain a 75mm thickness

2.4 Pruning

All pruning work required (including root pruning) should be in accordance with Australian Standard No 4373-1996 - Pruning of Amenity Trees.

2.5 Tree Damage

In the event of damage to a tree or the TPZ, the Project Arborist shall be engaged to inspect and provide advice on remedial action. This should be implemented as soon as practicable and certified by the Project Arborist.

2.6 Post construction maintenance

In the event of any tree deteriorating in health after the construction period, the Project Arborist shall be engaged to provide advice on any remedial action. Remedial action shall be implemented as soon as practicable and certified by the Project Arborist.

3 EXCAVATION AND FILL IN TPZ

3.1 Excavation within TPZ

If excavation within the TPZ is required the following shall be applied to preserve tree root systems:

- Excavation within TPZ must be carried out under the instruction and supervision of the Project Arborist.
- A root mapping exercise is to be undertaken and certified by the Project Arborist. Root mapping shall be undertaken by either ground penetrating radar, air spade, water laser or by hand excavation using hand tools, taking care not to damage the bark and wood of any roots.
- The purpose of the root mapping shall be to locate woody structural roots greater than 40mm in diameter. Where possible, flexible clumps of smaller roots, including fibrous roots, should be retained if they can be displaced temporarily or permanently beyond the excavation without damage.
- If digging by hand, a fork shall be used to loosen the soil and help locate any substantial roots.
- Once roots have been located, the trowel shall be used to clear the soil away from them without damaging the bark.
- Exposed roots to be removed shall be cut cleanly with a sharp saw or secateurs.
- Roots temporarily exposed shall be protected from direct sunlight, drying out and extremes of temperature by appropriate covering.

3.2 Fill within TPZ

Placement of fill material within the Tree Protection Zone of trees to be retained should be avoided where possible. However, where fill cannot be avoided:

- All fill material to be placed within the TPZ should be approved by Project Arborist and consist of a course, gap-graded material to provide aeration and percolation to the root zone. Materials containing a high percentage of ‘fines’ is unacceptable for this purpose.
- The fill material should be consolidated with a non-vibrating roller to minimise compaction of the underlying soil.
- No fill material should be placed in direct contact with the trunk.

4 DEMOLITION OF SURFACING/STRUCTURES IN TPZ

4.1 Definitions of surfacing and structures

For the purposes of this guidance, the following broad definitions apply:

• **Surfacing:** Any hard surfacing used as a vehicular road, parking or pedestrian path including tarmac, solid stone, crushed stone, compacted aggregate, concrete and timber decking.

• **Structures:** Any man-made structure above or below ground including service pipes, walls, gate piers, buildings and foundations. Typically, this would include drainage structures, services, car-ports, bin stores and concrete slabs that support buildings.

4.2 Demolition and access

Roots frequently grow adjacent to and beneath existing surfacing/structures so great care is needed during access and demolition. Damage can occur through physical disturbance of roots and/or the compaction of soil around them from the weight of machinery or repeated pedestrian passage. This is not generally a problem whilst surfacing/structures are in place because they spread the load on the soil beneath and further protective measures are not normally necessary. However, once they are removed and the soil below is newly exposed, damage to roots becomes an issue and the following guidance must be implemented:

- No vehicular or repeated pedestrian access into TPZ permitted unless on existing hard surfacing or root zone protection.
- Regular vehicular and pedestrian access routes must be protected from compaction with temporary root zone protection as set out in Appendix 5.
- Where a TPZ is exposed by the work, it must be protected as set out in AS4970 until there is no risk of damage from the development activity.

4.3 Removal of surfacing/structures

Removing existing surfacing/structures is a high-risk activity for any adjacent roots and the following guidance must be observed:

- Appropriate tools for manually removing debris may include a pneumatic breaker, crow bar, sledgehammer, pick, mattock, shovel, spade, trowel, fork and wheelbarrow.
- Machines with a long reach may be used if they can work from outside the TPZ or from protected areas within the TPZ.
- Debris to be removed from the TPZ manually must be moved across existing hard surfacing or temporary root zone protection in a way that prevents compaction of soil. Alternatively, it can be lifted out by machines provided this does not disturb the TPZ.
- Great care must be taken throughout these operations not to damage roots.

5 INSTALLATION OF SURFACING/STRUCTURES IN TPZ

5.1 **Basic principles:** New surfacing/structures in a TPZ are potentially damaging to trees because they may disturb the soil and disrupt the existing exchange of water and gases in and out of it. Adverse impact on trees can be reduced by minimising the extent of these changes within the TPZ.

- **Surfacing:** Suitable surfacing should be relatively permeable to allow water and gas movement, load spreading to avoid localised compaction and require little or no excavation to limit direct damage. The actual specification of the surfacing is an engineering issue that needs to be considered in the context of the bearing capacity of the soil, the intended loading and the frequency of loading. The detail of product and specification are beyond the scope of this guidance and must be provided separately by the appropriate specialist.

- **Structures:** Where possible structures are to be constructed above ground level on piled supports and redirecting water to where it is needed. The detailed design and specification of such structures is an engineering issue that should be informed and guided by the Project Arborist. Conventional strip foundations in the TPZ for any significant structure may cause excessive root loss and are unlikely to be acceptable. However, disturbance can be significantly reduced by supporting the above ground part of the structures on small diameter piles/piers or

cast floor slabs set above ground level. The design should be sufficiently flexible to allow the piles to be moved if significant roots are encountered in the preferred locations.

5.2 Establishing the depth of roots

The precise location and depth of roots within the soil is unpredictable and will only be known when careful digging starts on site. Ideally, all new surfacing within a TPZ should be no-dig, i.e. requiring no excavation whatsoever, but this is rarely possible on undulating surfaces.

New surfacing normally requires an evenly graded sub-base layer, which can be made up to any high points with granular, permeable fills such as crushed stone or sharp sand. This sub-base must not be compacted as would happen in conventional surface installation. Some limited excavation is usually necessary to achieve this and need not be damaging to trees if carried out carefully and large roots are not cut.

Tree roots and grass roots rarely occupy the same soil volume at the top of the soil profile, so the removal of a turf layer up to 50mm is unlikely to be damaging to trees. It may be possible to dig to a greater depth depending on local conditions but this would need to be assessed by the Project Arborist.

6 SERVICES IN TPZ

For the purposes of this guidance, services are considered as structures. Excavation to upgrade existing services or to install new services within a TPZ may damage retained trees and should only be chosen as a last resort. In the event that excavation emerges as the preferred option, the decision should be reviewed by the Project Arborist before any work is carried out. If excavation is agreed, all digging should be done carefully and follow the guidance set out in 3.1 above.

7 SOFT LANDSCAPING IN TPZ

For the purposes of this guidance, soft landscaping includes the re-profiling of existing soil levels and covering the soil surface with new plants or an organic covering (mulch). It does not include the installation of solid structures or compacted surfacing.

Soft landscaping activity after construction can be extremely damaging to trees.

No significant excavation or cultivation shall occur within the TPZ (e.g. planting holes). Where new designs require levels to be increased to tie in with new structures or surrounding ground level, good quality and relatively permeable top soil should be used for the fill. It should be firmed into place but not over compacted in preparation for turfing or careful shrub planting.

All areas close to tree trunks should be kept at the original ground level and have a mulched finish rather than grass to reduce the risk of mowing damage.

APPENDIX 7

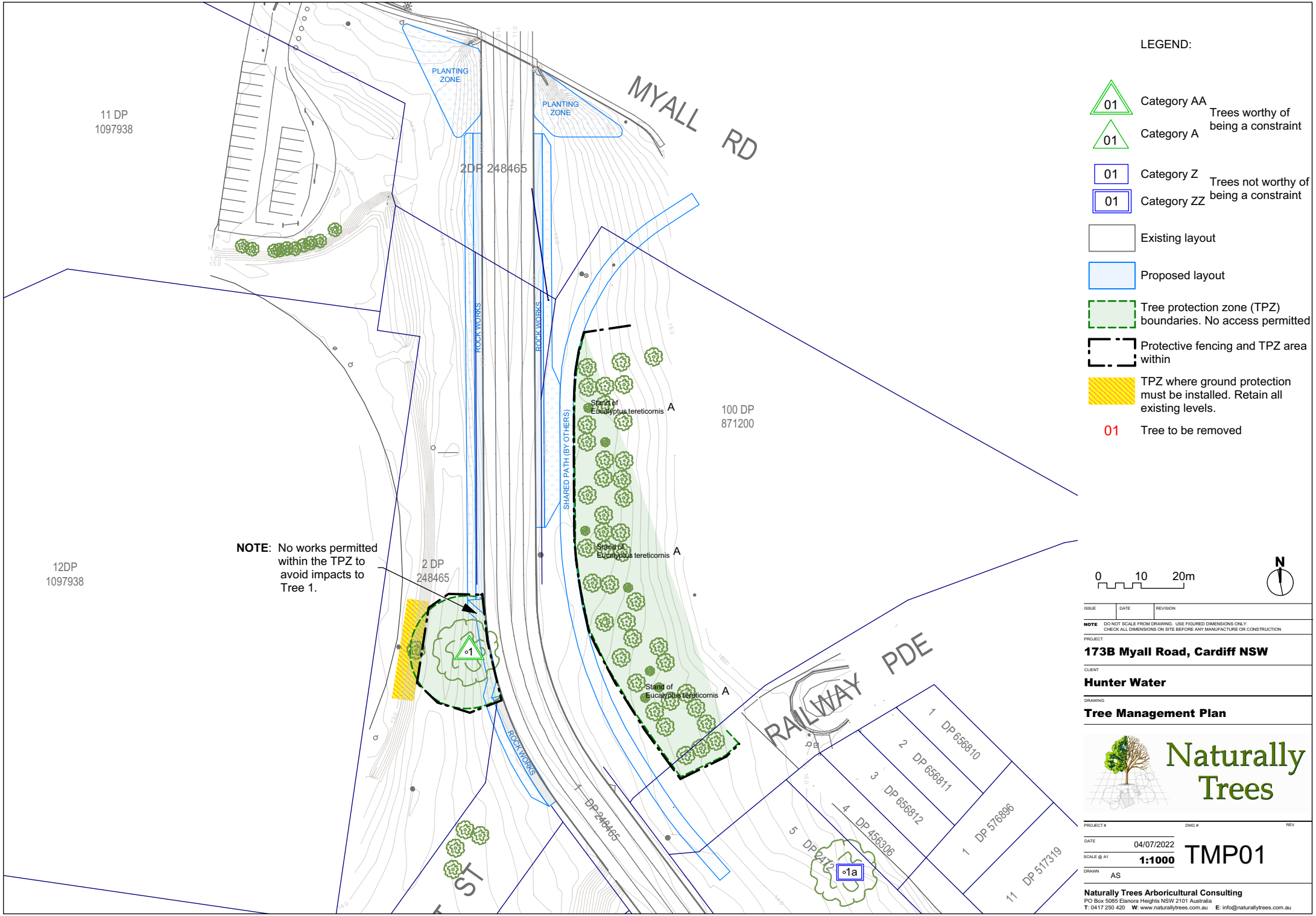
Schedule of works and responsibilities

Hold Point	Task	Responsibility	Certification	Timing of Inspection
1	Indicate clearly (with spray paint) trees approved for removal only	Principal Contractor	Project Arborist	Prior to demolition and site establishment
2	Establishment of tree protection fencing and additional root, trunk and/or branch protection	Principal Contractor	Project Arborist	Prior to demolition and site establishment
3	Supervise all excavations works proposed within the TPZ	Principal Contractor	Project Arborist	As required prior to the works proceeding adjacent to the tree
4	Inspection of trees by Project Arborist	Principal Contractor	Project Arborist	As required during construction period
5	Final inspection of trees by Project Arborist	Principal Contractor	Project Arborist	Completion of works

APPENDIX 8

Tree management plan

-refer attached Tree Management Plan, Dwg No. TMP01,
by Naturally Trees dated 4 July 2022



ISSUE	DATE	REVISION

NOTE DO NOT SCALE FROM DRAWING. USE FIGURED DIMENSIONS ONLY. CHECK ALL DIMENSIONS ON SITE BEFORE ANY MANUFACTURE OR CONSTRUCTION

PROJECT
173B Myall Road, Cardiff NSW

CLIENT
Hunter Water

DRAWING
Tree Management Plan

Naturally Trees

PROJECT #	DWG #	REV
DATE	04/07/2022	
SCALE @ A1	1:1000	TMP01
DRAWN	AS	

Naturally Trees Arboricultural Consulting
PO Box 5085 Elanora Heights NSW 2101 Australia
T: 0417 250 420 W: www.naturallytrees.com.au E: info@naturallytrees.com.au

APPENDIX H

Noise and Vibration Impact Assessment

RENZO TONIN & ASSOCIATES
inspired to achieve

Acoustics
Vibration
Structural Dynamics

STORMWATER AMENITY IMPROVEMENT: WINDING CREEK, CARDIFF

Construction Noise and Vibration Impact Assessment

29 July 2022

Aurecon

TM711-01F03 (r8) Cardiff REF Construction.docx

35 1982-2017 ACOUSTIC ENGINEERING EXCELLENCE

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aaac Association of Australian Acoustical Consultants

Document details

Detail	Reference
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Prepared for:	Aurecon
Address:	Level 5, 116 Military Road, Neutral Bay, Sydney Australia 2089
Attention:	Katie Schultz

Document control

Date	Revision history	Non-issued revision	Issued revision	Prepared	Instructed	Authorised
20.05.2022	Draft	0-2	3	R.Phillips	R.Phillips	A.Leslie
24.05.2022	Draft # 2	-	4	R.Phillips	R.Phillips	A.Leslie
03.06.2022	Final. Update for client comments	-	5	R.Phillps	R.Phillips	A.Leslie
05.07.2022	Final	6	7	R.Phillps	R.Phillips	A.Leslie
29.07.2022	Final. Update figure	-	8	R.Phillps	R.Phillips	A.Leslie

Executive summary

Renzo Tonin & Associates has been engaged Aurecon to undertake a noise and vibration impact assessment as part of the Review of Environmental Factors (REF) for the Hunter Water Stormwater Amenity Improvement Works at Winding Creek, Cardiff. The Proposal involves stormwater channel amenity works, including channel wall naturalisation and planting works.

The assessment considers the following impacts on nearby sensitive receivers:

- Construction noise impacts from the works in accordance with the *Interim Construction Noise Guideline* (Department of Environment and Climate Change, 2009).
- Construction vibration impacts from the works in accordance with *Assessing Vibration: A technical guideline* (Department of Environment and Conservation, 2009) for human disturbance and relevant standards for structural damage from vibration.

Construction noise

The construction noise assessment found that nearby residential and other sensitive receivers that are located near works will be noise affected during the construction works.

During standard hours construction, exceedances of the noise management levels (NMLs) are predicted throughout the study area. Construction noise at nearby residential receivers is predicted to be more than 10 dB(A) above the NML, which is considered moderately intrusive, however no receivers are predicted to be highly noise affected.

Mitigation measures have been provided to reduce and manage noise levels and are to be reviewed and adopted where feasible and reasonable during construction.

Construction vibration

A review of potential construction vibration impact impacts to nearby receivers has been completed. Potential vibration impacts have been assessed against the relevant guidelines for structural damage from vibration and for human disturbance.

There are no reinforced or unreinforced non-heritage structures within the minimum working distance for cosmetic damage.

The Former Colliery Tramway is located approximately 12 metres from the southern extent of works which is beyond the minimum working distance of 10 metres for sensitive structures. To prevent any vibration generating plant and equipment operating within the minimum working distance, a 10 metre exclusion zone would be established surrounding the Former Colliery Tramway and demarcated with flagging and a sign to ensure no vibratory plant would be operated within this zone.

There are no receivers predicted to be within the minimum working distances for human comfort.

Contents

List of tables

1 Introduction

1.1 Proposal scope

Renzo Tonin & Associates has been engaged by Aurecon to undertake a noise and vibration impact assessment as part of the Review of Environmental Factors (REF) for the Hunter Water Stormwater Amenity Improvement Works at Winding Creek, Cardiff (the Proposal).

The Proposal would involve approximately 200 metres of amenity works (naturalisation of the creek). The works would include 180 metres of channel work and 20 metres planting along the Winding Creek stormwater channel within Wilkinson Park in Cardiff. The amenity works includes replacing the concrete channel banks with natural (rock rip rap and native plants) materials on either side of the channel and planting adjacent to Myall Road.

1.2 Proposal construction activities

The key construction activities and associated works of the Proposal are summarised in Table 1-1 blow.

Table 1-1: Construction activities and associated works

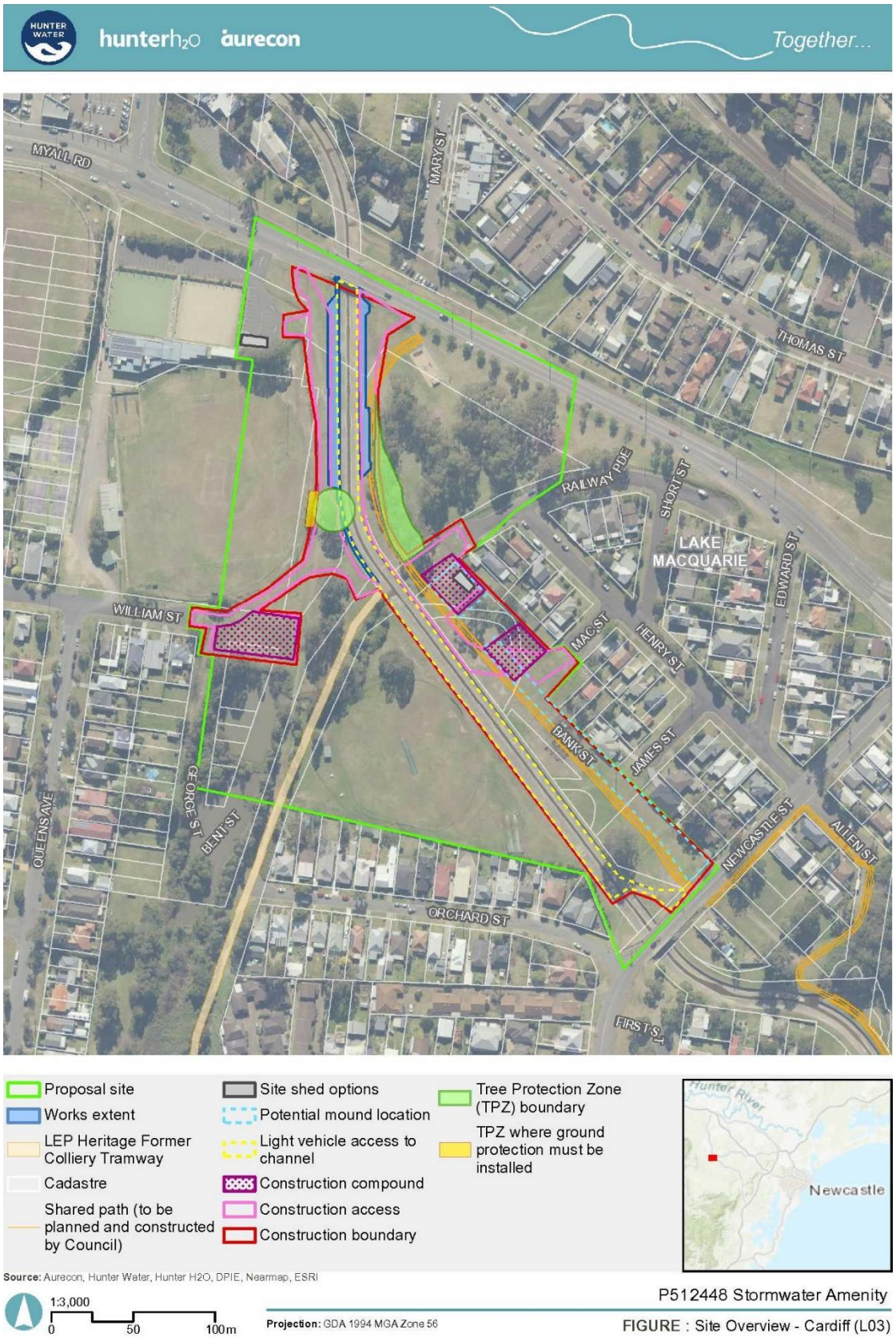
Construction activity	Description
Site establishment	• placing temporary fencing and signage to designate site access and construction zones • setting up security measures • establishing ancillary facility including site amenities and site sheds, laydown and stockpiling areas
Environmental controls	• install temporary flow diversion in channel base e.g. sandbags and/ or barriers on a section by section basis • install temporary erosion and sediment controls • place spill kits
Investigations	• pre-construction asset inspections
Removal of shared pathway	• temporarily remove a section of the shared pathway which would be installed by Council prior to construction
Materials delivery	• deliver fill materials to laydown areas
Structural works – Stage 1 (removing concrete channel)	• channel structural works would be completed in sections. This phasing of structural works would ensure protection of the Proposal site during stormwater flow events in the channel • excavator to remove turf and topsoil within and move to stockpile • sawcut channel wall and undertake bank works within the Proposal site • excavate channel wall below base of channel (refer detailed design in Appendix A) and temporarily stockpile spoil for disposal • batter slopes to be shaped at a 1V:2H to facilitate placement of fill and rock revetment (rip-rap) • demolishing existing drainage outlet headwall
Dewatering	• dewater groundwater or surface water within excavations using portable pumps as required and appropriate disposal
Waste disposal	• Dispose construction waste including spoil to a licensed waste facility

Construction activity	Description
Structural works – Stage 2 (asset protection/restoration and transition wall works)	• Construct transition retaining walls (sandstone blocks) grouted to existing bank wall • reconstruct drainage outlet headwall from sandstone and backfill with stabilised sand • concrete encase sewer on eastern bank if required
Structural works – Stage 3 (bank protection works)	• place select fill and rock revetment (rip-rap) • place planting material in planting areas • place erosion control matting (thick jute mat) and plant native plants (refer to species list in design drawings, Appendix A) • install permanent fence along edge of works at interface with council shared pathway
Site restoration	• reinstate council shared pathway • final landscaping/rehabilitation • remove temporary environmental controls • remove construction compounds such as construction fencing and signage, waste bins and waste materials

Construction of the Proposal is scheduled to occur between November 2022 and be completed by June 2024.

The Proposal site overview is shown in Figure 1-1 below.

Figure 1-1: Proposal site overview



1.3 Report objectives

The noise and vibration impact assessment objectives are to:

- Identify existing noise conditions and relevant noise and vibration objectives
- Assess potential construction noise and vibration impacts
- Recommend feasible and reasonable mitigation and management measures to limit the noise and vibration impacts of the construction works.

1.4 Relevant policies and guidelines and assessment aspect

This assessment considers policies, guidelines and standards presented in Table 1-2.

Table 1-2: Construction noise and vibration policies, guidelines and standards

Guideline/policy document	Assessment aspect
Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)	Airborne noise and ground-borne noise impacts (including construction traffic within the construction support site boundary)
Assessing Vibration: a technical guideline (Department of Environment and Climate Change, 2006)	Vibration amenity
British Standard BS 7385: Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration (BSI, 1993)*	Vibration impacts to structures impacts
German Standard DIN 4150-3 (2016) *Structural vibration – Effects of vibration on structures (Deutsches Institut für Normung, 2016)*	Vibration impacts to structures impacts
*NSW Road Noise Policy (*Department of Environment, Climate Change and Water, *2011)*	Construction road traffic noise impacts (on public roads)
Noise Policy for Industry (Environment Protection Authority, 2017)	Establishing the existing noise environment

1.5 Acoustic concepts, terminology & quality

This report is technical in nature and uses acoustic terminology throughout. A summary and explanation of the common acoustic terms that has been used in this report is presented in Section A.1.

Some of the key acoustic concepts used in this report are outlined in Section A.2.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

2 Existing noise environment

2.1 Noise and vibration-sensitive receivers

A desktop land use survey was carried out to identify the receiver types and uses of buildings around the Proposal that could potentially be impacted by noise or vibration from the Proposal. During construction planning, further review of potentially impacted noise-sensitive receivers should be undertaken to confirm that impacts are mitigated and managed appropriately.

The noise and vibration-sensitive receivers are generally separated into the following major categories, with further details of the breakdowns of categories and noise and vibration objectives presented in Section 3:

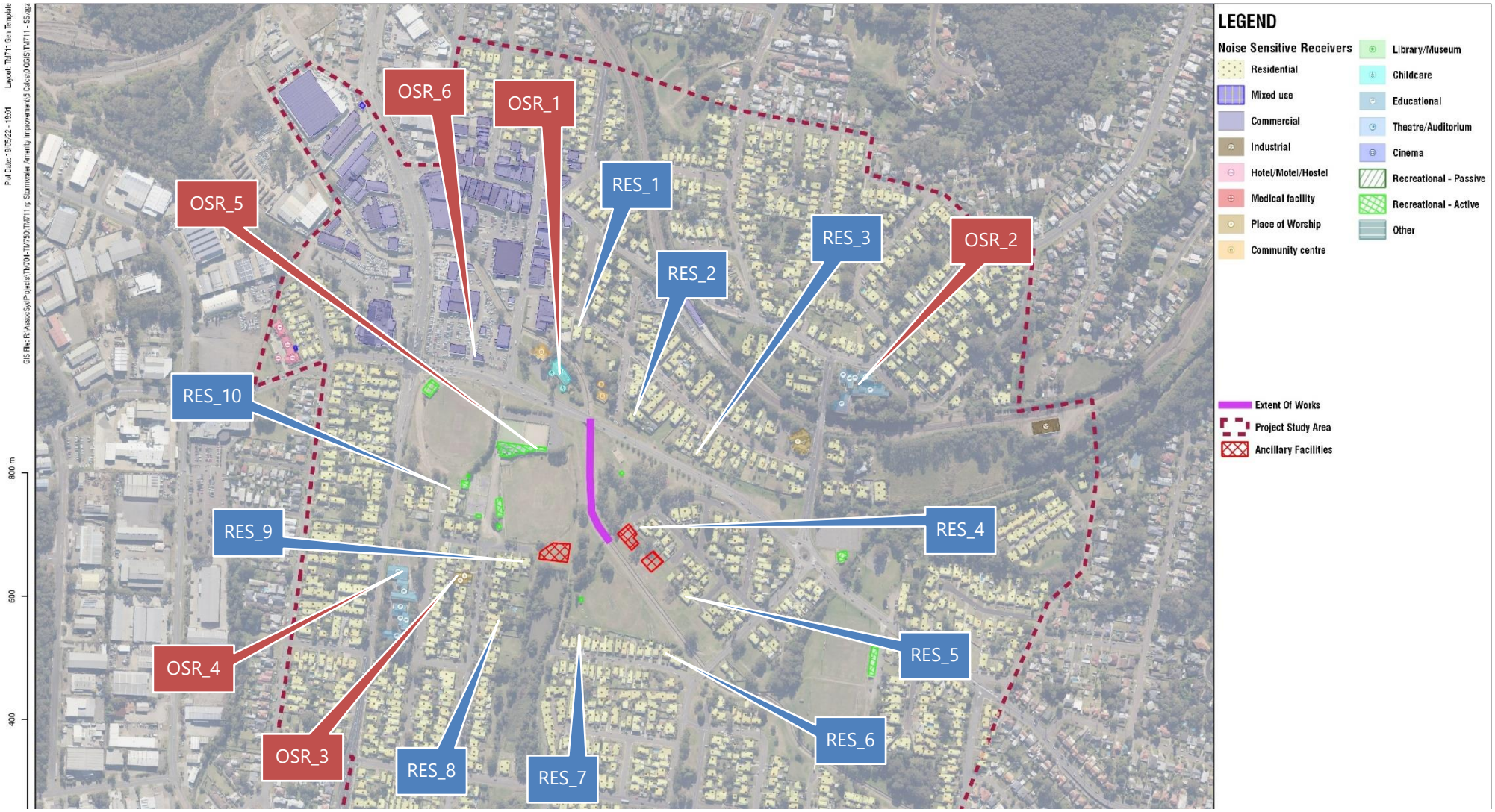
- Residential receivers (including mixed use buildings and aged care facilities) [RES]
- Other noise and vibration-sensitive receivers [OSR], including:
    - Classrooms at schools and other educational institutions
    - Hospital wards and operating theatres
    - Places of worship
    - Childcare centres
    - Active recreation areas (eg. sports fields/activities which generate their own noise and are generally less sensitive to external noise)
    - Passive recreation areas (eg. areas used for low intensity and low noise producing activities which have the potential to be impacted by external noise such as reading or meditation)
    - Community centres
    - Special noise and/or vibration-sensitive receivers (eg. laboratories, recording studios)
- Commercial premises (including offices and retail outlets) [OSR]
- Industrial premises [OSR].

All assessed noise and vibration-sensitive receiver types for the Proposal are shown in APPENDIX B. A number of the nearest representative noise sensitive receivers surrounding the Proposal have been identified for the purposes of reporting noise levels at nearby noise sensitive receivers. These selected receivers are detailed in Table 2-1 and identified in Figure 2-1 below.

Table 2-1: Nearest and representative noise sensitive receivers

Receiver ID	Receiver type	Description	Address/location	Approximate closest distance to the Proposal, (m)
RES_1	Residential	Residence	40 Thomas Street, Cardiff	140
RES_2	Residential	Residence	14 Mary Street, Cardiff	60
RES_3	Residential	Residence	16 Thomas Street, Cardiff	175
RES_4	Residential	Residence	28 Railway Parade, Cardiff	60
RES_5	Residential	Residence	3 James Street, Cardiff	100
RES_6	Residential	Residence	3 Orchard Street, Cardiff South	210
RES_7	Residential	Residence	25 Orchard Street, Cardiff South	170
RES_8	Residential	Residence	12 Queens Avenue, Cardiff	220
RES_9	Residential	Residence	2 William Street, Cardiff	120
RES_10	Residential	Residence	4 Russell Street, Cardiff	210
OSR_1	Child-care centre	Harrison Street Early Education	54 Harrison Street, Cardiff	75
OSR_2	Education facility	St Kevin's Primary School	228 Main Road, Cardiff	400
OSR_3	Place of worship	Hunter Presbyterian Church	3 Queens Avenue, Cardiff	210
OSR_4	Educational facility	Cardiff Public School	64 Macquarie Road, Cardiff	310
OSR_5	Active recreation	Cardiff Bowling Club	175 Myall Road, Cardiff	60
OSR_6	Commercial	Kia Motors	54 Macquarie Road, Cardiff	200

Figure 2-1: Nearby sensitive receivers to proposal



2.2 Noise monitoring

Background noise varies over the course of any 24 hour period, typically from a minimum at 3:00 am in the morning, to a maximum during morning and afternoon traffic peak hours. Therefore, the *Noise Policy for Industry* (NPfI) (EPA, 2017), referenced by the ICNG for determining the Rating Background Level (RBL), requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods. The NPfI defines these periods as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays
- **Night** is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

2.3 Existing background noise levels

Long term unattended noise monitoring was conducted for a continuous period from 26 April to 6 May 2022, to measure ambient and background noise levels in the vicinity of residential receivers around the proposed works. Calibration of the noise monitors was conducted before and after the monitoring period, with no significant calibration drift observed. The unattended noise monitoring location [M1] and observed noise environment are summarised in Table 2-2 below and shown on the map in APPENDIX B. The existing measured background and ambient noise levels are presented in Table 2-3.

The noise monitoring methodology is provided in APPENDIX C. A summary of the unattended noise monitoring results along with a graphical recorded output from the long-term noise monitoring are included in APPENDIX D. The graphs in APPENDIX D were analysed in accordance with the procedure outlined in the NPfI to determine an Assessment Background Level (ABL) for each day, evening and night period in each 24-hour period of noise monitoring. Based on the median of individual ABLs an overall single Rating Background Level (RBL) for the day, evening and night period is determined over the entire monitoring period in accordance with the NPfI.

Table 2-2: Unattended noise monitoring location

Noise logger #	Location	Observed noise environment
M1	28 Railway Parade, Cardiff	Ambient noise environment had contribution from noise natural environment (bird noise etc.) in addition to distant traffic noise. Background noise levels had contribution from distant traffic noise from surrounding roads

Table 2-3: Measured existing ambient and background noise levels, dB(A)

Noise logger #	Location	Rating background noise levels (RBL), L_{A90}			Ambient noise levels, L_{Aeq}		
		Day	Evening	Night	Day	Evening	Night
M1	28 Railway Parade, Cardiff	43	39	32	50	46	46

3 Noise and vibration criteria

3.1 Construction noise criteria

3.1.1 Noise metrics

For the assessment of construction noise, which is typically temporary in nature and highly variable, the EPA's Interim Construction Noise Guideline (ICNG) uses three noise metrics to determine the potential construction noise impact.

L_{Aeq} - To protect against long-term repeated noise exposure, the indicator for assessing the cumulative noise exposure level over a specific time interval is the equivalent sound pressure level, denoted as L_{Aeq}. The L_{Aeq} indicator accounts for the total energy content from all sources of sound under consideration. The fact that the L_{Aeq} is a cumulative measure means that louder activities have greater influence of the L_{Aeq} level than do quieter ones, and activities that last longer in time have greater L_{Aeq} than do shorter ones. An increase in the number of events also increases the L_{Aeq}. Further, people react to the duration of noise events, judging longer events to be more annoying than shorter ones, assuming equal maximum noise levels.

L_{Amax} - It is important to note that even though L_{Aeq} levels are numerically lower than maximum noise levels (denoted as L_{Amax}). None of the noise is ignored, just as all the rain that falls in the rain gauge in one hour counts toward the total. In the case of noisy but short-lived maximum noise events, which can sometime result in immediate short-term awakening reaction, potential impact is assessed using the LAmax indicator in which its emergence above the background noise environment is evaluated.

L_{A90} - The L_{A90} is the level of noise that is present almost constantly, or for 90 percent of the time and is commonly referred to as the background noise. Typical examples of what types of noise may contribute to the background noise levels are continuously flowing traffic or air conditioner noise.

3.1.2 Noise management levels (NMLs)

The *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) provides guidelines for assessing noise generated during the construction phase of developments. There are two methods described for the assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria. A qualitative assessment is recommended for small projects with duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the scale of the construction works proposed, a quantitative assessment is carried out herein, consistent with the ICNG.

Table 3-1 reproduced from the ICNG, sets out the airborne noise management levels and how they are to be applied for residential receivers.

Table 3-1: Noise management levels at residential receivers

Time of day	Management level $L_{Aeq\ (15\ min)}$ *	How to apply
Recommended standard hours: Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before/ after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see *ICNG* section 7.2.2.

* Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metre above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 3-2 sets out the ICNG noise management levels for other noise sensitive receiver locations.

Where premises are noise-sensitive and cannot be suitably classified by the categories in this table, it is recommended that the recommended 'maximum' internal noise levels presented in AS/NZS 2107:2016 are adopted.

Table 3-2: Noise management levels at other noise sensitive land uses, dB(A)

Land use	Time of day	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Childcare centre[2]	When in use	Outdoor noise level	50[2]
Classrooms at schools and other educational institutions	When in use	Indoor noise level Outdoor noise level[1]	45 55
Hospital wards and operating theatres	When in use	Indoor noise level Outdoor noise level[1]	45 55

Land use	Time of day	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Places of worship	When in use	Indoor noise level	45
		Outdoor noise level[1]	55
Hotel/Motel/Hostel	When in use	Indoor noise level	40
		Outdoor noise level [5]	60
Community centres	When in use	Indoor noise level	40[6]
		Outdoor noise level [6]	60[6]
Active recreation areas [4]	When in use	Outdoor noise level	65
Passive recreation areas [3]	When in use	Outdoor noise level	60
Commercial premises	When in use	Outdoor noise level	70
Industrial premises	When in use	Outdoor noise level	75

Notes:
1. Outdoor noise level based on internal noise level in ICNG and assumes 10 dB loss through an open window
2. An external screening level of 50 dB(A) is adopted for assessing childcare centres, based upon the recommended noise levels in the Association of Australian Acoustical Consultants (AAAC) Guideline for Child Care Centre Acoustics Assessment (2013). This considers the centre has sleeping areas.
3. Passive recreation - Areas used for low intensity and low noise producing activities which could be impacted by external noise such as reading or meditation
4. Active recreation - Sports fields/activities which generate their own noise and are generally less sensitive to external noise
5. Based upon AS2107 (Sleeping areas: Hotels near major roads), and 20 dB(A) outside to inside difference (closed windows)
6. Community centres have been assessed to an external noise level of 60 dB(A). Depending on the intended use of the centre, the noise management level may vary.

3.1.3 Summary of construction noise management levels

Table 3-2 presents the construction noise management levels established for the nearest noise sensitive residential receivers based upon the noise monitoring outlined in Section 2.

Table 3-3: Construction noise management levels at residential receivers, dB(A)

Rating background level (RBL)	Noise management level $L_{Aeq(15min)}$
Day	**Day (Standard) [1]**
43	53

Notes:
1. Standard construction hours, as defined in Section 4.1.

Works outside standard construction hours are not proposed for the Proposal and have therefore not been addressed in this report. Should any works be proposed to be required outside of standard hours, they will require strong justification as per the ICNG. Where clear justification is provided, an assessment of potential impacts would be undertaken against suitable noise management levels considering the RBL values presented in Section 2.3 along with the feasible and reasonable mitigation and management measures.

3.2 Construction-related road traffic noise

When trucks and other vehicles are operating within the boundary of a construction site, road vehicle noise contributions are included in the overall predicted $L_{Aeq(15minute)}$ construction site noise emissions. When construction-related traffic moves onto the public road network a different noise assessment

methodology is appropriate, as vehicle movements would be regarded as 'additional road traffic' rather than as part of the construction site.

Construction-related traffic operating on the public road network, especially heavy vehicle movements travelling on roads located immediately adjacent to construction sites are likely to be associated to the Proposal by the community. However, once the heavy vehicles move further from the Proposal site onto major sub-arterial or arterial roads, the noise may be perceived as being part of the general road traffic.

Noise from construction traffic on public roads is not assessed under the ICNG, although the guideline does reference the *Environmental Criteria for Road Traffic Noise* (EPA 1999), which has been superseded by the RNP. The RNP states that in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person. For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments (in this case the construction area), any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario.

Where the road traffic noise levels are predicted to increase by more than 2 dB as a result of construction traffic, consideration would be given to applying feasible and reasonable noise mitigation measures to reduce the potential noise impacts and preserve acoustic amenity.

In considering feasible and reasonable mitigation measures where the relevant noise increase is greater than 2 dB, consideration should be given to the actual noise levels associated with construction traffic and whether these levels comply with the road traffic noise criteria in the RNP presented in Table 3-4.

Table 3-4: Construction-related road traffic noise assessment criteria

Road type	Day criteria (7am – 10pm)	Night criteria (10pm – 7am)
Freeway/ arterial/ sub-arterial roads	60 $L_{Aeq\ 15\ hour}$	55 $L_{Aeq\ 9\ hour}$
Local roads	55 $L_{Aeq\ 1\ hour}$	50 $L_{Aeq\ 1\ hour}$

3.3 Construction vibration criteria

Construction vibration is associated with three main types of impact:

- disturbance to building occupants
- potential damage to buildings
- potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to the buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The International System of Units (SI unit) for distance is the metre (m), although common industrial standards include mm.
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is metres per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.
- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is metres per second squared (m/s^2). Construction vibration goals are summarised below.

Construction vibration goals are summarised below.

3.3.1 Disturbance to buildings occupants

The acceptable vibration values to assess the potential for human annoyance from vibration are set out in the *Environmental Noise Management Assessing Vibration: A Technical Guideline* (AVTG) (DEC, 2006). To assess the potential for vibration impact on human comfort, an initial screening test will be done based on peak velocity units, as this metric is also used for the cosmetic damage vibration assessment. The screening test is based on the continuous vibration velocity (i.e. vibration that continues uninterrupted for a defined period). If the predicted vibration exceeds the initial screening test, the total estimated Vibration Dose Value (i.e. eVDV) will be determined based on the level and duration of the vibration event causing exceedance.

The initial screening test values and VDVs recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected are presented in Table 3-5. The 'Low probability of adverse comment eVDV' represent the preferred and maximum value presented in the AVTG.

Table 3-5: Vibration management levels for disturbance to building occupants

Place and Time	Initial screening test Velocity, PEAK, mm/s (>8Hz)	Low probability of adverse comment eVDV $m/s^{1.75}$	Adverse comment possible eVDV $m/s^{1.75}$	Adverse comment probable eVDV $m/s^{1.75}$
Critical areas (day or night)[1]	0.28	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Residential buildings 16 hr day[2]	0.56	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night[2]	0.40	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Offices, schools, educational institutions and places of worship (day or night)	1.10	0.4 to 0.8	0.8 to 1.6	1.6 to 2.4
Workshops (day or night)	2.20	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

1. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above
2. Daytime is 7:00 am to 10:00 pm and night-time is 10:00 pm to 7:00 am

3.3.2 Damage to buildings or structures

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard *BS 7385 Part 2 – 1993 Evaluation and measurement for vibration in buildings* and German Standard *DIN 4150-3: 2016 Structural Vibration – Part 3: Effects of vibration on structures*. There is no Australian Standard for assessment of structural building damage caused by vibration energy.

It is noted that vibration levels required to cause minor cosmetic damage are typically 10 x higher than levels that will cause disturbance to building occupants. Many building occupants assume that building damage is occurring when they feel vibration or observe rattling of loose objects, however, the level of vibration at which people perceive vibration or at which loose objects may rattle is far lower than vibration levels that can cause damage to structures.

Within British Standard 7385 Part 1, different levels of structural damage are defined:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 are for the protection against cosmetic damage, however guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

> *7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.*

Within DIN4150-3, damage is defined as "*any permanent consequence of an action that reduces the serviceability of a structure or one of its components"* (p.4). The Standard also outlines:

"For buildings as in lines 2 and 3 of Tables 1, 4 or B.1, the serviceability is considered to have been reduced if, for example

- *cracks form in plastered or rendered surfaces of walls;*
- *existing cracks in a structure are enlarged;*
- *partitions become detached from load-bearing walls or floor slabs.*

These effects are deemed 'minor damage. " (DIN4150.3:2016, p.6)

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

3.3.2.1 British Standard

British Standard 7385: Part 2 '*Evaluation and measurement of vibration in buildings*', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types.

BS 7385 sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in BS7385 relate to transient vibrations which does not give rise to resonant responses in structures and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 3.6 may need to be reduced by up to 50%.

BS7385 goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 3.6 and major damage to a building structure may occur at values greater than four (4) times the tabulated values.

Fatigue considerations are also addressed in BS7385 and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 3.6 should not be reduced for fatigue considerations. It is noteworthy that, extra to the guide values nominated in Table 3.6, the standard states that:
"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."

Table 3.6: BS 7385 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50

Notes: Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

Notes:

1. Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.
2. PPV values increase between specified frequencies as detailed in BS7385-2
3. Values referred to are at the base of the building, as per Section 6.3 of BS7385-2

3.3.2.2 German Standard

German Standard DIN 4150 - Part 3 (2016) '*Vibration in buildings - Effects on Structures*' (DIN 4150-3:2016), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3:2016 presents the recommended maximum limits over a range of frequencies (Hz), measured at the foundations, in the plane of the uppermost floor of a building or structure or vertically on floor slabs. The vibration limits at the foundations increase as the frequency content of the vibration increases. The criteria are presented in Table 3.7.

Table 3.7: DIN 4150-3:2016 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s				
		At foundation in all directions at frequency of			Plane of floor uppermost storey in horizontal direction	Floor slabs, vertical direction
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that because of their particular sensitivity to vibration, cannot be classified under Groups 1 and 2 and are of great intrinsic value (eg listed buildings)	3	3 to 8	8 to 10	8	20

3.3.3 Heritage structures and items

Heritage items are considered on a case by case basis, and care should be taken as these structures can be difficult to repair in the case of damage. It should be noted that British Standard BS 5228-2:2009 states that *'a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*' (p.39) when compared to other structures.

As part of the identification of noise and vibration sensitive receivers discussed in Section 2.1, potentially impacted heritage receivers should be identified nearby to the construction works areas.

Where a structure is found to have defects, or is structurally unsound following an inspection, maximum vibration criteria are to be established for that specific structure for works to not further damage the structure. As stated previously, German Standard DIN 4150: Part 3 provides guidance for structures that are sensitive to vibration (eg. structurally unsound).

A conservative vibration damage screening level of 2.5 mm/s has been adopted as a screening level for heritage structures. This does not necessarily reflect that there would be a vibration impact on the structure if this level is exceeded, instead it is a suitable vibration level that is used as part of the construction vibration management process to trigger further investigation.

If a heritage building or structure is found to be structurally unsound (following inspection), the conservative cosmetic damage objective of 2.5 mm/s peak component particle velocity (from DIN 4150) would be considered, and appropriate protections put in place.

The general approach to manage potential vibration impacts on heritage items would be to:

1. Identify heritage items where the 2.5 mm/s peak component particle velocity objective may be exceeded during specific construction activities
2. Carry out a structural engineering report on identified heritage items, to confirm structural integrity of the building and confirm if item is 'structurally sound'
3. Adopt the appropriate screening level from BS7385 Part 2 if the item was confirmed as 'structurally sound', or
4. Adopt the more conservative cosmetic damage level of 2.5 mm/s (long-term impacts) or 3 mm/s (short term impacts, with additional consideration for frequency as outlined in DIN 4150-3: 2016) peak component particle velocity if the item was confirmed as 'structurally unsound'.

3.3.4 General vibration (building damage) screening criterion

In accordance with *BS 7385-2 and DIN 4150-3*, a conservative vibration damage screening level (peak component particle velocity) per receiver type is outlined below:

- reinforced or framed structures: 25.0 mm/s
- unreinforced or light framed structures: 7.5 mm/s
- heritage structures (structurally unsound): 2.5 mm/s.

Where the predicted and/or measured vibration is greater than shown above, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure will be completed to determine the applicable vibration limit.

3.3.5 Damage to vibration sensitive equipment

Some high technology manufacturing facilities, hospitals and laboratories utilise equipment that is highly sensitive and susceptible to vibration, for example scanning electron microscopes and micro-electronic manufacturing facilities. In addition, buildings housing sensitive computer or telecommunications equipment may require assessment against stricter criteria than those nominated for building damage.

There is no explicit guidance on acceptable vibration levels for such equipment, so recommended vibration levels should be obtained from instrument manufacturers. In the absence of equipment specific data provided by manufacturers, there are generic vibration criteria that can be used to assess the impact of vibration generating activities on buildings housing vibration sensitive equipment. For example, the Vibration Criteria (VC) curves are often referred to as they are generic and apply to all tools/ equipment types within each category. The VC curves are defined over the frequency range 8 to 100 Hz.

Table 3-8 below summarises a range of suitable and conservatively stringent vibration limits that are applicable to buildings housing vibration sensitive equipment which may potentially be affected by construction vibration.

Table 3-8: Acceptable vibration limits for vibration measured on building structure housing sensitive equipment

Equipment Requirements	Vibration Limit[1] mm/s,		Description of Use[3]
	RMS[4]	Peak [5]	
Computer Areas[2]	0.7	1.0	Barely perceptible vibration. Adequate for computer equipment accommodation environments.
Medical[2, 3]	0.1	0.14	Vibration not perceptible. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A[3]	0.05	0.07	Vibration not perceptible. Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc

Notes: 1. As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz. Vibration measured on the building structure near vibrating equipment or in areas containing sensitive equipment.

2. Based on AS 2834 Computer Accommodation

3. Gordon CG Generic Vibration Criteria for Vibration Sensitive Equipment

4. Root Mean Square value representing the average value of a signal

5. In the absence of Peak limits, RMS limits are converted to Peak by conservatively assuming the vibration signal is sinusoidal and random with a nominal crest factor of 1.414

3.3.6 Damage to buried services

Section 5.3 of DIN 4150-3: 2016 also sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values, which apply at the wall of the pipe, are reproduced and presented in Table 3-9 below. For long-term vibration the guideline levels presented in Table 3-9 should be halved.

Table 3-9: DIN 4150-3: 2016 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

Line	Pipe Material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Vitrified clay, concrete, reinforced concrete, prestressed concrete, metal (with or without flange)	80
3	Masonry, plastics	50

For continuous vibration the guideline levels presented in Table 3-9 should be halved.

Recommended vibration goals for electrical cables and telecommunication services such as fibre optic cables range from between 50 mm/s and 100 mm/s. It is noted however that although the cables may sustain these vibration levels, the services they are connected to, such as transformers and switch blocks, may not. It is recommended that should such equipment be encountered during the construction process an individual vibration assessment should be carried out. This may include a

specific vibration assessment addressing impact on the utility and consultation with the utility provider to confirm specific vibration requirements.

4 Construction noise and vibration assessment

4.1 Construction hours

4.1.1 Standard construction hours

The recommended standard hours for construction are defined in the ICNG. Whilst the standard construction hours are not mandatory, limiting construction works to within standard construction hours as much as practicable assists in managing noise or vibration impact and provides a lengthy respite period whilst people are most likely to be relaxing or sleeping.

4.1.2 Works outside standard construction hours

The ICNG identifies five categories of works that might be undertaken outside the recommended standard hours (OOH):

1. the **delivery of oversized plant or structures** that police or other authorities determine require special arrangements to transport along public roads
2. **emergency work** to avoid the loss of life or damage to property, or to prevent environmental harm
3. **maintenance and repair of public infrastructure** where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
4. **public infrastructure works** that shorten the length of the project and are supported by the affected community
5. works where a proponent demonstrates and justifies a **need to operate outside the recommended standard hours**.

There are no OOH works proposed for the Proposal.

4.1.3 Summary of construction hours

Construction works for the Proposal are proposed to take place during the ICNG standard construction hours, which are:

- 7:00am to 6:00pm Monday to Friday
- 8:00am to 1:00pm on Saturday
- No work performed on Sunday and Public Holidays

4.2 Construction noise and vibration activities and assumptions

4.2.1 Construction activities and noise sources

Table 4-1 following summarises the likely plant and equipment and the assumed sound power levels for construction activities associated with the Proposal. The scenarios are based upon the activities provided in Table 1-1. The sound power levels for the majority of activities presented in Table 4-1 are based on maximum levels given in Table A1 of Australian Standard 2436 - 2010 '*Guide to Noise Control on Construction, Demolition and Maintenance Sites*', ICNG, information from past projects and information held in the Renzo Tonin & Associates library files.

Table 4-1: Noise modelling assumptions for construction - activities and equipment

Scenario	Plant / Equipment	Operating weight kg	Assumed no. units	Sound Power Level (Lw re: 1pW), dB(A) L_{Aeq}
S1 Site establishment & environmental controls	Franna/ mobile crane		1	99
	Trucks		4 per hour	106
	Hand tools including hammer or core drills		1	107
	Assumed combined activity noise level			**108**
S2 Ancillary facilities Including waste disposal	Franna crane	20 tonne	1	99
	Trucks		4 per hour	106
	Wheel loader		1	110
	Generator		1	94
	Assumed combined activity noise level			**110**
S3 Investigations	Franna crane	20 tonne	1	99
	Tracked excavator w bucket	19 tonne	1	103
	Hand tools including hammer or core drills		1	107
	Assumed combined activity noise level			**108**
S4 Removal of shared path	Tracked excavator w bucket	19 tonne	1	107
	Concrete saw		1	119
	Tracked excavator w hydraulic hammer	19 tonne	1	119
	Trucks		4 per hour	106
	Hand tools including hammer or core drills		1	107
	Assumed combined activity noise level		**1**	**119**
S5 Structural works – Stage 1 (removing concrete channel)	Tracked excavator w bucket	19 tonne	1	107
	Concrete saw		1	119
	Tracked excavator w hydraulic hammer	19 tonne	1	119
	Franna/ mobile crane	20 tonne	1	99
	Trucks		4 per hour	106
	Hand tools including hammer or core drills		1	107
	Assumed combined activity noise level			**119**

Scenario	Plant / Equipment	Operating weight kg	Assumed no. units	Sound Power Level (Lw re: 1pW), dB(A) L_{Aeq}
S6 Dewatering	Pump		1	90
S7 Structural works – Stage 2 (asset protection/restoration and transition wall works)	Tracked excavator w bucket	19 tonne	1	107
	Franna/ mobile crane	20 tonne	1	99
	Hand tools including hammer or core drills		1	107
	Concrete truck		1	108
	Concrete pump		1	103
	Assumed combined activity noise level			**112**
S8 Structural works – Stage 3 (bank protection works)	Tracked excavator w bucket	19 tonne	1	107
	Franna/ mobile crane		1	99
	Assumed combined activity noise level			**108**
S9 Reinstatement of shared pathway	Hand tools		1	107
	Concrete truck		1	108
	Concrete pump		1	103
	Assumed combined activity noise level			**110**
S10 Site restoration	Hand tools		1	107
	Tracked excavator w bucket	19 tonne	1	107
	Franna/ mobile crane	20 tonne	1	99
	Trucks		4 per hour	106
	Assumed combined activity noise level			**110**

Notes

1. Number of units operating at any one time may change on site. Assumptions in table are for modelling purposes, based on a conservative, but realistic estimate of the likely number of units operating concurrently for each activity.
2. Assumed activity noise level in brackets () includes all noise sources for that activity, including high noise impact sources in brackets. Assumed activity noise level outside brackets assumes high noise impact sources in brackets is not operating.

4.3 Construction airborne noise assessment

Construction noise levels were predicted by modelling the noise sources, receiver locations, and operating activities across the construction scenarios based on the information presented in Section 4.2.1**.**

4.3.1 Noise prediction methodology

A noise model was developed for the Proposal using the CadnaA computer modelling program and noise levels were predicted using the noise propagation algorithm ISO 9613-2 (1996), which incorporates moderately adverse meteorological conditions, implemented in accordance with ISO/TR 17534-3 (2015).

The noise prediction model considers:

- Location of noise sources and sensitive receiver building locations
- Height of sources and receivers referenced to digital ground contours for the site and surrounding area
- Sound Power Levels (SWL) of plant and equipment likely to be used during the various construction activities
- Each noise-sensitive building in the Proposal has been assessed separately, considering all facades
- Separation distances between sources and receivers
- Acoustic shielding, potential reflections and attenuation from intervening structures, barriers and topography (natural and purpose built)
- Ground absorption between the source and receiver, typically assuming 0.5.

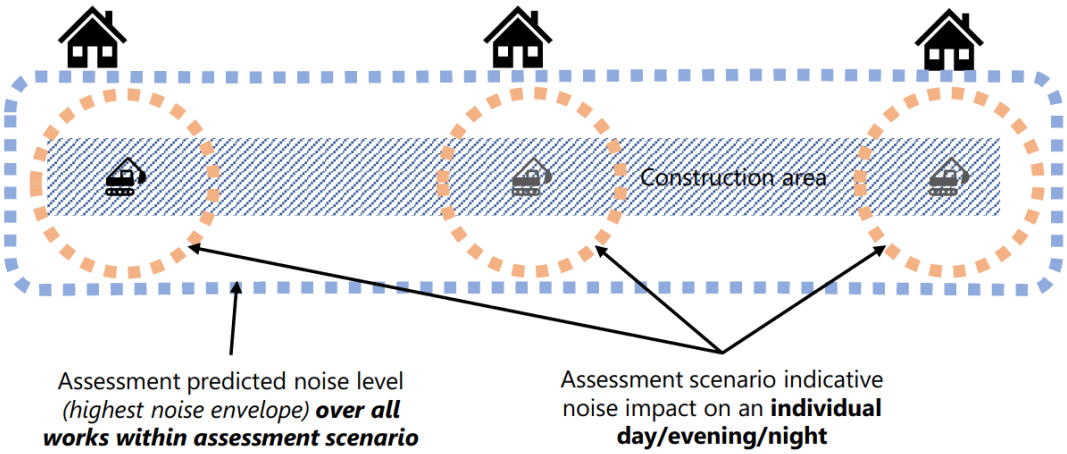
Construction noise levels are assessed at the most noise affected facade and floor level of a receiver building. Construction noise levels experienced at other points on the building may be lower.

The predicted levels are conservative and represent the equipment/plant operating simultaneously in any 15 minute period. Where plant items are not operating simultaneously, or for reduced times in a 15 minute period, noise impacts could be lower than predicted.

A 5 dB(A) penalty in accordance with the ICNG has been factored into the noise modelling levels where applicable to allow for particularly annoying activities, such as rock hammering, saw cutting and jack hammering.

Additionally, these noise levels assume that the assessed activities could occur anywhere within the assessed construction works area, with the predicted level based upon when works are at the closest point to each receiver. While in practice, noise intensive construction works would occur at different locations throughout the work area, resulting in differing noise levels at each receiver. This means that predicted noise levels are only likely to occur when works are at the closest point to each receiver. The noise impacts may be lower than predicted as the construction activities move around or progress around the construction site. This concept is demonstrated in Figure 4-1, and should be considered when reviewing the predicted noise levels in this assessment.

Figure 4-1: Predicted level are based works at the closest point of the entire works area



The worst affected receivers are typically the receivers with direct line-of-sight to the construction work area. Receivers located without direct line-of-sight to the construction area would typically be exposed to construction noise levels 5 to 10 dB(A) lower than the levels predicted for the worst affected receivers.

Section 4.3.2 presents the predicted noise levels each of the representative receiver locations for the various assessment scenarios for each stage of the Proposal. In addition, a summary of all assessed receivers is provided based on the level of predicted impact as shown in Table 4-2 below.

APPENDIX E presents receiver noise impact maps, which provide the predicted construction noise level compared with the Proposal NML (see Table 3-2 and Table 3-3) for all receivers within the study area. These maps are to give receivers an indication of the likely noise impact from the different stages of construction. Both APPENDIX E and the following sections colour code the predicted impact based upon Table 4-2so that the amount the predicted noise level is over the NML can be reviewed.

Table 4-2: Key to the predicted construction noise results tables

Assessment	Time of day	Key		
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue) Clearly audible	11-20 dB(A) over NML (mid blue) Moderately intrusive	>20 dB(A) above NML (dark blue) Highly intrusive

Notes: 1. Highly noise affected (HNA) which is greater than 75 dB(A) is shown with **Bold** text and applies to residential receiver buildings only during standard construction hours.

4.3.2 Construction noise results

4.3.2.1 Representative receivers

The following tables provide the predicted construction noise levels at representative residential and other sensitive receivers (including commercial) within the study area. The predicted noise levels are colour coded based upon the level of exceedance of the NML as detailed in Table 4-2.

Table 4-3: Predicted construction noise levels at representative residential receivers – Standard construction hours

Representative receiver (Figure 2-1)	NML (day)	Predicted noise level for each scenario, LAeq, 15min, dB(A)									
		S1	S2	S3*	S4*	S5*	S6	S7*	S8*	S9*	S10*
RES_01	53	54	48	54	60	65	36	58	54	51	56
RES_02	53	59	53	59	66	70	41	63	59	57	61
RES_03	53	52	53	53	63	63	34	56	53	54	54
RES_04	53	69	71	71	71	72	43	71	71	71	71
RES_05	53	57	59	59	61	64	35	59	59	59	59
RES_06	53	53	55	55	58	61	<30	55	55	55	55
RES_07	53	54	56	56	61	63	34	56	56	56	56
RES_08	53	54	56	56	60	61	<30	56	56	56	56
RES_09	53	66	68	68	68	68	37	68	68	68	68
RES_10	53	52	54	54	61	61	<30	54	54	54	54

Notes: * Includes construction noise from ancillary facilities

Highly noise affected (HNA) which is greater than 75 dB(A) is shown with **Bold** text and applies to residential receiver buildings.

Table 4-4: Predicted construction noise levels at representative other sensitive receivers

Representative receiver (Figure 2-1)	NML	Predicted noise level for each scenario, LAeq, 15min, dB(A)									
		S1	S2	S3*	S4*	S5*	S6*	S7*	S8*	S9*	S10*
OSR_01	50	54	49	54	58	65	36	58	54	49	56
OSR_02	53	45	45	45	55	56	<30	49	45	46	47
OSR_03	55	54	56	56	60	61	<30	56	56	56	56
OSR_04	55	48	50	50	57	58	<30	51	50	50	50
OSR_05	65	60	54	60	67	71	42	64	60	58	62
OSR_06	70	50	47	50	59	61	<30	54	50	50	52

Notes:

* Includes construction noise from ancillary facilities

4.3.2.2 Summary of results

The following tables provide a summary of all assessed residential and other sensitive receivers (including commercial and industrial) within the study area. The level of exceedance is based upon the ranges shown in Table 4-2.

Table 4-5: Number of residential receivers over the noise management levels

Construction scenario		Day (standard hours) $L_{Aeq, 15minute}$			
		Highly noise affected > 75 dB(A)	1 - 10 dB(A) above NML	11 - 20 dB(A) above NML	> 20 dB(A) above NML
S1	Site establishment & environmental controls	-	55	6	-
S2	Ancillary facilities	-	59	11	-
S3	Investigations	-	76	11	-
S4	Removal of shared path and waste disposal	-	275	21	-
S5	Structural works – Stage 1	-	344	46	-
S6	Dewatering	-	-	-	-
S7	Structural works – Stage 2	-	120	11	-
S8	Structural works – Stage 3	-	76	11	-
S9	Reinstatement of shared pathway	-	71	11	-
S10	Site restoration	-	98	11	-

Table 4-6: Number of other sensitive receivers (including commercial and industrial) over the noise management levels

Construction scenario Assessment reference		1 - 10 dB(A) above NML	11 - 20 dB(A) above NML	> 20 dB(A) above NML
S1	Site establishment & environmental controls	1		
S2	Ancillary facilities	1		
S3	Investigations	2		
S4	Removal of shared path and waste disposal	13[2]		
S5	Structural works – Stage 1	18[2]	2	
S6	Dewatering			
S7	Structural works – Stage 2	4		
S8	Structural works – Stage 3	2		
S9	Reinstatement of shared pathway	2		
S10	Site restoration	4		

Notes

1. Other sensitive receivers including commercial, industrial have been assessed against the respective NMLs
2. This includes multiple buildings from Cardiff Public School

4.3.3 Discussion of results

4.3.3.1 Residential receivers

During standard construction hours, the assessment found that a number of residential receivers located near to the construction work area have the potential to be noise affected (ie. > NML) by the works during various louder construction stages. During most activities, nearby residences are predicted to be between 10 dB(A) to 20 dB(A) above the NML, which is considered to be moderately intrusive. There are no residential receivers predicted to be highly noise affected (ie. > 75 dB(A)) across all works.

Impacts would be greatest during periods of where high noise generating plant and equipment such as concrete saws and excavators with hydraulic hammers are used. This would occur during the removal of shared path activity, and the stage 1 structural works when removing concrete channel, which represent a short duration of the overall proposed works.

All three ancillary facilities are located close to residential receivers. Noise impacts to these residences would be highest during deliveries and when storing materials and equipment in the laydown areas. The noise impacts are based upon heavy machinery operating, which would not occur all the time and would only be as required, and restricted to standard construction hours. During periods when these machines are not operating, construction noise levels would be expected to be lower. Laydown areas and other fixed location noise generating equipment should be located as far as practicable from residences near to the compound. In addition, site sheds and structures should be positioned to provide acoustic shielding to the residences where possible.

All assessed residences within the study area for each construction activity are shown on the noise maps in APPENDIX E.

In light of the predicted noise levels, it is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce noise levels as much as possible to mitigate the impact from construction noise. Further details on feasible and reasonable construction noise mitigation and management measures to reduce noise impacts are detailed in Section 4.6.

4.3.3.2 Non-residential receivers

The predicted noise levels at the nearest non-residential receivers are generally predicted to be not more than 10 dB(A) above the NMLs. Up to 20 non-residential receivers are predicted to be impacted (ie. > NML) by the works, this includes 18 receiver buildings up to 10 dB(A) above the NML and two receivers between 11 dB(A) to 20 dB(A) above the NML during noise intensive Stage 1 Structural works.

The most impacted receivers would be the surrounding active recreation receivers such as the Cardiff Bowling Club which is approximately 60 metres from the proposal with an exceedance of up to 6 dB(A). Other impacted non-residential receivers include the Harrison Street Early Education childcare facility across Myall Road where works are occurring towards the northern extent of the Proposal. The childcare is located approximately 75 metres from the proposal with a predicted exceedance of up to 15 dB(A). In

addition, Cardiff Public School is located approximately 310 metres the south-west of the Proposal with an exceedance of up to 2 dB(A).

Feasible and reasonable mitigation and management measures to reduce noise impacts are detailed in Section 4.6.

4.4 Construction-related road traffic

The proposed construction packages does not include a large number of associated heavy vehicle movements. During the Proposal the following construction-related road traffic activities are expected:

- During peak periods, the highest levels of traffic generated during construction works is expected to be three heavy vehicles per hour (i.e. six vehicle movements) during the day period.

Construction vehicles are required to access the site via the following roads which are shown on the map on Figure 1-1:

- Western access via William Street
- Eastern access via Railway Parade
- Alternate eastern access via Mac Street

All of the above listed roads are local roads with low existing traffic volumes. As the site cannot be accessed via a more direct route from a major road such as Myall Road, there is not alternative to the proposed local road access points.

It is estimated that up to four heavy vehicle movements (i.e. two movement each way) along each of the proposed eastern and western access routes would comply with the local road daytime criteria of 55 dB(A) $L_{Aeq,1hr}$.

Recommendations have been provided in Section 4.6 to minimise impacts from construction related road traffic noise.

4.5 Construction vibration assessment

The pattern of vibration radiation is very different to the pattern of airborne noise radiation and is very site specific as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver. Accordingly, based on a database containing vibration measurements from past projects and library information, Table 4-7 and Table 4-8 below presents the recommended minimum working distances for vibration intensive plant.

Table 4-7: Minimum working distances (m) for cosmetic damage (continuous vibration)

Plant item	Minimum working distance (m)		
	Reinforced or framed structures (e.g. commercial buildings)[1]	Unreinforced or light framed structures (e.g. residential buildings)[1]	Sensitive structures (e.g. heritage structures)[2]
Concrete saw	5	5	5
Place compactor/Wacker packer	5	5	5
Small percussive drill	5	5	5
10-20t excavator with hydraulic hammer attachment	5	5	10

Notes 1) Initial screening test criteria reduced by 50% due to potential dynamic magnification in accordance with BS7385.
2) A site inspection should determine whether a heritage structure is structurally unsound.
3) Minimum working distances are in 5m increments only to account for the intrinsic uncertainty of this screening method.

Table 4-8: Minimum working distances (m) for human annoyance (continuous vibration)

Plant item	Minimum working distances (m)				
	Critical areas 0.28 mm/s	Residences		Offices 1.1 mm/s	Workshops 2.2 mm/s
		Day 0.56mm/s	Night 0.40 mm/s		
Concrete saw	15	10	10	5	5
Place compactor/Wacker packer	20	10	15	5	5
Small percussive drill	20	10	15	5	5
10-20t excavator with hydraulic hammer attachment	30	20	25	15	10

Vibration intensive works are not expected to be associated with the ancillary facilities.

4.5.1 Cosmetic damage

4.5.1.1 Reinforced and unreinforced structures

The identified minimum working distance for an excavator with excavator with hydraulic hammer attachment for both reinforced and unreinforced structures is five metres. The nearest building is the Cardiff Scout Hall which is approximately 45 metres to the north of the works.

Given the above, there are no reinforced or unreinforced structures within the minimum working distance identified Table 4-7 above. The minimum working distances for cosmetic damage surrounding the works are shown on the map in APPENDIX F.

4.5.1.2 Heritage structures

The Former Colliery Tramway is located approximately 12 metres from the southern extent of works. This would potentially be within the minimum working distance for an excavator with rock breaker attachment, which is 10 metres. The minimum working distance is based on the vibration damage

screening level of 2.5 mm/s for heritage structures which assumes that the heritage items is structurally unsound.

To prevent any vibration generating plant and equipment operating within the minimum working distance, a 10 metre exclusion zone would be established surrounding the Former Colliery Tramway and demarcated with flagging and a sign to ensure no vibratory plant would be operated within this zone.

4.5.2 Human response

The minimum working distance for residences during the day is 20 metres for an excavator with hydraulic hammer attachment. The nearest residences are 14 Mary Street to the north-east of the Proposal extent, and 28 Railway Parade to the east. Both of these residences are approximately 60 metres from the proposed works.

Given the above, there are no receivers within the minimum working distances for human comfort. The minimum working distances for human comfort are shown on the map in APPENDIX F.

As all nearby receivers are predicted to comply with the relevant vibration criteria for cosmetic damage and human annoyance, vibration impacts have not been considered any further in this assessment.

4.6 Construction mitigation and management measures

Based upon the assessment results, a number of the construction works scenarios are predicted to exceed the noise and vibration management levels. As such, all feasible and reasonable measures should be investigated to minimise the noise impacts on nearby sensitive receivers.

This section sets out the noise and vibration management measures to be considered and implemented if feasible and reasonable. These should be considered and implemented where feasible and reasonable where there is potential for the noise management levels presented in Section 3.1 to be exceeded by the construction works either individually or cumulatively.

4.6.1 Noise control measures

Table 4-9 summarises actions that can be applied to manage the potential for noise to impact on sensitive receivers near the Proposal construction works, which are to be applied where reasonable and feasible.

Table 4-9: Noise mitigation and management measures

Action required	Applies to	Details	Estimated noise benefit
At-source mitigation measures			
Equipment selection	Airborne noise Vibration	Use quieter and less noise/vibration emitting construction methods where feasible and reasonable. Where loud plant and/or equipment are being used in construction works, where feasible and reasonable the selection of alternative quieter plant and/or equipment should be considered for tasks.	Variable. Minimise noise impact and reduce risk of annoyance.
Rental plant and equipment	Airborne noise	The noise levels of plant and equipment items are to be considered in rental decisions, with quieter and less noise/vibration emitting construction methods where feasible and reasonable.	Variable. Minimise noise impact and reduce risk of annoyance.
Use and siting of plant	Airborne noise Vibration	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. - The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. - Plant used intermittently to be throttled down or shut down. - Noise-emitting plant to be directed away from sensitive receivers.	Up to 20 dB reduction + reduce vibration
Non-tonal and ambient sensitive reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.	5-10 dB reduction
Minimise disturbance arising from delivery of goods	Airborne noise	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers if possible. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.	Variable. Reduce noise/ vibration impact + risk of annoyance.
Silencers on mobile plant	Airborne noise	Where possible reduce noise from mobile plant through additional fittings including: - Residential grade mufflers - Air Parking brake engagement is silenced. Ensure plant including the silencer is well maintained.	0-20 dB reduction Reduce annoyance + sleep disturbance.
Prefabrication of materials off-site	Airborne noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.	5-20 dB reduction Reduce noise/ vibration impact + risk of annoyance
Engine compression brakes	Airborne noise	Limit the use of engine compression brakes in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.	5-20 dB reduction

Action required	Applies to	Details	Estimated noise benefit
Path mitigation measures			
Construction hoarding as noise barrier	Airborne noise	Any construction hoarding installed on each worksite shall be constructed as a noise barrier, where practicable to screen the work areas from commuters using the station platforms during construction works, and to provide shielding to the nearest affected receivers.	Receiver **with** line of site of the works area: 5-10 dB reduction Receiver **without** line of site of the works area: 0-5 dB reduction
Site sheds	Airborne noise	Site sheds to be located within the ancillary facilities to provide shielding to nearby residences.	Receiver **with** line of site of the ancillary facility works area: 5-10 dB reduction
Laydown and stockpiling	Airborne noise	Locate laydown and stock piling as far from residences within the construction works areas.	Variable. Minimise noise impact and reduce risk of annoyance.
Management measures			
Construction Environmental Management Plan update	Airborne noise	The Construction Environmental Management Plan (CEMP) including at minimum relevant section for construction noise and vibration management must be prepared prior to the commencement of construction and regularly updated to account for changes in noise management issues and strategies.	-
Implement stakeholder consultation measures	Airborne noise	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted to notify the community of upcoming works: • Project Specific Website • Project Infoline • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings. Additionally, it is recommended that as nearby potentially impacted schools may be noise affected, consultation be undertaken in order to assist with minimising scheduling high noise generating construction activities during sensitive periods for these receiver buildings (ie. exam periods) where feasible and reasonable.	Keeps stakeholders informed of the likely impact. Community may identify solution to assist in managing impacts.
Register of noise and vibration sensitive receivers	Airborne noise	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number. The register may be included as part of the Project's Community Liaison Plan or similar document.	Assists with keeping stakeholders informed of the likely impact. Assists with planning and reducing potential noise/ vibration impact + risk of annoyance

Action required	Applies to	Details	Estimated noise benefit
Site inductions	Airborne noise	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Permissible hours of work • Any limitations on noise generating activities with special audible characteristics • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.	Keeps construction workforce informed of actions required to minimise noise and vibration impact.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors. No excessive revving of plant and vehicle engines. Controlled release of compressed air.	0-20 dB reduction Reduce annoyance + sleep disturbance.
Heavy vehicle routes	Airborne noise	Construction heavy vehicles and delivery vehicles should be scheduled during standard construction hours where feasible and reasonable. During periods where it is expected that heavy vehicles accessing the site would be greater than four movements per hour (i.e., more than two in and two out), access should be distributed between the eastern and western access points to minimise impacts to the residences along the routes.	Minimises noise impacts
Verification monitoring	Airborne noise	In response to noise complaints, a noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan (CNVMP) or CEMP and any approval conditions.	Minimises noise impacts

4.6.2 Noise monitoring

The following approach could be adopted with regard to noise monitoring procedures during the construction works.

- In response to complaints where appropriate. Where the noise is identified to be from the Proposal and an understanding of the construction noise level would assist with investigating and addressing the complaint, noise monitoring must be carried out to confirm construction noise levels and verify predicted noise impacts. Reasonable and feasible noise reduction measures must be investigated, where necessary.

As part of construction planning, when a contractor is appointed and the specific construction methodology is known and the likely construction equipment are also known the potential construction impacts are to be reviewed to determine that they are consistent with those presented in this construction noise and vibration impact assessment and confirm that the associated mitigation and management measures are appropriate.

The attended measurements will need to be carried out by an appropriately trained person in the measurement and assessment of construction noise and vibration, who is familiar with the requirements of the relevant standards and procedures.

5 Conclusion

This noise and vibration impact assessment has been prepared as part of the Review of Environmental Factors (REF) to describe and assess the noise and vibration impacts associated with the Stormwater Amenity Improvement Works: Winding Creek, Cardiff. The key findings of the assessment are detailed below.

5.1 Construction noise assessment

Noise emissions from the proposed construction works have been predicted and assessed against the relevant noise management levels set by the ICNG during the recommended standard hours for construction.

During standard construction hours, the assessment found that receivers located near to the construction works areas are likely to be noise affected by the works, with potentially moderately intrusive levels of construction noise during typical works. No receivers are predicted to be highly noise affected (i.e. > 75 dB(A)).

Due to the predicted impacts determined in this assessment, recommendations to manage and/or minimise noise and vibration impacts where they occur have been provided in Section 4.6 and are to be reviewed and incorporated where feasible and reasonable.

5.2 Construction traffic noise assessment

Construction related road traffic noise has been assessed. Given the site constraints, all traffic is required to access the site via local roads. As part of the Proposal, up the three heavy vehicles per hour (i.e. six vehicle movements) are expected to be generated. Where more than four heavy vehicles movements per hour are required, to comply with the local road noise goals, heavy vehicles should be distributed between the eastern and western access points.

5.3 Construction vibration assessment

Potential vibration impacts on residential, other sensitive receivers and heritage receivers has been reviewed against the relevant guidelines for cosmetic damage from vibration and for human disturbance.

All nearby buildings and structures are located outside of the minimum working distances for cosmetic damage impacts from vibration. The Former Colliery Tramway is located approximately 12 metres from the southern extent of works which is beyond the minimum working distance of 10 metres for sensitive structures. To prevent any vibration generating plant and equipment operating within the minimum working distance, a 10 metre exclusion zone would be established surrounding the Former Colliery Tramway and demarcated with flagging and a sign to ensure no vibratory plant would be operated within this zone.

All nearby receivers are predicted to comply with the relevant vibration criteria for human annoyance from vibration.

References

1. ASHRAE Applications Handbook (SI) (2003), Chapter 47 Sound and Vibration Control, pp47.39-47.40

2. British Standard (2008), *BS 6472-2008: Evaluation of human exposure to vibration in buildings (1-80Hz)*

3. British Standard (2009), *Code of practice for noise and vibration control on construction and open sites- Part 2: Vibration*, BS 5228-1:2009

4. NSW Department of Climate Change and Water (2011), *Road Noise Policy* (RNP)

5. NSW Department of Environment and Climate Change (2009), *Interim Construction Noise Guideline* (ICNG)

6. NSW Department of Environment Conservation (2006), *Assessing Vibration; a technical guideline* (AVTG)

7. NSW Environment Protection Authority (1999), *Environmental Criteria for Road Traffic Noise* (ECRTN)

8. NSW Environment Protection Authority (2016), *Noise Policy for Industry* (NPfI)

9. Standards Australia (2016), *Acoustics - Recommended design sound levels and reverberation times for building interiors,* AS/NZS 2107:2016

10. Standards Australia (2016), *Guide to Noise Control on Construction, Demolition and Maintenance Sites*, AS 2436:2010 (R2016)

11. International Organization for Standardization (1996), *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation*, ISO 9613-2:1996

12. International Organization for Standardization (2015), *Acoustics - Software for the calculation of sound outdoors - Part 3: Recommendations for quality assured implementation of ISO 9613-2 in software according to ISO 17534-1*, ISO/TR 17534-3:2015

13. British Standard (1993), BS 7385: Part 2-1993 Evaluation and Measurement for Vibration in Buildings

14. German Standard (2016), *DIN 4150-3: 2016-02, Structural vibration - Effects of vibration on structures*

APPENDIX A Technical terms and concepts

A.1 Glossary of terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment Point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of common sounds in our daytime environment:

threshold of hearing	0 dB	The faintest sound we can hear
	10 dB	Human breathing
almost silent	20 dB	
	30 dB	Quiet bedroom or in a quiet national park location
generally quiet	40 dB	Library
	50 dB	Typical office space or ambience in the city at night
moderately loud	60 dB	CBD mall at lunch time
	70 dB	The sound of a car passing on the street
loud	80 dB	Loud music played at home
	90 dB	The sound of a truck passing on the street
very loud	100 dB	Indoor rock band concert
	110 dB	Operating a chainsaw or jackhammer
extremely loud	120 dB	Jet plane take-off at 100m away
threshold of pain	130 dB	
	140 dB	Military jet take-off at 25m away

dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.

Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

A.2 Acoustic concepts

A.2.1 Sound and noise

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound. Sound is a vibration that travels as an audible wave of pressure through the air from a source to a receiver location such as the human ear. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) is a unit of measurement used to express the ratio of a quantity to another on a logarithmic scale to make the wide range of sound pressure more manageable.

Sound power is the rate at which a source emits acoustic energy and is unaffected by the environment. It is a property of the source that is emitting acoustic energy.

In contrast, **sound pressure** is the effect, and it is affected by factors associated with the built and natural environment such as distance, direction, obstacles etc. The sound pressure is the acoustic energy or 'noise level' at a distance away from the noise source. The relationship between sound power and sound pressure can be explained by considering the analogy of an electric heater, which radiates heat into a room and temperature is the effect. Like sound pressure, temperature also reduces with distance from the source following the inverse square law.

In this technical working paper, **sound power level** is identified by the symbols **SWL** or $\mathbf{L_w}$, while **sound pressure level** is represented by **SPL** or $\mathbf{L_p}$, and both have the same scientific unit in dB.

A.2.2 Individual's perception of sound

The loudness of sound depends on its sound pressure level. The A-weighted decibel [dB(A)] is generally used for the purposes of environmental noise impact assessment as it has been adjusted to account for the varying sensitivity of the human ear to different frequencies of sound. People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dB(A) is a good measure of the loudness of environmental noise to the human ear as it considers this frequency dependant sensitivity.

Different noise sources having the same dB(A) level generally sound equally loud. However, the frequency of a sound is what gives it a distinctive pitch or tone – for example, the rumble of distant thunder is an example of a low frequency sound and a whistle is an example of a high frequency sound. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 to 90 dB(A). The following table provide some points of reference, measured in dB(A), of familiar sounds and those from construction activities.

Table A-1 Perception of sound - familiar sounds and construction noise

Common sounds	Construction noise	Sound pressure level
Leaf blower at operator's ear	Concrete saw or jack hammer 7 metres away	90 dB(A)
Airplane cabin during cruise (Airbus 321)	Excavator (with bucket) 7 metres away	80 dB(A)
General traffic noise kerbside next to Military Road	Towable compressor 7 metres away	75 dB(A)
Normal conversation at 1 metre		60 dB(A)
Outdoor air conditioning unit 1 metre away	Towable compressor 50 metres away	55 dB(A)
General office		50 dB(A)
Inside private office	Ground-borne noise from road header tunnel excavation between depths of 20 metres to 50 metres	40 dB(A)
Inside bedroom		30 dB(A)

In terms of sound perception, a change of 1 dB(A) or 2 dB(A) in the sound pressure level is difficult for most people to detect, while a 3 dB(A) to 5 dB(A) change corresponds to a small but noticeable change in loudness. An increase in sound level of 10 dB(A) is perceived as a doubling of loudness. However,

individuals may perceive the same sound differently since many factors can influence an individual's response, including:

- The specific characteristics of the noise (eg. frequency, intensity, duration of the noise event)
- Time of day noise events occur
- Individual sensitivities and lifestyle
- Reaction to an unfamiliar sound
- Understanding of whether the noise is avoidable and the notions of fairness.

A.2.3 Environmental noise assessment indicators

Environmental noise is an accumulation of noise pollution that occurs outside and is most commonly attributed to various modes of transport as well as industrial and construction activities. Environmental noise has been shown to have an adverse effect on the quality of life, especially following long-term exposure. The focus of the present technical assessment is on annoyance and sleep disturbance as they constitute most of the burden related to the impact of environmental noise on health outcomes. Noise annoyance is defined by the World Health Organization as a feeling of displeasure, nuisance, disturbance or irritation caused by a specific sound. Sleep disturbance relates to difficulty with sleep initiation, consolidation as well as awakening and reduced quality of sleep.

In New South Wales, contemporary environmental noise assessment criteria for addressing noise annoyance and sleep disturbance are specified by the Environment Protection Authority (EPA). Potential road traffic noise impact is assessed in accordance with the NSW Road Noise Policy. For motorway and ventilation facilities that are permanently fixed, and associated noise emissions are long-term in nature, noise criteria have been adopted in accordance with the Noise Policy for Industry. For enabling construction activities which are temporary in nature and highly variable, EPA's Interim Construction Noise Guideline provides the underlying assessment principles for the determination of potential construction noise impact.

L_{Aeq} - To protect against long-term repeated noise exposure, the indicator for assessing the cumulative noise exposure level over a specific time interval is the equivalent sound pressure level, denoted as LAeq. The LAeq indicator accounts for the total energy content from all sources of sound under consideration. The fact that the L_{Aeq} is a cumulative measure means that louder activities have greater influence of the LAeq level than do quieter ones, and activities that last longer in time have greater LAeq than do shorter ones. An increase in the number of events also increases the LAeq. Further, people react to the duration of noise events, judging longer events to be more annoying than shorter ones, assuming equal maximum noise levels.

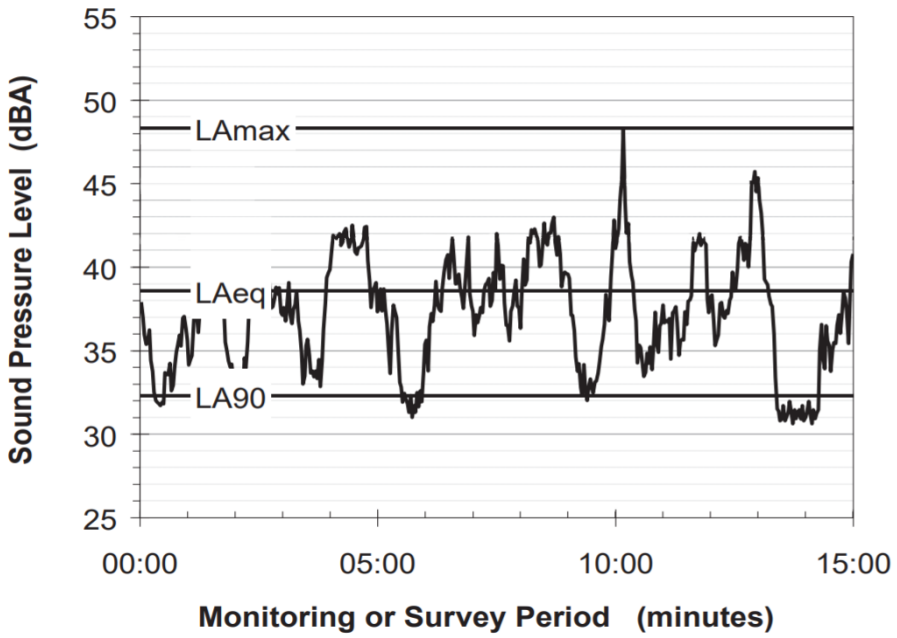
L_{Amax} - It is important to note that even though L_{Aeq} levels are numerically lower than maximum noise levels (denoted as LAmax). None of the noise is ignored, just as all the rain that falls in the rain gauge in one hour counts toward the total. In the case of noisy but short-lived maximum noise events, which can

sometime result in immediate short-term awakening reaction, potential impact is assessed using the LAmax indicator in which its emergence above the background noise environment is evaluated.

L_{A90} - The L_{A90} is the level of noise that is present almost constantly, or for 90 percent of the time and is commonly referred to as the background noise. Typical examples of what types of noise may contribute to the background noise levels are continuously flowing traffic or air conditioner noise.

These three noise indicators of L_{Amax}, L_{Aeq} and L_{A90} are presented in Figures A-1 for example noise monitoring survey period showing the sound pressure level of a varying noise environment such as environmental noise.

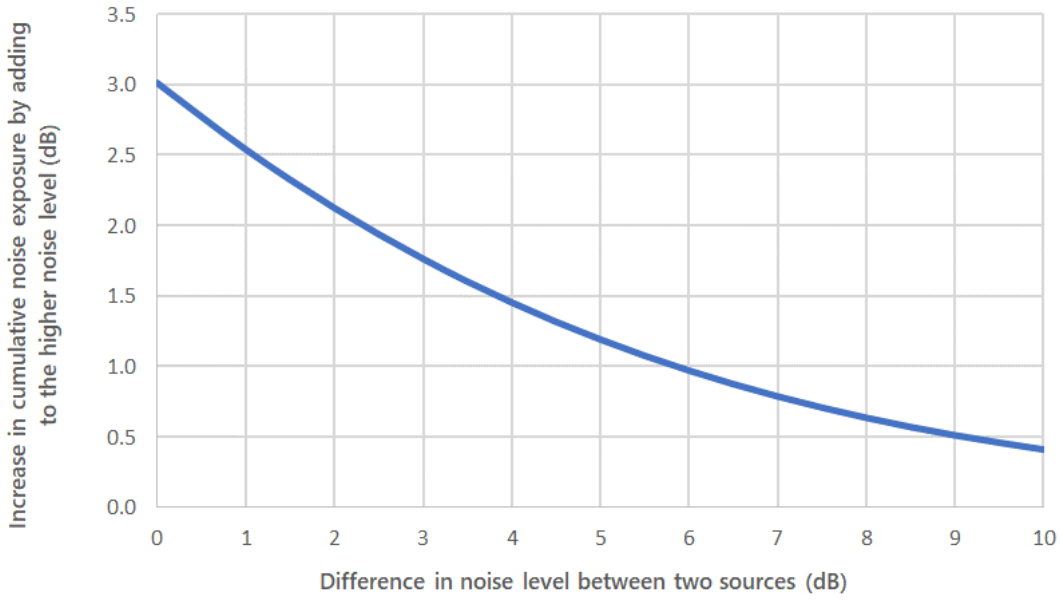
Figure A-1: Environmental noise assessment indicators



A.2.4 Cumulative sound exposure

As illustrated in Figure A-2, for two activities that result in the same amount of acoustical energy or noise level at a receiver location, the cumulative sound exposure level would be 3 dB higher than the level of just one single activity. This is because the decibel (dB) scale is logarithmic. Conversely, if the activity closer to your home results in noise exposure level that is 10 dB higher than the activity occurring further away, the quieter works would contribute very little to the cumulative noise exposure level.

Figure A-2: Difference in noise level between two sources



APPENDIX B Locality Map and Land Use Survey

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0
100
200
300 m

LEGEND

Noise Sensitive Receivers

- Residential
- Mixed use
- Commercial
- Industrial
- Hotel/Motel/Hostel
- Place of Worship
- Community centre
- Childcare
- Educational
- Recreational - Active
- Heritage

- Work areas
- Ancillary facilities
- Noise Monitoring Location
- Project Study Areas

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r0	SS	17/06/22	Prepare figures	RP

A3 Original

Co-ordinate System: MGA Zone 56

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STORMWATER AMENITY INPROVEMENT PROJECT - CARDIFF

Land use, Worksites and NCAs

Sheet 1 of 1

APPENDIX C Noise monitoring methodology

C.1 Noise monitoring equipment

A noise monitor consists of a sound level meter housed inside a weather resistant enclosure. Noise levels are monitored continuously with statistical data stored in memory for every 15-minute period.

Long term noise monitoring was conducted using the following instrumentation:

Description	Type	Octave Band Data
RTA06 (NTi Audio XL2)	Type 1	1/1 octaves

Notes: All meters comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated either Type 1 or Type 2 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4230 or 4231 calibrator. No significant drift in calibration was observed.

C.2 Meteorology during monitoring

Measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the INP. The Bureau of Meteorology (BOM) provided meteorological data, which is considered representative of the site, for the duration of the noise monitoring period. The data was modified to allow for the height difference between the BOM weather station, where wind speed and direction is recorded at a height of 10 metres above ground level, and the microphone location, which is typically 1.5 metres above ground level (and less than 3 metres). The correction factor applied to the data was taken from Australian Standard AS1170.2 1989 Section 4.2.5.1.

C.3 Noise vs time graphs

Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. In this report, noise values measured or referred to include the L_{10}, L_{90}, and L_{eq} levels. The statistical descriptors L_{10} and L_{90} measure the noise level exceeded for 10% and 90% of the sample measurement time. The L_{eq} level is the equivalent continuous noise level or the level averaged on an equal energy basis. The measurement sample periods are 15 minutes. The Noise - vs- Time graphs representing measured noise levels, as presented in this report, illustrate these concepts for the broadband results.

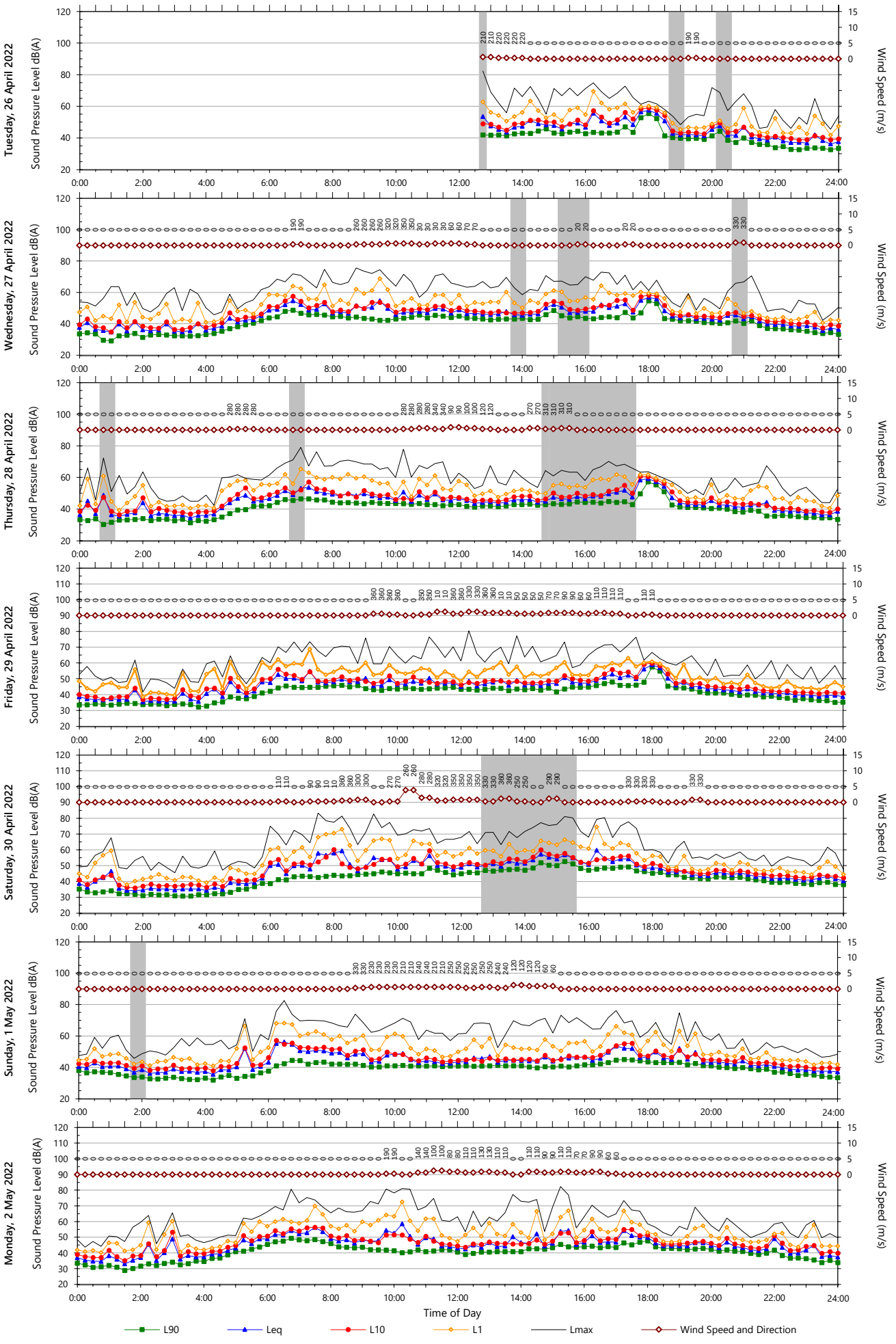
C.4 Noise monitoring location

C.4.1 M1 - 28 Railway Parade, Cardiff

APPENDIX D Unattended noise monitoring results

Unattended Monitoring Results

Location: Back yard



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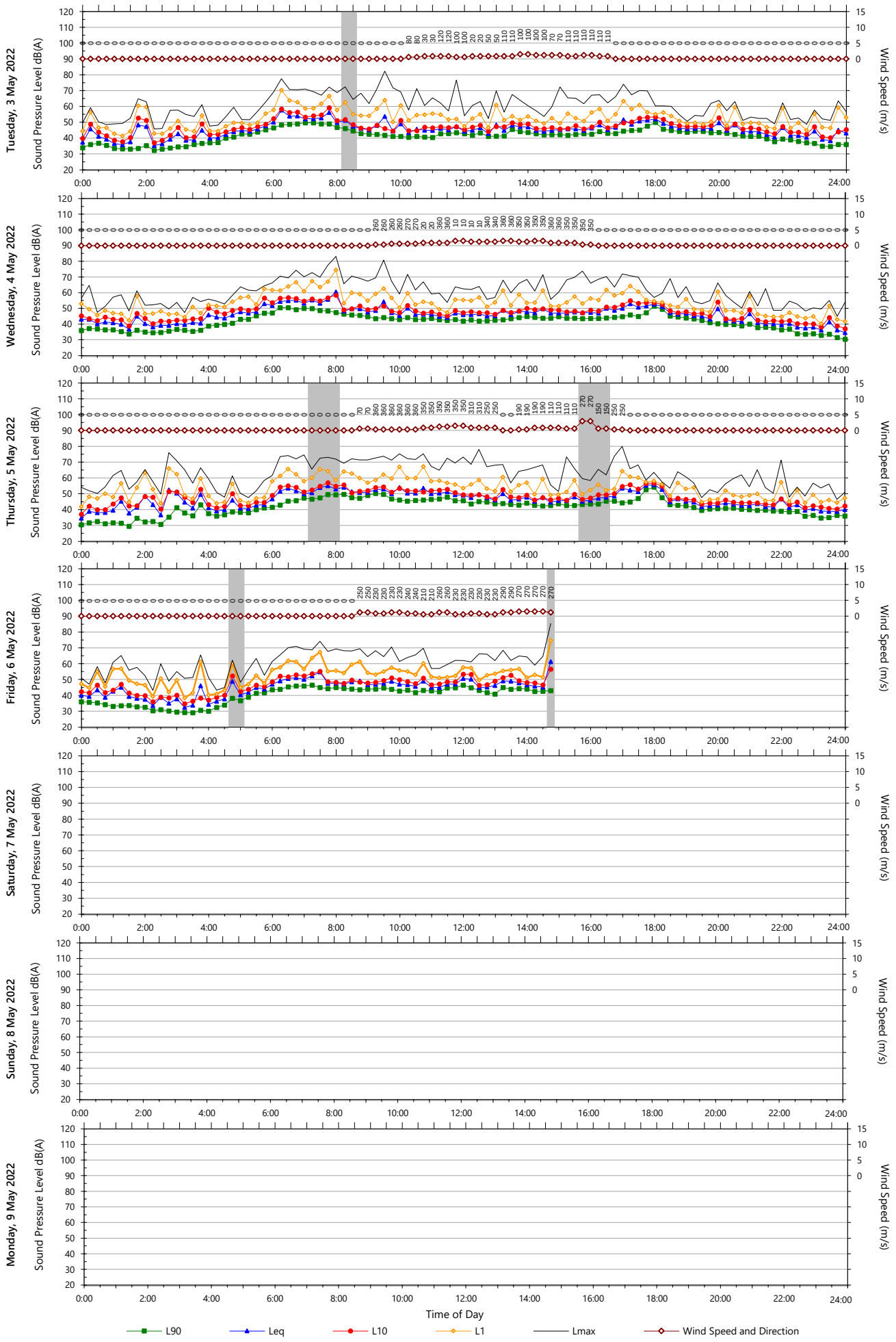
Unattended Monitoring Results

Location: Back yard



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APPENDIX E Predicted construction noise impacts

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LEGEND

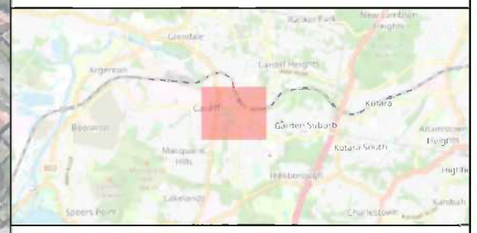
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



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FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

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Maximum Predicted LAeq 15min Noise Excedance for Site Establishment & Environmental controls Works during Standard Daytime

Plot Date: 20/05/22 - 20:35 Layout: TM711 Gen Template (r1) STD HOURS

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LEGEND

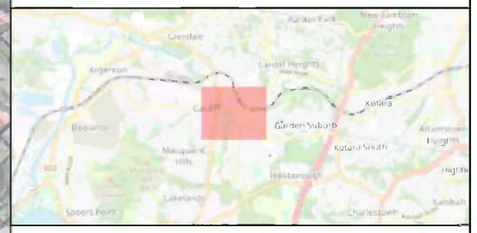
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



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NOTE: Do not scale from this drawing.

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STORMWATER AMENITY IMPROVEMENT PROJECT - CARDIFF

Maximum Predicted LAeq 15min Noise Excedance for Ancillary facilities Works during Standard Daytime

Plot Date: 20/05/22 - 20:35 Layout: TM711 Gen Template (r1) STD HOURS

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LEGEND

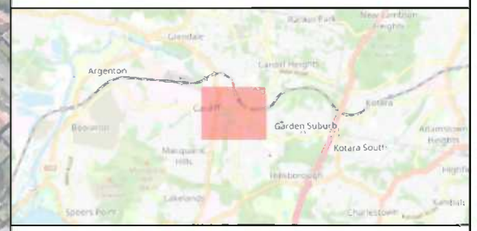
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



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Co-ordinate System: MGA Zone 56

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FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

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STORMWATER AMENITY IMPROVEMENT PROJECT - CARDIFF

Maximum Predicted LAeq 15min Noise Excedance for Removal of shared path Works during Standard Daytime

Plot Date: 20/05/22 - 20:35 Layout: TM711 Gen Template (r1) STD HOURS

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600 m

0 200 400

LEGEND

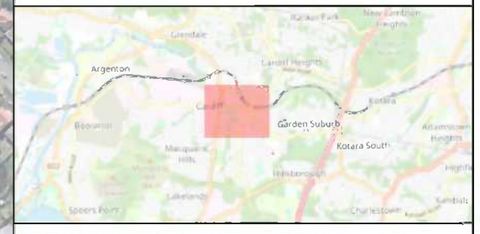
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



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A3 Original

Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 300 350 m

1:4500 At A3

FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

CLIENT

HUNTER WATER

ACOUSTIC CONSULTANT

RENZO TONIN & ASSOCIATES
inspired to achieve
Ph (02) 8218 0500 Fax (02) 8218 0501

STORMWATER AMENITY IMPROVEMENT PROJECT - CARDIFF

Maximum Predicted LAeq 15min Noise Excedance for Investigations Works during Standard Daytime

Plot Date: 20/05/22 - 20:35 Layout: TM711 Gen Template (r1) STD HOURS

GIS File: \\syd-server\vtagroupsyd\AssocSydProjects\TM701-TM750\TM711 rp Stormwater Amenity Improvement\5 Calcs\0 QGIS\TM711 - SS (r1) ALe.qgz

LEGEND

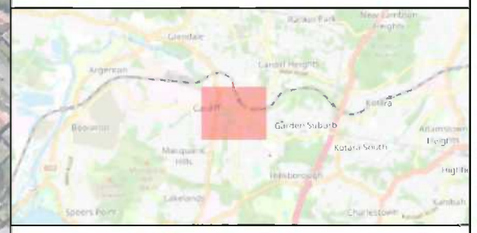
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



REV	BY	DATE	DESCRIPTION	APPROVER
r1	ALe	20/05/22	Updated figures	RP
r0	SS	20/05/22	Prepare figures	RP

A3 Original

Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 300 350 m

1:4500 At A3

FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

CLIENT

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STORMWATER AMENITY IMPROVEMENT PROJECT - CARDIFF

Maximum Predicted LAeq 15min Noise Excedance for Structural works – Stage 1 Works during Standard Daytime

Plot Date: 20/05/22 - 20:35 Layout: TM711 Gen Template (r1) STD HOURS

GIS File: \\syd-server\vtagroupsyd\AssocSydProjects\TM701-TM750\TM711 rp Stormwater Amenity Improvement\5 Calcs\0 QGIS\TM711 - SS (r1) ALe.qgz

LEGEND

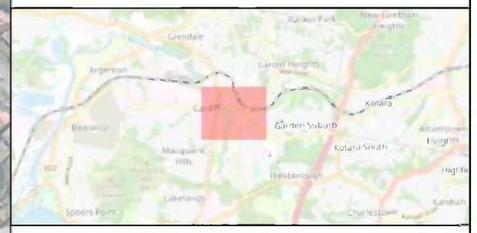
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



REV	BY	DATE	DESCRIPTION	APPROVER
r1	ALe	20/05/22	Updated figures	RP
r0	SS	20/05/22	Prepare figures	RP

A3 Original

Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 300 350 m

1:4500 At A3

FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

CLIENT

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STORMWATER AMENITY IMPROVEMENT PROJECT - CARDIFF

Maximum Predicted LAeq 15min Noise Excedance for Dewatering Works during Standard Daytime

Plot Date: 20/05/22 - 20:35 Layout: TM711 Gen Template (r1) STD HOURS

GIS File: \\syd-server\vtagroupsyd\AssocSydProjects\TM701-TM750\TM711 rp Stormwater Amenity Improvement\5 Calcs\0 QGIS\TM711 - SS (r1) ALe.qgz

LEGEND

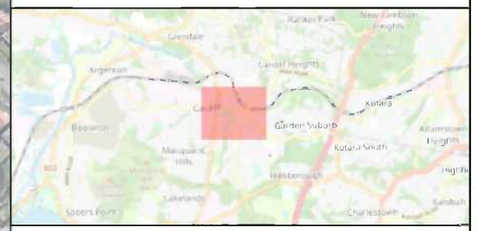
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



REV	BY	DATE	DESCRIPTION	APPROVER
r1	ALe	20/05/22	Updated figures	RP
r0	SS	20/05/22	Prepare figures	RP

A3 Original

Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 300 350 m

1:4500 At A3

FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

CLIENT

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STORMWATER AMENITY IMPROVEMENT PROJECT - CARDIFF

Maximum Predicted LAeq 15min Noise Excedance for Structural works – Stage 2 Works during Standard Daytime

Plot Date: 20/05/22 - 20:36 Layout: TM711 Gen Template (r1) STD HOURS

GIS File: \\syd-server\vtagroupsyd\AssocSydProjects\TM701-TM750\TM711 rp Stormwater Amenity Improvement\5 Calcs\0 QGIS\TM711 - SS (r1) ALe.qgz

600 m

0 200 400

LEGEND

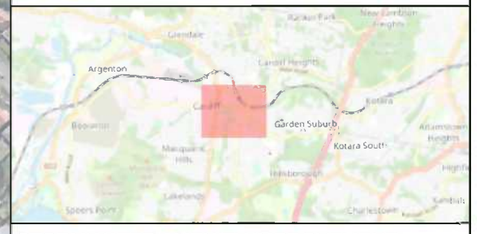
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



REV	BY	DATE	DESCRIPTION	APPROVER
r1	ALe	20/05/22	Updated figures	RP
r0	SS	20/05/22	Prepare figures	RP

A3 Original

Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 300 350 m

1:4500 At A3

FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

CLIENT

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STORMWATER AMENITY IMPROVEMENT PROJECT - CARDIFF

Maximum Predicted LAeq 15min Noise Excedance for Structural works – Stage 3 Works during Standard Daytime

Plot Date: 20/05/22 - 20:36 Layout: TM711 Gen Template (r1) STD HOURS

GIS File: \\syd-server\vtagroupsyd\AssocSydProjects\TM701-TM750\TM711 rp Stormwater Amenity Improvement\5 Calcs\0 QGIS\TM711 - SS (r1) ALe.qgz

600 m

0 200 400

LEGEND

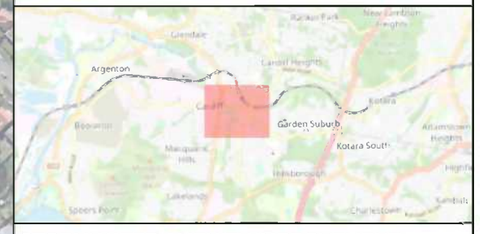
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



REV	BY	DATE	DESCRIPTION	APPROVER
r1	ALe	20/05/22	Updated figures	RP
r0	SS	20/05/22	Prepare figures	RP

A3 Original

Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 300 350 m

1:4500 At A3

FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

CLIENT

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STORMWATER AMENITY IMPROVEMENT PROJECT - CARDIFF

Maximum Predicted LAeq 15min Noise Excedance for Reinstatement of shared pathway Works during Standard Daytime

Plot Date: 20/05/22 - 20:36 Layout: TM711 Gen Template (r1) STD HOURS

GIS File: \\syd-server\vtagroupsyd\AssocSydProjects\TM701-TM750\TM711 rp Stormwater Amenity Improvement\5 Calcs\0 QGIS\TM711 - SS (r1) ALe.qgz

LEGEND

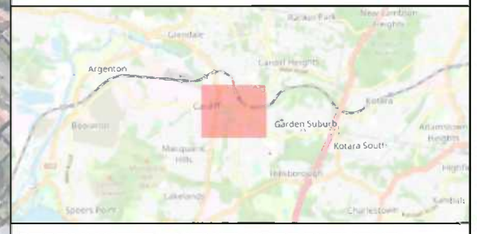
Noise Sensitive Receivers

- Residential
- Non-Residential

- Extent Of Works
- Ancillary Facilities
- Project Study Area

Predicted level of exceedance (LAeq 15min), dB(A)

- Below NML
- < 10 dB above NML (Clearly audible)
- 11 - 20 dB above NML (Moderately intrusive)
- > 20 dB above NML (Highly intrusive)



REV	BY	DATE	DESCRIPTION	APPROVER
r1	ALe	20/05/22	Updated figures	RP
r0	SS	20/05/22	Prepare figures	RP

A3 Original

Co-ordinate System: MGA Zone 56

0 50 100 150 200 250 300 350 m

1:4500 At A3

FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

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STORMWATER AMENITY IMPROVEMENT PROJECT - CARDIFF

Maximum Predicted LAeq 15min Noise Excedance for Site restoration Works during Standard Daytime

APPENDIX F Construction vibration minimum working distances

Plot Date: 06/07/22 - 11:51 Layout: TM711 lu map

GIS File: R:\Assoc\SydProjects\TM701-TM750\TM711 rp Stormwater Amenity Improvement\5 Calcs\0 GIS\TM711 - SS.qgz

LEGEND

Noise Sensitive Recievers

- Residential
- Mixed use
- Commercial
- Place of Worship
- Community centre
- Childcare
- Educational
- Recreational - Active
- Heritage

Work Areas

MWD during Activity in Work Area

- Cosmetic Damage to Reinforced and Unreinforced Structures
- Cosmetic Damage to Heritage Structures
- Residential Human Annoyance

STORMWATER AMENITY INPROVEMENT PROJECT - Cardiff

Minimum Working Distances during activity

REV	BY	DATE	DESCRIPTION	APPROVER
r0	SS	06/07/22	Prepare figures	RP

A3 Original | Co-ordinate System: MGA Zone 56

0 25 50 75 100 125 m

1:2,200 At A3

FULL SIZE A3, REDUCED TO A4

NOTE: Do not scale from this drawing.

CLIENT: HUNTER WATER

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