SURFACE WATER ASSESSMENT

Henry Lawson Drive Stage 1A, NSW

July 2021

Project Number: 20-596

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ACRONYMS AND ABBREVIATIONS

AGL	Above Ground Level
BDCP	Bankstown Development Control Plan 2015
BGL	Below Ground Level
BLEP	Bankstown Local Environment Plan 2015
Cwth	Commonwealth
DECCW	Department of Environment, Climate Change and Water (NSW) now EES
DPIE	Department of Planning, Industry and Environment (NSW)
EES	Department of Environment, Energy and Science (NSW) (formerly OEH, and, prior, DECCW)
EIS	Environmental impact statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwth)
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
ERSED	Erosion and sediment
GPTs	Gross pollutant traps
ha	hectares
km	kilometres
LGA	Local Government Area
m	metres
mg/L	Milligrams per litre
mV	millivolts
NSW	New South Wales
NTU	Nephelometric turbidity unit
PPT	Parts per thousand
REF	Review of Environmental Factors
SEPP	State Environmental Planning Policy (NSW)
S/m	Siemens per metre
TSS	Total suspended solids(mg/L)
WM Act	Water Management Act 2000
µS/cm	Microsiemens per centimetre
°C	Degrees Celsius

1. INTRODUCTION

Transport for NSW (Transport) is proposing to upgrade Henry Lawson Drive between Keys Parade, Milperra, to Tower Road, Bankstown Aerodrome (known as the Henry Lawson Drive Upgrade Stage 1A) (the overall proposal). The proposal consists of upgrading a 1.3 kilometre (km) length of Henry Lawson Drive and an additional 480 metres (m) along Milperra Road, including intersection upgrades.

This Surface Water Quality Assessment (the assessment) has been prepared to assess the potential water quality impacts of the proposal during construction and operation, and provide baseline water quality data for the receiving waters, the Georges River and Milperra Drain. It will support a Review of Environmental Factors (REF) being prepared by Transport under Division 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act) and an Environmental Impact Statement (EIS) being prepared under Division 4.1 of the EP&A Act.

Road widening and intersection upgrades would occur within an area included in the *State Environmental Planning Policy (Coastal Management SEPP) 2018 Coastal Wetlands*.

The aim of this Policy is to promote an integrated and co-ordinated approach to land use planning in the coastal zone in a manner consistent with the objects of the Coastal Management Act 2016, including the management objectives for each coastal management area, by—

a) managing development in the coastal zone and protecting the environmental assets of the coast, and
b) establishing a framework for land use planning to guide decision-making in the coastal zone, and
c) mapping the 4 coastal management areas that comprise the NSW coastal zone for the purpose of the definitions in the Coastal Management Act 2016.

1.1. Purpose and Scope of Report

This report has been prepared to support the REF and EIS for the proposal. This report has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for the proposal. The REF has been prepared for the majority of the proposal, where Transport can approve works under the State Environmental Planning Policy (Infrastructure) 2008 (referred to as the 'REF proposal'). However, as part of the proposal is located within areas mapped as coastal wetlands under the State Environmental Planning Policy (Coastal Management) 2018, this is subject to an EIS. The work within mapped coastal wetlands is deemed designated development and is referred to as the 'EIS proposal'. These areas are shown in Figure 1-1.

The purpose of this report is to describe the proposal, to document the likely impacts of the proposal on the environment, impacts of the environment on the proposal and to detail suitable mitigation measures if required. It will document the current surface water quality of the Georges River, document the likely impacts of the proposal on the surface water quality during construction and operation, and detail suitable mitigation measures if required. This report also describes the potential likely impacts and mitigation measures with reference to the REF and EIS proposal areas.

The scope of the report includes:

- Construction Surface Water Quality Assessment:
  - Provide a literature review of the water quality conditions of the Georges River and Milperra Creek.
  - Provide a literature review of turbidity impacts on waterways and riparian environments.
  - Establish ecological values of each waterway.
  - Identify an indicative protection level for each waterway using ANZG (2018) Guidelines for Fresh and Marine Water Quality and the Water Quality Objectives in NSW.
  - Identify indicators to the risks to environmental values.

    - Predict and assess the potential impact of possible discharges of construction water to the waterways with consideration to the concept design Erosion and Sediment Control Strategy.
- Operation Surface Water Quality Assessment:
    - Provide a qualitative operation surface water assessment.

REF and EIS Proposal Areas

This assessment evaluates the proposed activities subject to both REF and EIS proposal areas.

For the REF, this assessment identifies the direct impacts from construction and operation activities on the REF proposal area (refer section 2.3). It also identifies the indirect impacts from proposed (REF) activities on surrounding areas, including any indirect impacts on coastal wetlands.

For the EIS, this assessment identifies the direct impacts from construction and operation activities on coastal wetlands (refer section 2.3.1). It also identifies the indirect impacts from proposed (EIS) activities on surrounding areas.

1.1.1. Secretary's Environmental Assessment Requirements

As sections of the proposal intersect with areas mapped as Coastal Wetlands, the proposed activities in these sections are deemed designated development. An EIS has been prepared to assess the designated development proposal (EIS proposal) under Division 4.1 of the EP&A Act. For this EIS, SEARs have been issued by the Department of Planning, Industry and Environment (DPIE), which describe assessment requirements. The requirements relevant to the Surface Water Quality Assessment for the EIS proposal area is presented in Table 1-1.

Section 8.1 summarises the surface water assessment for the EIS proposal area, drawing on information from other sections of this report that specifically addresses the SEARs.

Table 1-1 Secretary's Environmental Assessment Requirements

Reference	Requirement	Where addressed
Water quality	An assessment of hydrology, and potential impacts on the quality and quantity of surface water resources with reference to the ANZG (2018) Guidelines for Fresh and Marine Water Quality or equivalent water quality guidelines.	Section 4.1.4, Section 5.1, Section 5.3, Section 6.1. Section 8.1 (EIS summary).
Water use	Details of water usage for the proposal including existing and proposed water licencing requirements in accordance with the Water Act 1912 and/or the Water Management Act 2000.	Under the WM Act, water use by public authorities for road construction and maintenance, and for dust suppression, are exempt activities under Clause 34(1), Clause 2 and Clause 11 of Schedule 4. Section 5.1.3. Section 8.1 (EIS summary).

Reference	Requirement	Where addressed
Coastal Processes	Consistency with coastal zone management plans.	Surface water quality criteria and management contained within this assessment is consistent with the water quality objectives in the Georges River Coastal Zone Management Plan 2013. Section 1.1.2. Section 8.1 (EIS summary).
Coastal Processes	The effects of coastal processes and coastal hazards including the effects of sea level rise and climate change	The potential for the proposal to impact on the volume of sediment in surface runoff, leading to an increase in sedimentation in the receiving waters is discussed in sections 6.1.2 and 7.1.1. An assessment of the potential for the proposal to impact on flow velocities and therefore scour potential and sedimentation in the receiving waters is provided in the Flooding Assessment Report.

1.1.2. Georges River Estuary Coastal Zone Management Plan 2013

The primary goal of the *Georges River Estuary Coastal Zone Management Plan* is "*to conserve and improve the existing natural environment of the Georges River Estuary, and to improve the water quality of the estuary through targeted pollution reduction*" (BMT WBM 2013).

The management aims related to surface water quality and with reference to this assessment identified in the Georges River Estuary Coastal Zone Management Plan 2013 (BMT WBM 2013) include:

- Water quality – to optimise water quality within the Georges River Estuary and its tributaries.
- Aquatic and riparian habitat – to protect, enhance and restore aquatic habitats and foreshore vegetation.
- Land use planning and development – to minimise the negative impacts of development in the catchment on waterway health.
- Bank erosion and sedimentation – to actively manage bank erosion and sedimentation.
- Foreshore protection – to manage existing built foreshore assets while maximising environmental values.

The management objectives related to surface water quality and with reference to this assessment identified in the Georges River Estuary Coastal Zone Management Plan 2013 (GRECZMP) (BMT WBM 2013) are included in Table 1-2. The location in the document where the objective has been assessed is included. The management objectives are listed in order of priority as per the GRECZMP (2013).

Table 1-2 Objectives from the GRECZMP 2013.

Management Objective	Where addressed
A1. Reduce the volume & pollutant load of stormwater runoff through the catchment	Section 6.3, Section 7.5. Appendix D, Appendix E
A2. All greenfield and redevelopments should have a minimal negative impact on flow and water quality, meeting targets for water quality proposed in the Botany Bay and Catchment WQIP	Section 6.2, Section 6.3, Section 7.5. Appendix D, Appendix E
A4. Minimise build-up of gross pollutants and illegal dumping of waste into and along the estuary foreshore and waterways	Section 7.5. Appendix E
E2. Reduce the causes and impacts of sedimentation in the estuary	Section 6.2, Section 6.3, Section 7.5. Appendix D, Appendix E
B3. Protect and improve the extent and condition of estuarine and riparian vegetation	Section 6.2, Section 6.3, Section 7.5. Appendix D, Appendix E
D2. To ensure integration of the Georges River Estuary Coastal Zone Management Plan aims and objectives into strategic planning initiatives and developments	Section 1.1.2.
D1. To ensure appropriate measures are taken and maintained to reduce the erosion and associated pollutant exports from areas under development	Section 6.2, Section 6.3. Appendix D

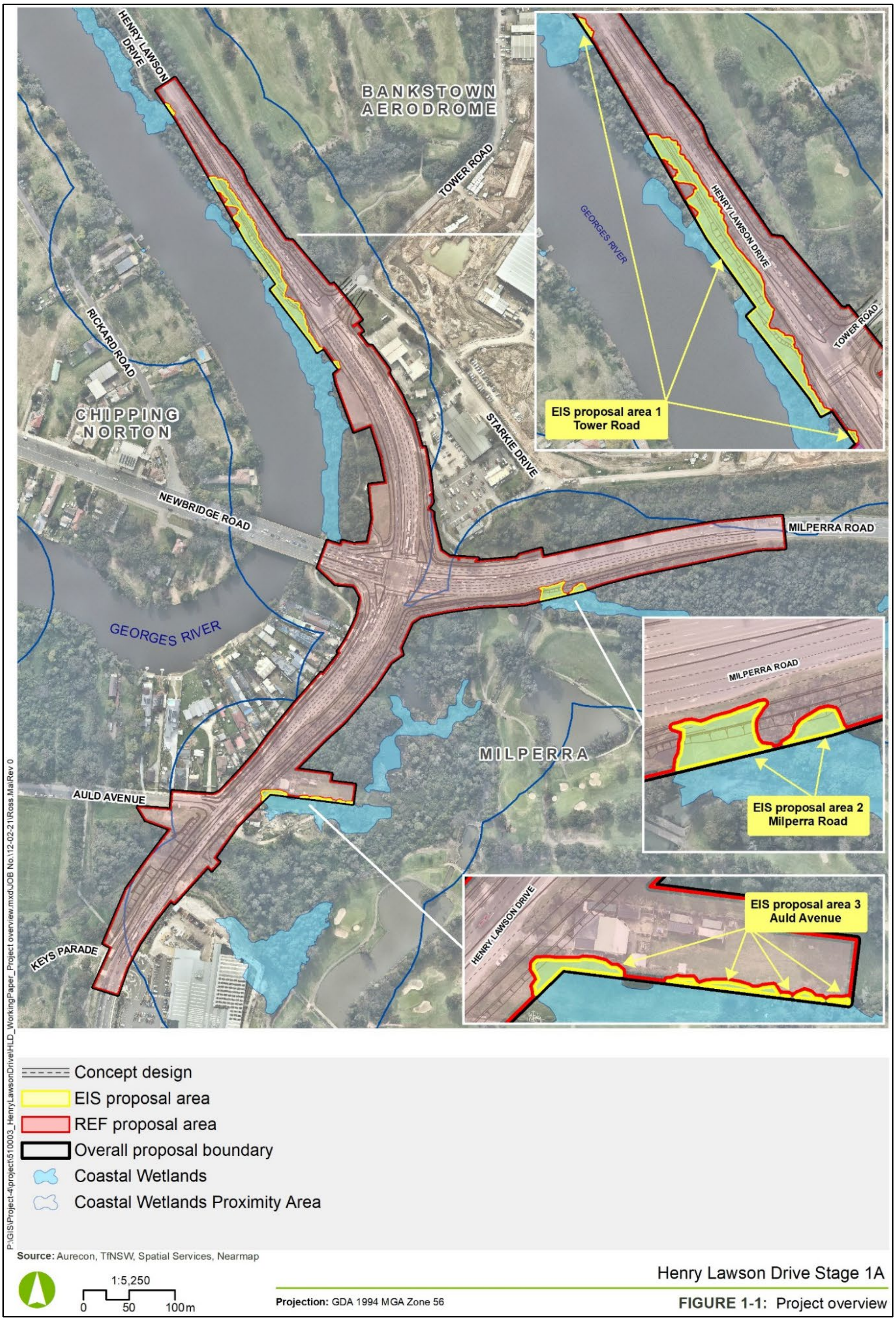

Figure 1-1 Project overview (source: Aurecon 2021).

2. THE PROPOSAL

2.1. Proposal Background

The proposal forms the first stage of the progressive upgrade to 7.5 kilometres of Henry Lawson Drive between the intersections of Hume Highway, Villawood, and the M5 South Western Motorway, Milperra.

The upgrade would help ease existing traffic issues and increase traffic capacity at key intersections to help meet growing demand, with residential, commercial and industrial development in the surrounding area expected to increase in the coming years. The upgrade would be delivered in three stages.

Subject to approval, construction of the Stage 1A proposal may commence in early 2023 and would take about two years to complete. Other stages of upgrading Henry Lawson Drive would be developed and assessed separately in the future.

2.2. Proposal Location and Setting

The proposal is located around 20 km south west of the Sydney CBD in the Canterbury-Bankstown City local government area. The proposal is mainly along Henry Lawson Drive and includes intersection upgrades at Tower Road, Newbridge/Milperra Road and Auld Avenue.

Henry Lawson Drive is a key connection for traffic moving between the Hume Highway, Milperra Road /Newbridge Road and the M5 Motorway. It is also used for local travel trips between residences and services. In terms of heavy vehicle access, Henry Lawson Drive is designated as a B-Double access route that connects surrounding large industrial areas of Milperra, Revesby, Chipping Norton and Moorebank.

The proposal is located to the east of the Georges River and surrounding recreational areas. There are a number of Coastal Wetlands within and surrounding the proposal associated with the Georges River.

Located to the south west of the proposal, is a residential area with detached housing and sporting fields and passive recreation areas. To the south east, is the Bankstown Golf Course and urban bushland areas. North of Milperra Road comprises retail and commercial development that backs onto the Bankstown Aerodrome and land currently being redeveloped, all of which access Henry Lawson Drive via Tower Road. Located north of Tower Road is the Georges River Golf Course.

2.3. Proposal Overview

2.3.1. Key Features of the REF Proposal Area

Key features of the proposal would include (Figure 1-1):

- Widening Henry Lawson Drive from two to four lanes.
- Upgrading the signalised intersection of Henry Lawson Drive and Tower Road including:
  - An additional right turn lane from Tower Road onto Henry Lawson Drive.
  - A new channelised short left-turn lane from Henry Lawson Drive (southbound) onto Tower Road.
  - An additional right turn lane from Henry Lawson Drive (northbound) onto Tower Road retaining the pedestrian crossing across Henry Lawson Drive on the southern side of the intersection.
- Upgrading the signalised intersection of Henry Lawson Drive and Milperra Road /Newbridge Road including:
  - An additional right turn lane on the Milperra Road and Newbridge Road approaches to Henry Lawson Drive.
  - An additional through lane on the Henry Lawson Drive southbound approach.
  - An additional right turn lane on Henry Lawson Drive northbound approach.

- Removing the dedicated left turn slip lane into the ALDI and fast-food area and access being retained via a standard property driveway.
- Retaining the existing bus stop on Milperra Road (eastbound) and moving the westbound bus stop 20 metres to the west.
- Altering access to Auld Avenue to a “left in/left out” only configuration.
- Installing a new Henry Lawson Drive road bridge over Milperra Drain to the south of Auld Avenue (referred to as the Auld Avenue bridge) to carry northbound traffic and retaining the existing bridge for southbound traffic.
- Constructing new footpaths on the eastern side of Henry Lawson Drive to connect Tower Road to the existing bus stop on the eastbound lanes of Milperra Road and a new footpath on the southern side between Henry Lawson Drive to the bus stop on the westbound lanes of Milperra Road.
- Widening the shared user pathway between Flower Power (Keys Parade) and Newbridge Road to three metres and reconstructing footpaths along the western side of Henry Lawson Drive, where required.
- Adjusting drainage including lengthening culverts, installing new drainage infrastructure and water quality controls.
- Relocating utilities (including electrical, gas, water and telecommunications).
- Final roadworks including pavement, kerb and gutters, signs, lighting and line marking.
- Ancillary work for the project including, but not limited to road furniture, tie-in works, landscaping, earthworks and the like.
- Temporary ancillary compounds, stockpile sites and associated facilities.

2.3.2. Key Features of the EIS Proposal Area

Key features of the EIS proposal are identified below for each EIS Proposal Area. There are three EIS proposal areas as described below and are shown in Figure 2-1, Figure 2-2 and Figure 2-3.

EIS Proposal Area 1 – Henry Lawson Drive Opposite Tower Road

The key features of EIS proposal area 1 are:

- Widening of Henry Lawson Drive northbound lanes.
- Installing of fill embankments along the edge of the new carriageway to meet existing ground levels.
- Extending existing stormwater culvert and installing outlet scour protection measures.
- Installing additional stormwater drainage infrastructure and water quality treatments.
- Installing a vegetated channel along the toe of the new fill embankment.
- Adjusting the existing shared path to suit the new re-alignment and to connect it back to the existing path.
- Installing road furniture, including road safety barriers.

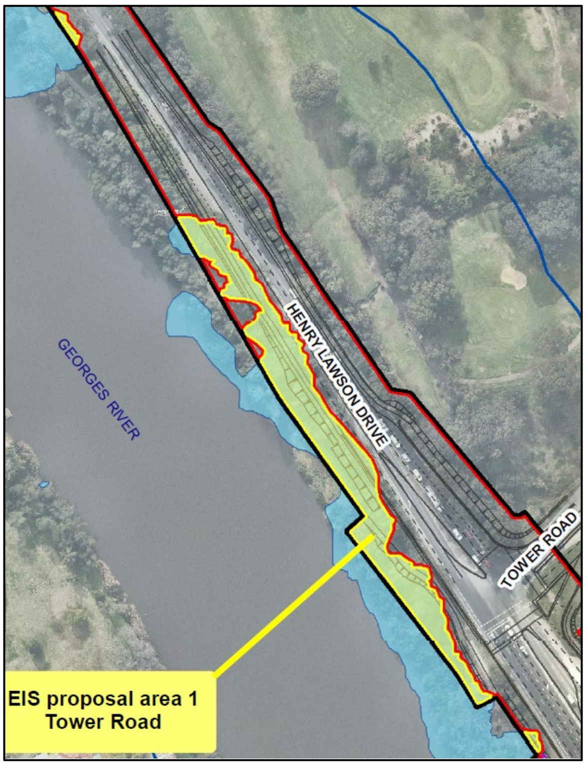

Figure 2-1 EIS proposal area 1

EIS Proposal Area 2 – Milperra Road Opposite Bankstown Aerodrome

The key features of the EIS proposal area 2 are:

- Installing a new bus stop relocated from its existing position on Milperra Road.
- Installing a section of a new footpath to the bus stop (connecting to the remainder of the new path to Henry Lawson Drive – REF proposal).
- Installing fill embankments along the edge of the new carriageway to meet existing ground levels.
- Extending existing stormwater culvert and installing outlet scour protection measures.
- Installing additional stormwater drainage infrastructure connecting to the outlet of the extended culvert.
- Installing road furniture, including road safety barriers.

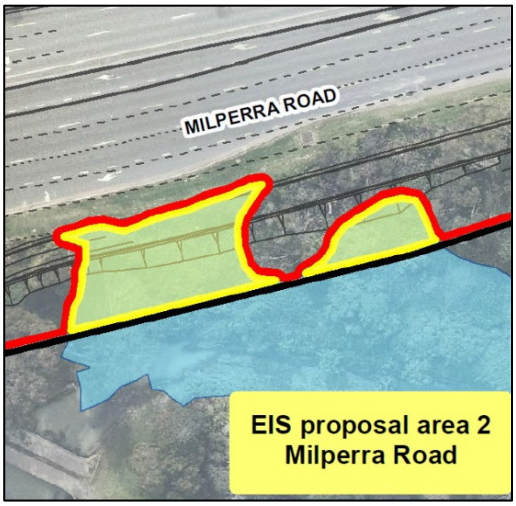

Figure 2-2 EIS proposal area 2.

EIS Proposal Area 2 – Henry Lawson Drive Opposite Auld Avenue

The key features of the EIS proposal area 3 are:

- Removing of existing ancillary structures.
- Installing temporary fencing, flagging of exclusion boundaries & temporary erosion and sediment controls for use as an ancillary facility and construction area.
- Installing fill embankments along the edge of the new carriageway to meet existing ground levels.
- Stabilising the ground surface following the completion of construction to minimise erosion.

Figure 2-3 EIS proposal area 3.

3. LEGAL AND POLICY REQUIREMENTS

3.1. Protection of the Environment Operations Act 1997 (POEO Act)

The *Protection of the Environment Operations Act 1997* (POEO Act) regulates waste management, noise, and air and water pollution. Under section 120 of the POEO Act the pollution of waters is an offence. An environment protection licence, under Chapter 3 of the Act, is normally required for an activity where water quality could be impacted. Road construction is one of those activities under Schedule 1 of the POEO Act. The proposal would involve road widening, bridge development and intersection upgrade, which are listed as road construction activities in Schedule 1 of the POEO Act.

3.2. Fisheries Management Act 1994 (FM Act)

Aims of the *Fisheries Management Act 1994* (FM Act) protects aquatic flora and fauna, and their habitats. The FM Act is governed by the Department of Primary Industries (DPI). One of the objectives of the FM Act is to 'conserve key fish habitats'. A policy definition of Key Fish Habitat (KFH) includes *"all marine and estuarine habitats to the astronomical tide level and most permanent and semi-permanent freshwater habitats including rivers, creeks, lakes, lagoons, billabongs, weir pools and impoundments up to the top of the bank"* (DPI 2017). The Proposal would be located adjacent to Georges River estuary and Milperra Drain. The policy and guidelines for aquatic habitat conservation are to ensure minimal impact of the proposal on receiving sensitive species and environments protected under the Act.

3.3. Coastal Management Act 2016

The Coastal Management Act 2016 (CM Act) is a state policy designed for the management, beneficial use, protection, and development of the land and water resources of the New South Wales coastal zone. One of the aims of the CM Act is to protect and improve on coastal wetland and littoral rainforest areas. The proposal is located adjacent to a sensitive receiving environment of the Georges River estuary and its tributaries, which contains mapped coastal wetlands. The policy and guidelines for aquatic habitat conservation are to ensure minimal impact of the proposal on the receiving species and environments protected under the Act.

3.4. State Environmental Planning Policy 2018 – Coastal Management

The aim of the State Environmental Planning Policy (Coastal Management) 2018 (SEPP CM) is to promote and integrate a co-ordinated approach to land use planning in the coastal zone in a manner that is consistent with the objects of the CM Act. The SEPP CM aims to manage development in the coastal zone and protect environmental assets off the coast and to establish a framework for land use planning to guide decision-making in the coastal zone. The proposal is located adjacent to a sensitive receiving environment, the Georges River estuary and its tributaries. These contain mapped coastal wetlands. These coastal wetlands and estuarine ecosystems are protected under the SEPP CM. The policy and guidelines for aquatic habitat conservation are to ensure minimal impact of the proposal on receiving sensitive species and environments protected under the Act.

3.5. Water Management Act 2000

The *Water Management Act 2000* (WM Act) provides guidance for sustainable and integrated management of the water sources within NSW. The WM Act ensures sustainable use and management of water sources through ecologically sustainable development, protection and enhancement of water resources, social and economic benefits, equitable sharing of water, management of water resources with native vegetation and native fauna and efficient use of water. Water sharing plans (WSPs) define the rules for water sharing for each regulated river between the users and the environment. Most WSPs fall under the WM Act.

Under the WM Act, water use by public authorities for road construction and maintenance, and for dust suppression, are exempt activities under Clause 34(1), Clause 2 and Clause 11 of Schedule 4.

3.6. Greater Metropolitan Regional Environmental Plan No 2 – Georges River Catchment (1999 EPI 52)

The *Greater Metropolitan Regional Environmental Plan No 2 – Georges River Catchment* (1999 EPI 52) (the plan) is applicable to development in the local government areas situated within the Georges River catchment. This plan aims to *maintain and improve the water quality of the Georges River and its tributaries* by ensuring that development within the catchment does not impact adversely on groundwater or surface water quality.

Under the plan, the planning principles are to be applied when a consent authority determines a development application (Part 2, 7 (b). As Part 2 of the plan applies, the following planning requirements that must be addressed that are relevant to the REF and EIS proposals and this assessment include:

- *Acid Sulphate Soils.*
- *Bank Disturbance.*
- *Land degradation (including erosion, sedimentation, pollution of ground or surface water and adverse effects on habitats and sensitive natural environments within the catchment).*
- *Stormwater runoff.*
- *Water quality.*
- *Wetlands.*

Land degradation processes should be avoided where possible or minimised where avoidance is not possible with the aim of reducing the impact of the development on water quality of the sensitive receiving environment, and the flow on effects associated with ecosystem health.

Construction and operation of the proposal would meet the aims of the plan through an avoid, manage, mitigate and monitor approach. During construction, this would occur by managing dirty water on-site through a network of erosion and sediment controls. Where captured stormwater cannot be reused on site or evaporated from its collection point, it would be discharged off-site by following guideline procedures. During operation, model results in the concept strategy show that with stormwater quality treatments, there is a reduction in the annual average weight of most pollutants. However, total nitrogen increases by 3.8 kg in the Georges River sub catchment and 7.4 kg in the Milperra Drain sub catchment. Safeguards and additional investigations would occur during detailed design to further minimise these increases.

Construction and post-construction water quality monitoring would occur upstream and downstream of the proposal to ensure that controls and site practices are effective at maintaining current environmental values.

3.7. Bankstown Local Environment Plan 2015

The *Bankstown Local Environment Plan 2015* (BLEP) aims to make local environmental planning provisions for land in the Bankstown Local Government Area (LGA) in accordance with the relevant standard environmental planning instrument under section 3.20 of the Act.

In particular, the aim of this BLEP 2015 is to manage growth that contributes to sustainability of the Bankstown community. The BLEP 2015 aims to protect and enhance landform and vegetation with particular focus on foreshores and bushland through the protection of the natural, cultural, and built heritage of the Bankstown LGA. Another aim of the BLEP 2015 is to consider the cumulative impact of development on the natural environment, waterways, on the capacity of infrastructure, and on the road network. Part 6 Clause 6.4A – Riparian land and watercourses is relevant for this assessment with the objectives of the clause to protect and maintain the following:

(a) water quality within watercourses,
(b) the stability of the bed and banks of watercourses,

(c) aquatic and riparian habitats,
(d) ecological processes within watercourses and riparian areas.

As described above under the *Greater Metropolitan Regional Environmental Plan No 2 – Georges River Catchment,* construction and operation of the proposal would meet the aims of Part 6 Clause 6.4A through an avoidance, management, mitigation and monitoring approach to ensure that water quality, the stability of bed and banks, aquatic and riparian habitats, and ecological processes within these environments is protected and maintained.

3.8. Bankstown Development Control Plan 2015

Part B12 of Bankstown Development Control Plan (DCP) 2015 supplements the LEP by providing additional objectives and development controls to control the development of flood liable land in the City of Bankstown. The objectives of Part B12 of the DCP:

(a) Reduce the risk to human life and damage to property caused by flooding through controlled development on land affected by potential floods.
(b) Apply a "merit-based approach" to development – takes account of social, economic and environmental as well as flooding considerations in accordance with the principles contained in the NSW Floodplain Development Manual (FDM).
(c) To control development and other activity within each of the individual floodplains within the City of Bankstown having regard to the characteristics and level of information available for each of the floodplains.
(d) To assess applications for development on land that could be flood affected in accordance with the principles included in the FDM, issued by the State Government.

The floodplains within the City of Bankstown are divided into categories of flood risk precincts (FRPs). The proposal area is situated within the high to medium flood risk precinct as detailed within the Bankstown DCP (2015). Areas of high FRPs are areas subject to a high hydraulic hazard or significant evacuation difficulties and located within the land impacted by the 100-year flood. Development should be restricted in these areas. Areas of medium FRPs are areas not subjected to a high hydraulic hazard or significant evacuation difficulties and located within the land impacted by the 100-year flood. Significant risk of flood damage can occur in these areas.

The measures that would be considered during the detailed design phase in order to manage construction and operational related flood risks and impacts are outlined in the Flooding Assessment Report (Lyall & Associates 2021).

3.9. Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Governments (ANZG 2018 – previously ANZECC 2000) have published the Australian and New Zealand Guidelines for Fresh and Marine Water Quality to provide benchmarks for assessment of the existing water quality of freshwater, groundwater and marine waters. These guidelines were developed as part of the National Water Quality Management Strategy (NWQMS).

The objectives of these guidelines are to provide guidance on the management of water quality of uses or values which include natural aquatic ecosystems, drinking water, primary industries, recreation and cultural and spiritual values. The proposal is located adjacent to a sensitive receiving environment of the Georges River estuary and its tributaries, which contain mapped coastal wetland. These coastal wetland ecosystems are protected under the SEPP 2018 – Coastal Management. The level of species protection assigned to the surrounding hydrological system is 'high conservation or ecological values systems' (ANZG 2018).

4. BACKGROUND

4.1. Existing Environment

4.1.1. Biodiversity

Mapped coastal wetland adjacent to the proposal area incorporates two Threatened Ecological Communities (TECs) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The ecological communities are provided in Figure 4-1 and include:

- Coastal Swamp Oak Forest of New South Wales and South East Queensland, which are mapped along the Georges River.
- Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion, which are mapped along Milperra Drain.

Mapped Plant Community Types (PCTs) adjacent or within the proposal area are provided in Figure 4-1 and include:

- Broad-leaved Ironbark – Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion (PCT 725) – *Endangered Biodiversity Conservation Act 2016* (BC Act).
- Coastal Freshwater Lagoons of the Sydney Basin and South East Corner (PCT 781) – *Endangered BC Act*.
- Forest Red Gum – Rough-barked Apple Grassy Woodland on Alluvial Flats of the Cumberland Plain, Sydney Basin (PCT 835) – *Endangered BC Act*.
- Swamp Paperbark – Swamp Oak tall shrubland on estuarine flats, Sydney Basin and South East Corner Bioregion (PCT 1236) – *Endangered BC Act*.
- Swamp Oak open forest on river flats of the Cumberland Plain and Hunter Valley (PCT 1800) – *Endangered BC Act*.
- Swamp Oak Swamp Forest Fringing Estuaries, Sydney Basin and South East Corner Bioregion (PCT 1234) – *Endangered BC Act*.

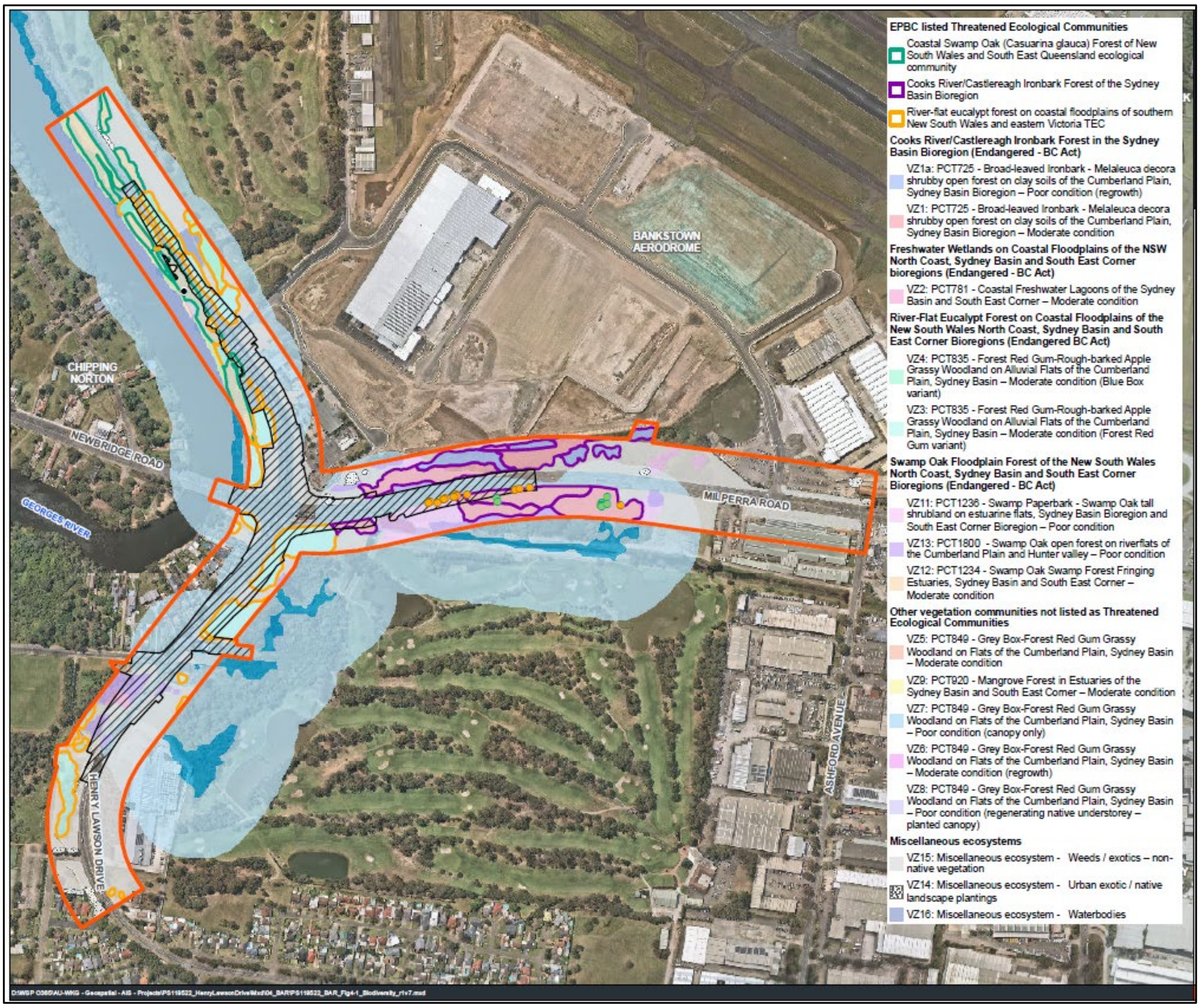

Figure 4-1 Biodiversity constraints for the proposal (source: WSP May 2021)

4.1.2. Climate

The closest weather station to the study area is Bankstown Aerodrome AWS (station number 066137) (BOM 2020). Rainfall records (BOM 2020) the station indicate a mean annual rainfall of 866.4 mm, that rainfall is generally greatest over summer. The average monthly maximum occurs in February (107.5 mm). The mean maximum temperature is in January (28.5 °C) and mean minimum temperature is in July (5.2 °C).

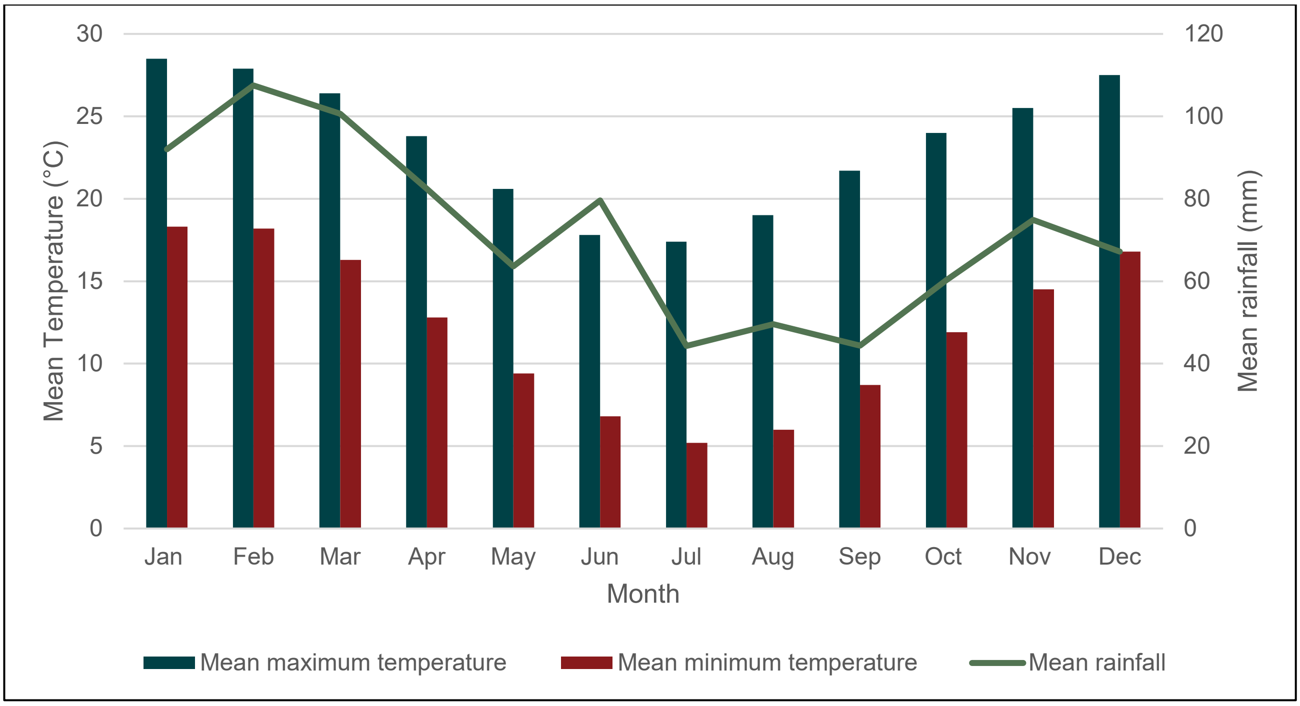

Figure 4-2 Mean monthly rainfall, mean minimum and maximum temperatures for Bankstown Aerodrome AWS (station 066137) for the years 1968 to 2021 (BOM 2020).

4.1.3. Soil, Geology and Topography

The proposal is located on an alluvial landscape unit, which is situated < 10 m above ground level (m AGL). The floodplains are mainly flat with slopes <1% (eSPADE 2021).

The underlying geology of the proposal area are Quaternary alluvial deposits, which are up to 2.5 million years old (Geological Survey of NSW 2021). The deposits include current and recent mud, silt, sand and gravel deposited by the river systems (Geological Survey of NSW 2021) and sourced from surrounding sandstone and shale (eSPADE 2021).

Two soil landscapes occur across the proposal area and are described in Table 4-1. Soil landscape reports are provided in Appendix A.

Table 4-1 Soil landscape data (eSPADE 2021).

Soil Landscape / Landscape Unit	Location in proposal area	Soil	Erosion Hazard
Richmond **Alluvial plains**	Directly adjacent to Henry Lawson Drive east and west, north of the intersection. For a short distance, west of Henry Lawson Drive south of the intersection.	Poorly structured orange to red clays loams, clays and sands. Texture may increase with depth. Kurosols (Australian Soil Classification) / Red Podzolic Soils (Greater Soil Group) occur within the Richmond Soil Landscape and within the proposal area.	Due to the low position in the landscape and generally good vegetation cover, the erosion hazard for non-concentrated flows is low. Erosion hazard for concentrated flows is moderate to high. The erosion hazard of these soils once vegetation is cleared is very high.
Disturbed Terrain **Areas disturbed by human activity.**	Across Henry Lawson Drive south of the intersection. East of Henry Lawson Drive north of the intersection (Bankstown Aerodrome).	Original soil has been removed, greatly disturbed or buried.	Limitations are dependent on the nature of the fill material. Limitations include mass movement hazard, soil impermeability, poor drainage and low fertility.

Acid Sulphate Soils

Acid Sulphate Soils (ASS) mapping for the proposal area indicate there is a high probability of occurrence from 1-3 m below ground surface in some areas to > 3 m below ground surface in other areas (Figure 4-3). ASS soils in the study area include (Cardno 2018):

- Class 3 soils, which are likely around Milperra Drain and the water areas of the Bankstown Golf Club (likely beyond 1 m below natural ground surface).
- Class 4 soils bordering the Georges River (likely beyond 2 m below natural ground surface).
- Class 5 soils located in other areas of the Bankstown Gold Club (unlikely but within 500 m of Class 3 and 4 above).

An ASS investigation (Cardno 2018) indicated that ASS are present at depths > 1.5 metres Below Ground Level (m BGL). The area where the investigation occurred is within proximity to the proposal. There is a very high probability of ASS being encountered to depths of 3 m in areas of the REF proposal, around the northern extent of the proposal area. EIS proposal areas 1 and 3 are within areas with a very high probability of ASS between 2 and 4 m below ground surface (Aurecon 2021).

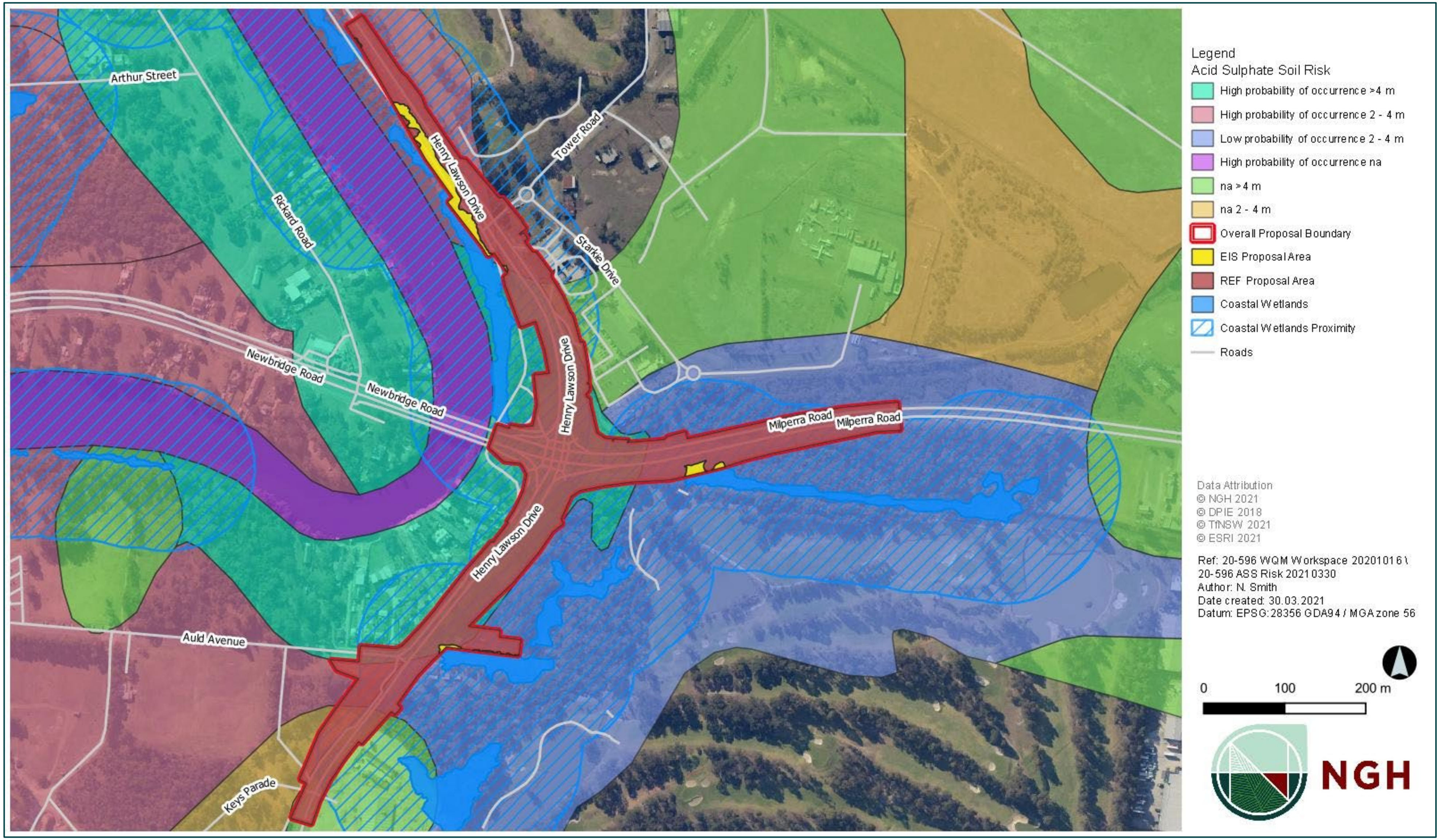

Figure 4-3 ASS probability of occurrence mapping for the proposal area.

Contamination

Aurecon Australasia Pty Ltd (Aurecon) prepared a Preliminary Site Investigation (PSI) (Aurecon 2021) for the proposal. Registered contaminated sites under the NSW EPA public register identified four sites in proximity to the proposal. These include, with relevance to the REF/EIS proposals:

- A former landfill that abuts the southernmost area of the proposal to the east (REF proposal and EIS proposal area 3).
- Caltex Service Station approximately 600 m east.
- United Group Rail Pty Limited landfill approximately 850 m east.
- BP Truck Stop Service Station abuts the central north east portion of the proposal (REF proposal and EIS proposal area 1).

PFAS has been detected in groundwater, surface water and soil at Bankstown Aerodrome, approximately 80 m west, and Department of Defence unexploded ordnance is within 3 km of the proposal. Historical practices at the Bankstown Aerodrome could have impacted soils, surface water and groundwater and are located adjacent EIS proposal areas 1 and 2. However, it is unlikely that contaminants of either of these locations would impact the proposal (Aurecon 2021).

The PSI (Aurecon 2021) identifies a moderate risk of CoPCs being present at concentrations above Tier 1 screening values and/or waste classification guidelines in the proposal area, which could be hazardous for the environment during construction works.

CoPCs that are likely to be encountered in soils and groundwater (Aurecon 2021) across the REF proposal area include:

- Heavy metals (Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Zinc).
- Polychlorinated Biphenyls (PCBs).
- Total Recoverable Hydrocarbons (TRH).
- Polycyclic Aromatic Hydrocarbons (PAH).
- Per and Poly-Fluoroalkyl Substances (PFAS).
- Volatile organic compounds (VOCs).
- Asbestos in soils.
- Inert landfill wastes.
- Landfill gasses (i.e. methane and carbon dioxide).
- Asbestos in fill material (given the elevated LOR used in 2019).

CoPCs that are likely to be encountered in soils and groundwater (Aurecon 2021) across the EIS proposal areas include:

- Heavy metals.
- PCBs.
- TRH.
- PAH.
- PFAS.
- VOCs.
- Asbestos in soils.
- Inert landfill wastes (EIS proposal area 3 only).
- Landfill gasses (EIS proposal area 3 only).

4.1.4. Hydrology and Water Quality

The Georges River and Milperra Drain are the receiving waters adjacent to the proposal area. The Georges River estuary is a drowned river valley (Alluvium 2020). The Georges River is located to the west of the proposal area and Milperra Drain to the east. The Georges River is categorised as a 7th order stream under the Strahler Stream Categorisation (DoI 2018) system. The Milperra Drain is a minor tributary of the Georges Rivers and is classified as a 2nd order stream. Sydney KFH mapping (DPI 2017) includes the Georges River estuary upstream and downstream of the proposal.

The estuary is delimited by the Liverpool Weir. The tidal range within the Georges River is less than 0.1 m from the Liverpool Weir to Botany Bay (BMT WBM 2013).

Coastal Wetlands are mapped adjacent to and within the proposal area (Figure 5-1). EIS proposal area 1 is in proximity to the Georges River and EIS proposal areas 2 and 3 are in proximity to Milperra Drain.

Existing Surface Water Quality

History

Surface water quality of waterways within the study area has been heavily impacted over the last two centuries due to changing land uses within the catchment and in-channel works (BMT WBM 2013).

Early settlement in the catchment was followed by land clearing and agriculture causing an increase to sediment loads and nutrients in the waterways. Additional impacts to water quality through the 20th century were due to the transition of the catchment from rural to urban land use (BMT WBM 2013). Historic and current impacts to water quality include sediment loading, contaminated leachate (including sewage) and polluted urban runoff (BMT WBM 2013), into the waterways of the study area.

Additional impacts to water quality were a result of uncontrolled sand extraction in the mid-20th century in the upper reaches of the Georges River, now the Chipping Norton Lakes. In-channel sand extraction resulted in reduced tidal flushing, enhanced bank erosion and water pollution (BMT WBM 2013).

Current Surface Water Quality

Vertically mixing occurs within the water column of the Georges River and its tributaries resulting in minor differences between the top and bottom profiles of the water column. The surface water in the study area is considered to be brackish with typical salinity values of 5 -10 parts per thousand (ppt) (BMT WBM 2013). This indicates that the tidal exchange starts to diminish in the Georges River reach in the study area. As the tidal exchange diminishes, tidal flushing also diminishes reducing pollution dispersion (BMT WBM 2013). It is noted that on occasion water quality monitoring occurs following rainfall, which sometimes explains the large differences in monitoring results. The range of values and the mean have been provided for the data provided from the Georges Riverkeeper and NGH, below.

Georges Riverkeeper is an organisation that works with eight member councils to care for the Georges River. Part of the work they undertake includes water quality monitoring at sites along the river. The closest WQM site to the proposal area is located at the mouth of Prospect Creek, approximately 1.7 km upstream. Surface water quality data collected at this location by Georges Riverkeeper since 2011 is included in Appendix B. 2019 and 2020 data are provided in Table 4-2. Older data includes pH, salinity and dissolved oxygen (% saturation).

Table 4-2 Surface water quality data or 2019 and 2020 (supplied by Georges Riverkeeper 2021).

	Dissolved Oxygen (% saturation)	Salinity (ppt)	pH	Turbidity (NTU)	Temperature (°C)	Total Dissolved Solids (TDS ppt)
Range	12.7 – 117.8	0.16 – 10.71	6.39 – 7.91	0.8 – 83.8	10.5 – 34.5	0.187 – 17.1

	Dissolved Oxygen (% saturation)	Salinity (ppt)	pH	Turbidity (NTU)	Temperature (°C)	Total Dissolved Solids (TDS ppt)
Mean	73.46	4.57	7.33	11.16	22.33	6.73

Surface Water Quality Monitoring

NGH was engaged by Lyall and Associates to complete a Water Quality Monitoring (WQM) Program for the proposal. The objectives of this surface WQM program is to collect site-specific baseline surface water quality data to understand the existing environment for this assessment.

The baseline surface water quality data may also be used by the construction contractor to demonstrate if impact to the SEPP Coastal Wetlands has/has not occurred during the construction period.

The WQM data are provided in Appendix C.

Methodology

The surface WQM locations are presented in Figure 4-4.

Surface WQM location SW01 was selected to target SEPP Coastal Wetland and is located upstream of the culvert discharging to Georges River from the catchment of the Bankstown Aerodrome redevelopment work, currently in construction.

Surface WQM location SW02 was selected to target SEPP Coastal Wetland and is within the Milperra Drain. Council is commencing their construction works on widening Milperra Drain. Surface water quality monitoring was taken from upstream of the Council works.

Surface WQM samples were sampled and analysed monthly from 4th November 2020 to 10th February 2021.

Surface water monitoring will include:

- Field parameters –dissolved oxygen, pH, turbidity, total dissolved solids, temperature, oxidation reduction potential, conductivity, specific conductance, salinity and GPS coordinates.
- Visual observation – Oil and grease (optical).
- Laboratory – Total suspended solids (TSS).
- Field observations – weather and rainfall (prior to and at the time of the sampling event), surrounding influencing factors/ e.g. land use activities, events, incidents.

The PSI (Aurecon 2021) recommends a Detailed Site Investigation (DSI) to identify the presence of CoPC. The DSI is recommended to be prepared in detailed design. The findings from the DSI should be used to update this assessment.

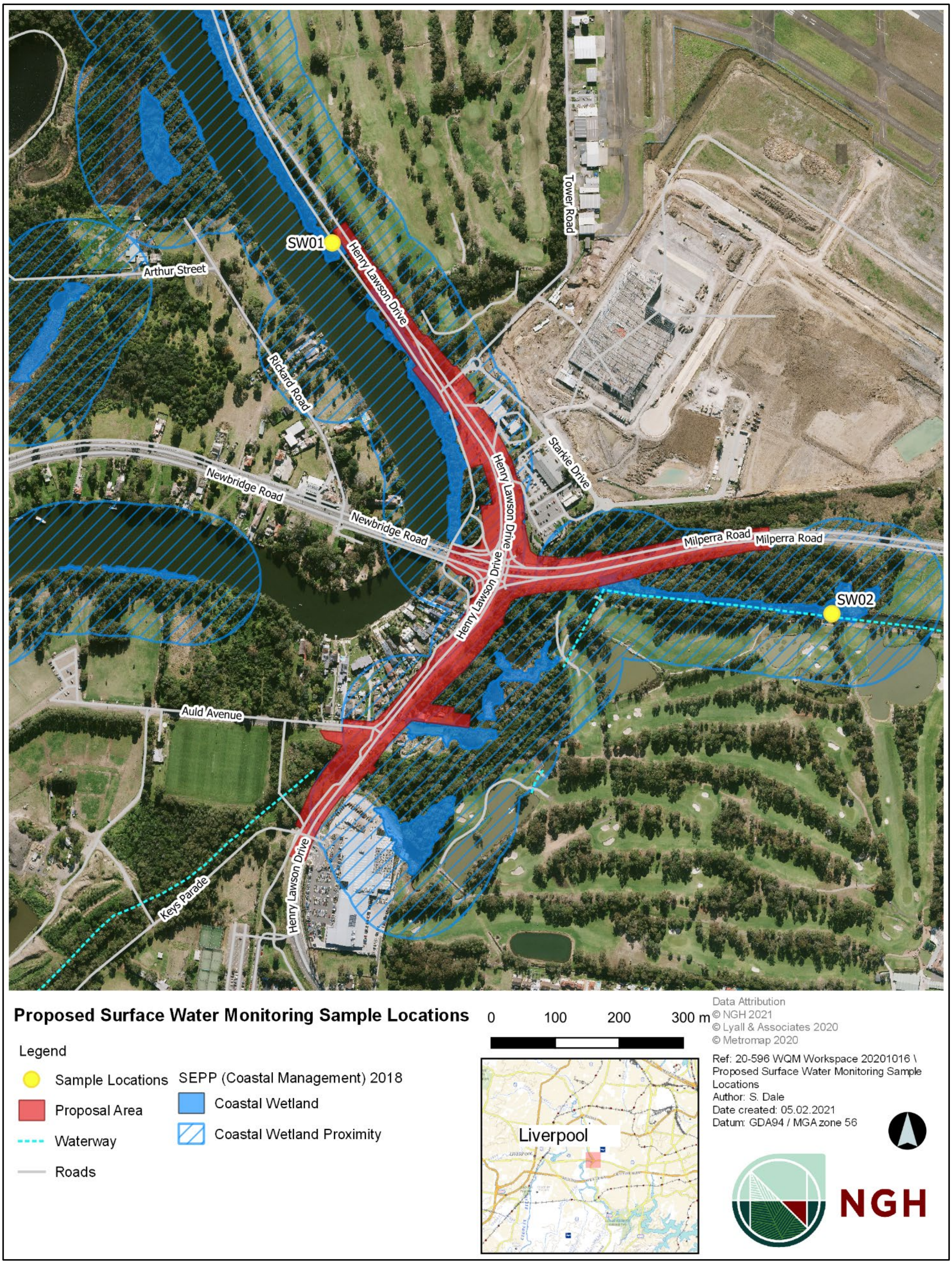

Figure 4-4 Water quality sampling location and the proposal area.

Results

Visual Field Observations

The visual observations of the water quality at SW01 at the sampling events was slightly turbid water. The visual observations of the water quality at SW02 at the sampling events was clear water and turbid when the channel bed was disturbed.

Result Assessment

The results of the parameters analysed in the field and by the laboratory have been averaged across the four sampling events and are included in Table 5-3. The full results for the surface WQM are included as Appendix C.

Table 4-3 Monthly surface water quality monitoring results for each monitoring location (November 2020 to April 2021).

Parameter	Unit	SW01		SW02		Comment
		Result range	Mean	Result range	Mean	
Oil and grease	Presence / Absence	Absent	Absent	Present - Absent	Absent	
Dissolved Oxygen (DO)	mg/L	0.12 – 10.54	4.53	2.81 – 16.04	9.45	When DO is too low, it can lead to loss of biota (e.g. fish kills) (ANZECC 2000). Low DO concentrations range from <2 – 4 mg/L and hypoxic DO concentrations (>0 – 2.0 mg/L) (WA Government 2017). Therefore, the levels of DO concentrations range from hypoxic to high. However, it is also noted that the DO concentrations should be taken determined by consecutive diurnal measurements under different weather conditions as DO concentrations fluctuate with temperature, salinity and air pressure (USGS n.d.). For example, at 20°C, 100% dissolved oxygen saturation for freshwater is 9.09mg/L. At the same temperature, 100% saturation for sea water is 7.34mg/L (Estuary Watch n.d.).
pH (field)	-	7.2 – 8.11	7.64	7.05 – 8.37	7.79	These values are within the pH range of 7.0 – 8.5 (DECCW 2006).
Temperature	°C	20.5 – 26.5	24.0	22.9 – 28.6	25.03	Temperatures over the summer months did not exceed the 29 °C as detailed in SMEC (2010).

Parameter	Unit	SW01		SW02		Comment
		Result range	Mean	Result range	Mean	
Oxidation Reduction Potential	mV	115.2 – 181.6	157.4	6.2 – 229.8	144.15	
Conductivity	S/m	0.00135 – 1.0898	0.3845	0.00111 – 0.1257	0.0815	
Specific Conductance	µS/cm at 25 °C	745 - 15246	6732	675 – 2352	1402.4	
Salinity	ppt	0.36 – 6.24	2.674	0.33 – 0.98	0.60	The higher salinity values are well within the range of historic salinity values of 5 – 10 ppt (BMT WBM 2013).
Total Suspended Solids	mg/L	<5 – 44	22	7 – 1420	12	Total Suspended Solids (TSS) refer to the particles that are larger than 1.2 microns and measured in the water column. Four of the five results were under 22 mg/L with one reading (4/11/2020) of 1420 mg/L (excluded from the mean).
Turbidity	NTU	3.6 – 31.67	17.64	2.9 – 9.73	6.32	Turbidity is a measure of the opacity of water and measured in Nephelometric Turbidity Units (NTU). Turbidity measurements include the suspended and dissolved loads. Refer to section 5 for the impacts of increased turbidity in waterways. The average NTU for the Georges River 1.7 km upstream of the proposal is 11.2 NTU (Georges Riverkeeper Data Appendix B).

Parameter	Unit	SW01		SW02		Comment
		Result range	Mean	Result range	Mean	
Total Dissolved Solids	mg/L	9 - 7080	2507.75	7 – 1254.5	605.17	TDS is a measure of all inorganic salts and organic compounds dissolved in water and therefore, a guide to water quality. The average TDS for the Georges River 1.7 km upstream of the proposal is 6,700 mg/L (Georges Riverkeeper Data Appendix B).

4.2. Ecological Values and Protection Levels

In the proposal area there are two threatened ecological communities under the EPBC Act and six listed as endangered under the BC Act (refer to section 4.1.1). Threatened flora and fauna are also part of these threatened ecological communities. These listed ecological communities contribute to the ecological values of the Georges River and its tributaries, as outlined in the GRECZMP (BMT WBM 2013). Key community values recorded include recreational activities, bushwalking and visual amenity that relate to overall health of the environment bushwalking, aesthetics, and recreational activities that depend on ecosystem health (BMT WBM 2013). To conserve the ecological values and the community values, conservation of the existing environment must be complemented by improvements in waterway health as a priority when managing any development (BMT WBM 2013).

An assessment of the ecological values of the proposal area, as described in the GRECZMP, in consultation with the ANZG (2018) condition categories resulted in the assignment of 'high conservation or ecological values system' category. The receiving waters of the proposal area are in a highly modified and urbanised environment. However, the high conservation value attributed to the remaining coastal wetlands in the Georges River estuary and tributaries result in a higher level of protection. The attributes of this category include highly valued ecosystems (ANZG 2018).

Indicative protection levels have been identified for the receiving waters using ANZG (2018) *Guidelines for Fresh and Marine Water Quality* and the *Water Quality Objectives* in NSW. The level of protection is defined as the degree of protection given to the waterway based on its ecosystem condition (ANZG 2018). To high ecological/conservation value systems, a 99% species protection Derived Guideline Value (DGV) should be applied when assessing water quality for toxicants (ANZG 2018).

However, the degree of protection afforded to a waterbody can also be based on its 'desired' ecosystem condition relative to the degree of human disturbance (ANZG 2018). The study area contains mapped areas of Coastal Wetland, identified under the *State Environmental Planning Policy (Coastal Management SEPP) 2018,* which is one of four coastal management areas under the *Coastal Management Act 2016*. Coastal wetlands are considered environmentally sensitive ecosystems to be preserved and protected (DPIE 2018).

The level of protection for this category can be determined using baseline data or an agreed threshold (ANZG 2018). Due to the historical anthropogenic impact to the estuary of the last two centuries, the natural variability of the receiving waters is already highly disturbed. However, the Georges Riverkeepers through local government and state legislation, have been working to improve water quality and wetland environments of the estuary through ongoing monitoring and education programs.

In summary, water quality leaving the site should avoid any impact to the current water quality as described in Table 4-5.

4.3. Indicators to the Risk of Environmental Values

Estuary health indicators adopted in the GRECZMP (BMT WBM 2013) for monitoring programs include:

- Chlorophyll a.
- Turbidity.
- Physico-chemical indicators such as salinity, dissolved oxygen, pH and temperature.
- Physical distribution change of estuarine macrophytes.
- Riparian vegetation distribution and condition.

The indicators used for this assessment and justification are included in Table 4-4.

Table 4-4 Indicators used for water quality monitoring.

Indicator	Stressor	Construction / Operation	Justification
Oil and grease (optical)	Increase	Construction Operation	Indication of petroleum hydrocarbons, oils, greases and lubricants that have the potential to spill or leak from use of plant and machinery during construction. Provided as an indicator by Transport (2020) and RTA (2011).
Dissolved oxygen (DO)	Decrease	Construction Operation	Indicates if the presence of a disturbance to the equilibrium of oxygen-consuming processes and oxygen-releasing processes and defines the saturation of oxygen in the water column (ANZG 2018). Reduction in DO leads to low or hypoxic conditions, limiting living conditions for aerobic organisms.
pH	Increase or decrease	Construction Operation	Low pH can cause adverse effects to fish and aquatic insects (ANZG 2018). Changes to pH, particularly a reduction, can lead to the increase in toxicity of several pollutants including aluminium, ammonia and cyanide. Indication of impact of acidic leachate from disturbance of ASS.
Temperature	Increase or decrease	Construction Operation	Loss of native organisms (ANZG 2018). Temperature is important in regulating other physical and chemical stressors such as DO.
Oxidation reduction potential (ORP)	Decrease	Construction Operation	Measures the ability of the waterbody to break down waste products. High ORP means lots of oxygen in the water for bacteria to efficiently decompose dead tissue and contaminants (Horne & Goldman 1994).
Conductivity	Increase or decrease	Construction Operation	The ability of water to conduct an electrical current. Changes in salinity (conductance) should be less than 5% from background levels in estuarine waters (ANZG 2018).
Specific Conductance	Increase or decrease	Construction Operation	Conductivity corrected to 25 °to allow comparable data.

Indicator	Stressor	Construction / Operation	Justification
Salinity	Increase or decrease	Construction Operation	Loss of native organisms. Used as an indicator of electrical conductivity (ANZG 2018). Salinity is used to measure salts in the water and includes Sodium, Chloride, Calcium, Magnesium, Potassium, carbonate and sulphate.
Total Suspended Solids (TSS)	Increase	Construction Operation	Increases in total suspended solids can blanket macrophytes and bed dwelling (benthic) organisms. Suspended fine particles also reduce light penetration through the water column, thereby reducing primary production, and clog fish gills (refer section 4.2.1). Landcom (2004), DECC (2008), Transport (2020) and RTA (2011) list TSS as an indicator.
Total Nitrogen (TN)*	Increase	Operation	Increase in TN concentration stimulates nuisance plant growth (e.g. algal blooms).
Total Phosphorus (TP)*	Increase	Operation	Increase in TP concentration stimulates nuisance plant growth (e.g. algal blooms).
Total Dissolved Solids (TDS)	Increase or decrease	Construction Operation	Increases or decreases in TDS can limit the growth of aquatic organisms and can be fatal. High levels of TDS reduce water clarity and increase turbidity.
Turbidity	Increase	Construction Operation	Refer to section 5 for the impacts of increased turbidity in waterways.

*TN and TP were not part of the water quality monitoring program. However, criteria have been included for these based on the ANZG (2018) guidelines for estuaries.

4.4. Water Quality Guidelines

Table 4-5 contains guideline values for the Georges River aquatic ecosystems and its tributaries as listed under the:

- ANZG (2018) (previously ANZECC 2000) Water Quality Guidelines for estuaries in South-east Australia.
- Water Quality Objectives (WQO).
- Managing Urban Stormwater – Soils and Construction Volume 1 (Landcom 2004) and 2D (main road construction) (DECC 2008) discharge guidelines.

Oil and grease guideline value as adopted by Managing Urban Stormwater (V1 2004 and V2D 2008) is 10 mg/L, by observation. Table 4-5 also contains the Georges Riverkeeper data from approximately 1.7 km upstream and the WQM results of SW01 (Georges River) and SW02 (Milperra Drain) for comparison.

The Georges River catchment in the study area is categorised as 'waterways affected by urban development' (DECCW 2006). The relevant water quality objectives for this reach of the Georges River and tributaries (including Milperra Drain) include the protection of (DECCW 2006):

- Aquatic ecosystems.
- Visual amenity.
- Primary contact recreation (longer term objective – 10 years or more).

The GRECZMP (BMT WBM 2013) includes an objective that all greenfield and redevelopments should meet the targets for water quality that are proposed in the Botany Bay and Catchment Water Quality Improvement Plan (WQIP) (Sydney Metropolitan Catchment Management Authority (SMCMA) 2011). These have been established with the aim of achieving best management practice for controlling pollutant loads in stormwater runoff within the Botany Bay catchment. The stormwater pollution reduction targets for greenfield and large re-developments that are contained in the Botany Bay and Catchment WQIP (SMCMA 2011) are:

- Gross pollutants – 90%
- Total suspended solids (TSS) – 85%
- Total phosphorus (TP) – 60%
- Total nitrogen (TN) – 45%

The Botany Bay and Catchment WQIP (SMCMA 2011) also includes a recommendation that NSW Government ensure that infrastructure developments minimise their negative impact on water quality.

Note that the ability to install water quality arrangements to meet current best management practice guidelines for the treatment of all runoff from the proposal corridor (not just from the additional paved area associated with the upgrade works) is constrained by the prevailing topography and limited corridor area as well as the configuration of the existing drainage system. Furthermore, the piped drainage systems that presently control runoff along the proposal corridor also control runoff from adjoining urban areas. It is therefore not practicable to treat runoff from the proposal corridor in isolation of the broader catchment. A more holistic approach to water quality within the broader stormwater network is therefore required.

Based on the above, an assessment has been made of the potential pollutant loads at locations downstream of the proposal corridor under present day (ie. pre-proposal) and post-proposal conditions. A set of management measures have been identified to offset increases in pollutant loads as a direct result of the proposal in order to meet the water quality objectives and maintain the environmental values for the Georges River Estuary and tributaries (refer section 1.1.2).

Where feasible, further measures to meet the Botany Bay and Catchment WQIP (SMCMA 2011) targets would need to be considered on a catchment wide basis, which is discussed further in Section 7.4.

Table 4-5 Water Quality guideline values and WQM results.

Indicator	ANZG (2018) Trigger Value	WQOs Trigger Value	Managing Urban Stormwater (V1 and V2D)	Georges Riverkeeper Data	WQM Results	
					SW01 Mean	SW02 Mean
Dissolved oxygen (DO) % saturation	80 – 110	80 – 110	-	73.46	4.5 mg/L	9.45 mg/L
Turbidity NTU (Nephelometric Turbidity Unit)	0.5 – 10	0.5 – 10	-	11.16	17.64	6.32
pH	7.0 – 8.5	7.0 – 8.5	6.5 – 8.5	7.33	7.6	7.8
Total suspended solids (TSS) mg/L	-	-	<50	-	22	12
Total dissolved solids mg/L	-	-	-	6.73	2507.8	605.1
Total Nitrogen µg/L	300	300	-	-	-	-
Total Phosphorus µg/L	30	30	-	-	-	-

5. IMPACTS OF TURBIDITY ON WATERWAYS AND RIPARIAN ENVIRONMENTS

5.1.1. Turbidity and Suspended Solids

Turbidity and Suspended Solids

Turbidity is a measure of the opacity of water and measured in Nephelometric Turbidity Units (NTU). It is an optical property of a liquid that causes light scatter and absorption (Brunton 1985). Turbidity measurements include the suspended and dissolved loads. These loads are what cause light scatter and absorption (Brunton 1985). The colour of the water column impacted by dissolved organic material contributes to the turbidity measurement. However, suspended sediments are usually the main contributor to turbidity (Dunlop et al. 2005).

In comparison, Total Suspended Solids (TSS) refer to the particles that are larger than 1.2 microns and measured in the water column (Dunlop et al. 2005). In comparison, particles in liquid smaller than two microns are considered dissolved solids. Measurements of suspended solids and dissolved solids are usually in metric mg/L.

Measurements of TSS and turbidity are not interchangeable. However, a correlation between TSS and turbidity can be made with long term monitoring of both turbidity and TSS measurements from the same water body (Henly et al. 2010). Turbidity measurements are often preferenced for field sampling as handheld turbidity measurement devices are simple to use. Once a correlation is determined, turbidity can be used and related to TSS.

Turbidity Impacts on Aquatic Environments

Suspended solids on the aquatic environment can have direct impacts on aquatic organisms (e.g. blanketing organisms on the channel bed) or indirect impacts (e.g. reduction of light penetration through the water column). The geochemical and physical characteristics of suspended solids, and the physical dynamics of the system they are within, are important to consider when assessing ecological and biological impact on the aquatic environment (Dunlop et al 2005).

Population decline in aquatic organisms is often a result of turbidity and sediment accumulation on the bed of the waterbody (Henly et al. 2010). Although most aquatic organisms are able to withstand short term exposures to suspended solids, negative impacts are likely to increase with increasing duration and magnitude of exposure events (Dunlop et al 2005).

Direct impacts of increases in suspended solids include blanketing of the macrophytes and bed-dwelling organisms (Dunlop et al 2005). Fine sediment is also responsible for clogging the gills of fish. The high capacity of the fine particles for ion exchange enables them to bind with biological membranes gills in fish and invertebrates (Pusey and Arthington 2003). The high ion exchange capacity of the fine silt and clay particles also enables them to bind with contaminants such as heavy metals and nutrients (Dunlop et al 2005).

Light is the primary source of energy in aquatic ecosystems (Boulton and Brock 1999). High levels of turbidity result in a reduction of light penetration in the water column (Pusey and Arthington 2003). The impact of reduced light penetration on aquatic environments is decreased primary production as a result of reduced ability for plants to photosynthesise (ANZG 2018). Depleted food sources result in declines in populations of fish, insects, molluscs, invertebrates and microorganisms (Henly et al. 2010).

Decreased light penetration can also impact the temperature of the water column. Changes to the regular temperature range can affect temperature-sensitive species by altering breeding cues and in other species there may be direct physiological effects (Dunlop et al. 2005).

Water naturally degrades contaminants, including herbicides and pesticides, with regular – optimum light penetration. When light penetration is reduced, the ability of the waters to breakdown contaminants by photolysis is decreased (Dunlop et al. 2005).

The deposition and re-suspension of sediments within a river enhances the erosive potential of these particles to scour channel bed and banks with increases in velocity (Pusey and Arthington 2003; Dunlop et al 2005). This in-channel erosion results in further sedimentation and turbidity impacts downstream.

5.1.2. Wetlands and Water Quality

Wetlands typically are a diverse ecosystem of plants and animals. They have the capacity to maintain and improve water quality by acting as filtering systems, removing pollutants, nutrients, and sediments (Australian Government 2016).

Water quality improvement occurs in various ways and includes (Australian Government 2016):

- Reducing in-channel erosion by spreading out and slowing down flows, thereby reducing sediment transport and accumulation downstream where it may affect other ecosystems.
- Wetlands in healthy condition can process and store nutrient and contaminants in the soils and vegetation. They can also reduce harmful bacteria.
- Urban stormwater and effluent can also be managed by healthy wetlands through improving the removal of suspended material and nutrients prior to its release downstream.

Threats to the health of wetlands include drainage and urban runoff, water extraction, earthworks, climate change, and nutrient and soil loss from poor agricultural practices (Australian Government 2016). The result of these pressures creates impacts such as:

- Sediment loads increase water turbidity. Increased turbidity blocks light required by aquatic plants.
- Introduction of contaminants such as herbicides, insecticides and fungicides.
- Increased supply of nutrients leading to algal blooms, which can then block light and release toxins.

6. CONSTRUCTION SURFACE WATER QUALITY ASSESSMENT

6.1. Risks to Surface Water Quality

6.1.1. Construction Impacts

Key risks to surface water quality during construction of the overall proposal would be increased sediment, nutrient loadings and potential mobilisation of contaminants associated with the following:

- Site disturbance resulting from vegetation clearing and exposure of soils. Disturbance activities include:
  - Topsoil stripping.
  - Excavation.
  - Soil stockpiling and transport.
- Earthworks that could potentially disturb ASS or other contaminants within the proposal area.
- Accidental spills or leaks of petroleum hydrocarbons, oil and grease, heavy metals or chemicals could pollute receiving waters. Examples of liquids includes fuel, oil, lubricants or other chemicals from vehicles, plant and machinery used, stored or refuelled on site.
- Contaminants from wash down of vehicles.
- Construction of drainage diversions and controls.
- In-channel works to duplicate the Henry Lawson Drive bridge across Milperra Drain.
- CoPCs, from surrounding contaminating land uses, exposed as a result of earthworks. The presence of CoPCs outlined in section 4.1.3 would be further confirmed through the preparation of a DSI in detailed design.

6.1.2. Impacts to Surface Water Quality

Potential impacts for both the REF proposal and the EIS proposal as a result of construction activities includes:

- Transportation of soils into receiving waters leading to increased TSS, increased nutrient loads and increases of other potential contaminants. The presence of CoPCs outlined in section 4.1.3 would be further confirmed through the preparation of a DSI in detailed design.
- Increased in-channel sediment accumulation, which would lead to smothering of aquatic flora and fauna. Impacts would be to the immediate area and could continue downstream.
- Acidic runoff into receiving waters from earthworks in ASS from earthworks and bridge development on waterfront land.
- Pollution of receiving waters and downstream environments from accidental spills and leaks of petroleum hydrocarbons, oil and grease, heavy metals or chemicals.
- Increased levels of gross pollutants resulting from construction activities and personnel.

Potential impacts to surface water quality of receiving waters can be managed through safeguards and mitigation measures. These are discussed in section 5.6.

6.1.3. Water Use

Water demand for the overall proposal is only indicative at this stage, however given the nature and scale of the proposal, the proposal is not expected to be water intensive. Water use during construction would be minor and largely used for dust suppression and for the construction of the widened carriageway (e.g. compaction). The water requirement would vary, dependent on material sources and methodologies applied by the construction contractor, and weather conditions. Sufficient potable water would be supplied for about 70 construction staff and this is expected to be about 80kL per annum. The proposed ancillary site on Henry

Lawson Drive, for site offices, is an existing building connected to the main water supply network. For other ancillary sites, potable water would be obtained from sources such as portable office water dispensers.

All non-potable water would be sourced from construction sediment sumps, a standpipe (if one is located nearby)), local sub-contractor watercarts or an alternative nearby source. Water would be sourced responsibly and in accordance with any water restrictions at the time of construction, or relevant exemptions would be sought. The overall proposal does not propose to extract water or to apply for a licence to extract water for construction needs or for domestic purposes. Water requirements and water supply options would be further investigated during detailed design.

6.2. Avoidance, Mitigation and Monitoring

Impacts to surface water quality would be managed through avoidance, mitigation, and monitoring during construction. A Construction Soil and Water Management Plan will be prepared, inclusive of Erosion and Sediment Control Plans, and implemented as part of the Construction Environmental Management Plan (CEMP). The receiving waters have been given a protection level "high conservation or ecological value systems". Water quality should be maintained or improved within the receiving waters as referenced under the relevant legislations and policies in section 3. Mitigation measures have been provided in section 6.3 with the aim to ensure that any runoff from the proposal during construction does not increase pollution to the sensitive receiving environment and that conservation of the ecological values (refer to section 4.2) are maintained.

Monitoring of the effectiveness of the mitigation measures would occur at a location upstream and downstream of the works in the Milperra Drain and Georges River in consultation with the *Guideline for Construction Water Quality Monitoring* (RTA, undated). Monitoring is further discussed in section 6.3.3.

6.3. Safeguards and Mitigation Measures

6.3.1. Erosion and Sediment Control Strategy

A preliminary Erosion and Sediment Control Strategy (strategy) has been designed for the construction of the proposal by Lyall & Associates based on a review of the concept design in conjunction with an assessment of existing site conditions and erosion potential as described in section 4.1. The potential impacts to water quality resulting from the construction of the proposal would be minimised by implementing temporary and permanent controls as outlined in the strategy (Appendix D).

The strategy would be used as the starting point in the preparation of a Construction Soil and Water Management Plan (SWMP) or similar as part of a Construction Environmental Management Plan (CEMP) prior to construction. It is noted that this strategy is indicative only and the final Erosion and Sediment Control Strategy would be based on the final design of road upgrade works, detailed design construction staging plans, construction methodologies and site management practices.

The strategy was based on the principles and design guidelines provided in:

- *Soils and Construction – Managing Urban Stormwater series* (collectively referred to herein as the 'Blue Book'), comprising:
  - *Volume 1* (Landcom, 2004).
  - *Volume 2D – Main Roads* (Department of Environment and Climate Change (DECC), 2008).
- *Transport for NSW QA Specification G38* (Transport for NSW (Transport), 2020).
- *RTA Procedure PN 143P Erosion and Sedimentation Management Procedure* (Roads and Traffic Authority (RTA), 2008).

Key elements of the strategy include:

- Staging of erosion and sediment (ERSED) control works to ensure:
  - 'Clean water' diversion drains and/or diversion banks are in place upslope of construction activities.

  - Drainage culverts and channels to control runoff through the site are in place, including temporary drainage diversion for new culverts.
- Progressive implementation of erosion and sediment controls applicable for each stage of construction.
- Defining the access locations and locations of:
  - Shaker grids to reduce risk of sediment tracking on to surrounding roads.
  - Stockpile sites to ensure they are located away from drainage lines.
- Conservation and treatment of topsoil.
- Minimisation and stabilisation of disturbed areas particularly on waterfront land.
- Managing the extent of exposed surfaces based on their flood potential and the duration that the areas would remain exposed.
- Stabilisation of batters using blankets, mulch or vegetation.
- Scour protection in drainage lines.
- Separation of clean and dirty water.
- Stabilisation of stockpiles.
- Monitoring daily weather and rainfall forecasts.
- Site and ERSED control maintenance.
- Progressive rehabilitation and monitoring of permanent drainage measures to ensure that temporary erosion controls can be removed.

The proposal has been divided into 33 control areas based on a concept design of staging construction. Average annual soil loss would be less than 150 m^2 for each area and therefore, no sediment basins are required (Appendix D). However, temporary sediment sumps could be used to store and control the release of dirty water discharge from the proposal during construction with their potential use is described in more detail below.

Water quality monitoring of the Georges River and Milperra Drain would occur upstream and downstream of construction works. Regular WQM would ensure that the ERSED controls are operating efficiently and managing potential impacts to water quality. WQM is discussed in more detail in section 6.3.3.

The full details of the preliminary concept ERSED strategy and indicative maps are provided in Appendix D. The preliminary strategy would be further developed following the detailed design stage with detailed contour information, detailed design construction staging plans and additional ground survey.

At the construction phase, the construction contractor will develop site specific Erosion Sediment Control Plan/s as part of the Construction Soil and Water Management Plan. These would further develop the detailed design ERSED strategy and include arrangements for wet weather events, including monitoring of potential high risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather.

Erosion and sediment controls

The strategy outlines indicative approach to the implementation of ERSED controls for the 33 control areas for the Stage 1A works. The ERSED controls would be used to avoid, manage and mitigate potential water quality impacts to sensitive receiving environments to maintain environmental values. Scheduled monitoring, and monitoring following rainfall events, of controls would occur to ensure they remain undamaged and operating correctly. Immediate action to rectify the controls would occur where damage or incorrect operation is evident.

Control measures specifically for the works associated with the proposed Auld Avenue bridge duplication are provided in Appendix D.

Temporary Diversion of Dirty Water

A combination of controls would be used to control dirty water and direct it to temporary sediment sumps (sumps). These controls could include:

- Diversion drains.

- Sediment fencing.
- Bunding.

Sumps would comprise geotextile lined storage bays, temporary sump pits (lined or unlined) or a series of check dams along the diversion drains. These designs would reduce flow velocities of surface runoff, reducing the capacity of the runoff to carry heavier sediments. These heavier sediments then drop out of suspension. Sedimentation in these sumps can be removed and disposed of at a relevant facility. Where space cannot afford a sump, other inline controls would be used including straw bales and gravel filters.

Diversion drains would likely be required to control off-site and on-site water due to site constraints and the proximity of construction works to adjoining residential and commercial properties along Henry Lawson Drive. Sumps and controls along these diversion drains would be sized to cater for a larger catchment. Temporary access crossings would be maintained across diversion drains for access to adjoining properties during construction.

Clean water would be controlled by permanent catch and toe drains in conjunction with temporary diversion drains to redirect clean water run-on from the construction footprint. Transverse drainage would be developed to allow the separation and movement of clean water through the construction footprint.

Local Erosion and Sediment Control Measures

Localised ERSED control measures could be used in conjunction or in place of the sumps, particularly where space is limited within the construction footprint or where additional controls are required where works are in close proximity to the Georges River and Milperra Drain. These measures could include:

- Staging of works to minimise the extent of disturbance at any one time.
- Temporary catch drains and earth bunding to divert on-site and off-site water toward receiving drainage lines.
- Temporary stabilisation or revegetation/rehabilitation works to reduce the extent of disturbed surfaces.
- Application of temporary surface treatments or blanketing on exposed soil surfaces.
- Sediment barriers in series using sediment fencing or silt bags.
- Filtration barriers in series using strawbales across flow paths or gravel filters around pit inlets.
- Drainage channels incorporating rock check dams at regular intervals.
- Vegetative buffer strips.

The indicative locations of all controls are provided in Figure 1 of Appendix D.

Acid Sulphate Soils

It is likely that construction activities associated with the proposal (e.g. constructing bridge piers, vegetation removal, earthworks) would disturb ASS. The preparation of an Acid Sulphate Soil Management Plan (ASSMP) is recommended prior to construction to incorporate controls to prevent potential leachate of ASS into the sensitive receiving environment and to treat, reuse and dispose of ASS.

6.3.2. Construction Water Management

Management of surface water during construction would be undertaken through the Construction Soil and Water Management Plan. The Plan would include the avoidance of water discharge off-site and ensure environmental values are maintained. The *Technical Guideline – Environmental Management of Construction Site Dewatering* (RTA 2011) would be used as guidance for the process of discharging captured runoff from sumps and exposed excavations. Where practicable, captured runoff would be reused on-site following the NSW Environmental Protection Authority's waste hierarchy, which includes the following repurposing of captured runoff for:

- Dust suppression.

- Compaction of material during earthworks.
- Irrigation for vegetation establishment.
- Plant wash down where appropriate within the scope of construction activities.
- Allowing stored runoff to evaporate in consultation with the weather forecast.

Where captured runoff cannot be reused on-site, it would be discharged from sumps following the processes outlined in the *Technical Guideline – Environmental Management of Construction Site Dewatering* (RTA 2011) and in accordance with Clauses 3.3 and 3.3.4 of G38 (Transport 2020). A flow diagram for managing the discharge of captured runoff from sediment sumps and excavations is provided in Figure 6-1 (refer also Appendix D).

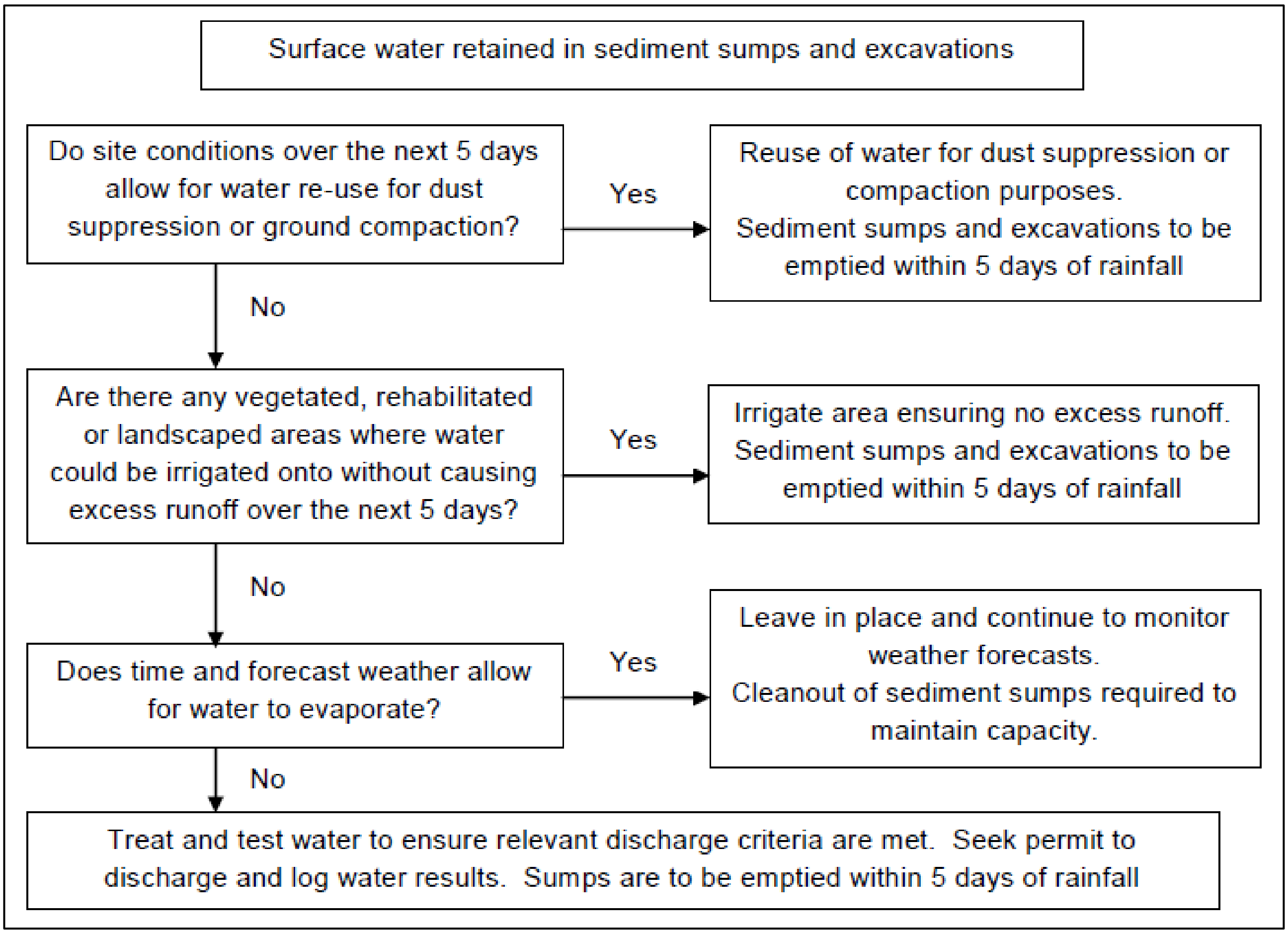

Figure 6-1 The process for managing the discharge of captured runoff from sumps and excavations.

6.3.3. Construction Water Quality Monitoring

During construction, a WQM program would be outlined in the Construction Soil and Water Management Plan. The WQM program would occur to ensure that ERSED controls and construction practices remain effective in avoiding or managing negative impacts to water quality and maintaining current environmental values of the sensitive receiving environments. Guidance for WQM is the *Guideline for Construction Water Quality Monitoring* (RTA, undated). Pre-construction phase WQM is detailed in section 4.1.4.

The objectives of construction phase monitoring are to:

- Identify if negative impacts to water quality are occurring as a result of construction activities.
- Rectification of controls or site practices if any exceedances to water quality parameters are identified.
- Demonstrate proposal compliance with avoidance, management and mitigation of construction impacts to surface water quality.

A sampling methodology would be prepared prior to sampling. Sampling would occur upstream of works to characterise baseline water quality. Sampling downstream of works would be used to determine if water quality impacts are occurring as a result of construction activities. A scheduled sampling program would be designed and included with the methodology. Additional sampling would also be required following rain events as soon as practicable. Parameters that should be included in the WQM during construction are outlined in Table 4-4.

Where results exceed the baseline water quality data either visually (oil and grease), in-situ (most water quality parameters) or laboratory (TSS/TDS), immediate action should be taken to rectify exceedances.

6.3.4. Summary of Safeguards and Mitigation Measures for the EIS Proposal Area

Construction safeguards and mitigation measures for the EIS proposal areas are provided in Table 6-1. These measures would be further defined during the detailed design phase as part of the detailed design's updated water quality and ERSED strategies.

Table 6-1 Construction safeguards and mitigation measures for the EIS Proposal Areas.

EIS Proposal Area	Safeguard / Mitigation Measure
EIS proposal area 1	Utilisation of the existing outlet to transverse drainage (EXD01) would minimise the extent of disturbance within EIS Proposal Area 1 to carry out permanent drainage works.
	Temporary diversion drains and/or sediment fencing would be provided along the toe of the fill embankment, constructed as part of proposed works, to collect runoff from the disturbed areas. Runoff would be treated through a series of sediment sumps and/or inline sediment control measures.
	Depending on the extent of temporary sediment sumps and in-line controls additional erosion controls could be implemented. For example, stabilisation of the fill batter with a cover such as temporary ground cover or spray-on soil binder prior to forecast rainfall.
	Works within tidal areas of the Georges River would need to include measures to control the dispersion of sediment, such as the provision of turbidity barriers.
EIS proposal area 2	Extension of the existing drainage systems to accommodate the widening of Milperra Road along its southern boundary, which would require the construction of a series of relocated drainage outlets within EIS proposal area 2. These drainage outlets would be implemented during the initial stages of construction to allow for the control of clean water through the site.
	Temporary diversion drains and/or sediment fencing would be provided along the toe of the fill embankment, constructed as part of proposed works, to collect runoff from the disturbed areas. Runoff would be treated through a series of sediment sumps and/or inline sediment control measures.
	Depending on the extent of temporary sediment sumps and in-line controls additional erosion controls could be implemented. For example, stabilisation of

EIS Proposal Area	Safeguard / Mitigation Measure
	the fill batter with a cover such as temporary ground cover or spray-on soil binder prior to forecast rainfall.
EIS proposal area 3	Sediment fencing would be installed along the perimeter of the site. Erosion and sediment controls would be integrated with the layout of the site to control sediment from disturbed areas and stockpiled material.
	Coastal wetland mapping encroaches along the boundary of the ancillary site. In these areas, there is an opportunity for the construction contractor to utilise sediment fencing as a measure to exclude ancillary work from the coastal wetlands in this area.

7. OPERATION SURFACE WATER QUALITY ASSESSMENT

7.1. Operational Impacts

The proposal would involve the upgrade of existing roads and intersection adjacent to sensitive receiving environments (refer to section 2). The widening of Henry Lawson Drive and upgrading of the intersections with Tower Road, and Milperra and Newbridge Roads, would increase the impervious area and result in additional runoff to the receiving environment.

7.1.1. Impacts to Surface Water Quality

Potential impacts to water quality are likely during operation of the Stage 1 of the proposal. Accidental spills and leaks from vehicles using the road network, the location of discharge points and increased runoff all pose a risk to the water quality objectives outlined in section 4.4. Increased runoff and potential for erosion around controls could increase sediment and nutrient loads to the receiving waters, impacting water quality and protection of the ecological values.

The contaminants likely to impact surface water quality from road runoff include:

- TSS from areas undergoing rehabilitation following disturbance.
- TSS from paved surfaces, drainages and control outlets.
- Heavy metals attached to particulates from paved surfaces.
- Hydrocarbons, oils and grease from spills/leaks.
- Gross pollutants from the road corridor.
- Nutrients from organic material and any potential spills during transportation.

Potential impacts to surface water quality of receiving waters can be managed through safeguards and mitigation measures. These are discussed in section 7.5. The potential impact to flood regimes is addressed by Lyall & Associates (2021) in the Flooding Assessment Report and not summarised in this assessment.

7.2. Assessment of Stormwater Quality Impacts

Lyall & Associates have prepared a Stage 1 – Concept Design and Environmental Assessment – Operational Water Quality Strategy (strategy). It is summarised here and provided in full in Appendix E.

The aim of the strategy is to limit the discharge of pollutants to meet the water quality objectives and maintain the environmental values for the Georges River Estuary and tributaries (refer section 1.1.2). The strategy is concept only and would be further developed during detailed design.

The MUSIC rainfall runoff modelling software was used to investigate the impact of the proposal, incorporating the increase in pavement (i.e. impervious area) and the increase of future traffic use. Two scenarios were run through the MUSIC software in order to compare water quality results between the 'pre-upgrade scenario' and the 'post-upgrade scenario', and the post-upgrade scenario with and without treatments.

7.3. MUSIC Modelling Results

Results of the MUSIC modelling are provided in Table 7-1. It includes the annual average weight of pollutants and the net change of pollutant loads compared to current conditions (in brackets), for the Georges River and Milperra Drain. The majority of the roadworks are within the Milperra Drain sub-catchment, which is expressed in the greater quantities of pollutants.

Table 7-1 Results of MUSIC modelling, annual average weights of pollutants.

Pollutant	Georges River			Milperra Drain		
	Pre-upgrade	Post upgrade		Pre-upgrade	Post Upgrade	
		No treatment	With treatment		No treatment	With treatment
Total suspended solids (kg/yr)	1803	2548 (745)	1008 (-795)	7940	10820 (2880)	6696 (-1244)
Total nitrogen (kg/yr)	17.0	22.5 (5.5)	20.8 **(3.8)**	85.1	106.0 (20.9)	92.5 **(7.4)**
Total phosphorus (kg/yr)	3.4	4.8 (1.4)	2.7 (-0.7)	15.2	20.5 (5.3)	14.4 (-0.8)
Gross pollutants (kg/yr)	206	278 (72)	77.7 (-128.3)	968	1270 (302)	647 (-321)

**Figures in (brackets) represent the change in pollutant load compared to current conditions. A positive value represents an increase in pollutant whilst a negative value represents a decrease compared to current conditions.*

Overall, the results of the net annual average weight of pollutants during operation of the proposal with treatment for both Georges River and Milperra Drain show a reduction compared to present day conditions. However, the net annual average weight of total nitrogen (kg) increases by 3.8 kg per annum in the Georges River sub catchment and by 7.4 kg per annum in the Milperra Drain sub-catchment, with treatments.

7.4. Safeguards and Mitigation Measures

MUSIC modelling was used in conjunction with site constraints and proposed works to identify opportunities to incorporate stormwater quality measures into a concept drainage design for the Stage 1 operational phase of the road upgrade. The layout of the concept stormwater quality strategy is shown in Figure 1 of Appendix E.

The concept stormwater strategy includes indicative designs only. Stormwater quality controls to treat road runoff as part of the concept strategy includes:

- Vegetated swales.
- Bioretention basins.

The use of bioretention basins at drainage outlets are the most effective method of treating road runoff. Vegetated swales would be used where space or topography at drainage outlets limits the use of the bioretention basins. However, in some locations space or topography also limits the use of vegetated swales.

The proposed strategy includes the following, the location of which are provided in Figure 1 of Appendix E:

- Two bioretention basins that would treat runoff to Milperra Drain by reducing flow velocities, allowing suspended particles to drop out of suspension. The design of the bioretention basins includes vegetation and filtration media, which acts to promote nutrient uptake and denitrification.
- Vegetated swales would treat runoff from drainage outlets located along Henry Lawson Drive discharging into the Georges River north of the intersection with Milperra Road, and into Milperra Drain to the south of the intersection.
- Space and topography do not allow for vegetated swales or bioretention basins in the corridor along Milperra Road to treat stormwater. Pollutant control devices have not been considered for the concept design in this corridor due to the restricted access for ongoing maintenance of pollutant control devices and the presence of a high-pressure gas main along the southern side of Milperra Road.

It is noted that a bioretention basin at drainage outlets to the Georges River and Milperra Drain of 70 m^2 and 100 m^2 respectively would be required to fully offset the predicted increase in TN. Given the limited available space in these locations, it is not practicable to provide bioretention basins.

Transport for NSW would further investigate and develop the water quality strategy during detailed design in consultation with Canterbury Bankstown City Council and with consideration of broader catchment initiatives. Opportunities would be investigated to implement stormwater quality measures to achieve the operational water quality objective, to identify additional opportunities to reduce total nitrogen loads to Georges River and Milperra Drain within the wider sub catchments where the proposal is located.

7.4.1. Post-construction Phase Monitoring

During operation, regular monitoring of stormwater quality controls would occur to ensure that site stabilisation techniques are sufficient in avoiding or managing negative impacts to water quality of the sensitive receiving environments.

Post-construction phase monitoring would include the regular maintenance and inspection of:

- Vegetated swales to ensure grades are maintained and the height of vegetation is maintained to acceptable levels.
- Removal of weeds, rubbish and sediment from vegetated swales.
- Bioretention basins to:
  - Remove rubbish and debris.
  - Remove accumulated sediment at five-to-ten-year intervals.
  - Emptying of spills by emergency response teams where required.
  - Remove any blockages.
  - Ensure appropriately vegetated by controlling growth and removing weeds.
  - Ensure basin fencing is appropriately maintained where it is recommended by detailed design risk assessments.

7.4.2. Operation Summary of Safeguards and Mitigation Measures for EIS Proposal Areas

Operation safeguards and mitigation measures for the EIS proposal areas are provided in Table 7-2. These measures would be further defined during the detailed design phase as described above in Section 7.4. All areas would be subject to landscaping works. This would include ground stabilisation and re-establishment of native vegetation in accordance with the proposal's Landscaping Plans (see Tract, May 2021).

Table 7-2 Operation safeguards and mitigation measures for the EIS Proposal Areas.

EIS Proposal Area	Safeguard / Mitigation Measure
EIS proposal area 1	A stormwater drainage system would divert stormwater runoff along the north-eastern boundary into a vegetated swale.
EIS proposal area 2	Stormwater drainage systems to divert water along the southern boundary of Milperra Road to discharge points.
EIS proposal area 3	A large portion of this area is located on a private property that is identified by Canterbury-Bankstown City Council as land to be acquired under a voluntary purchase scheme. Upon proposal completion, the property would be returned to a state suitable for its zoning as RE1.

8. CUMULATIVE IMPACTS

Cumulative impacts relate to the combined effect of similar or different impacts on a particular value or receiver and may occur concurrently or sequentially. For these purposes, cumulative impacts are associated with other known or foreseeable developments occurring in proximity to the proposal. The incremental effects of the proposal on existing water quality background conditions of the receiving waters and therefore the coastal wetlands, have been taken into account.

The proposal would contribute to overall infrastructure development or redevelopment in the local government area. The projects occurring in proximity to the proposal currently and in the future include:

- Recent developments:
  - Flower Power Complex.
- Developments currently in construction:
  - Milperra Drain Widening by Bankstown Council.
  - Bankstown Airport Redevelopment by Bankstown Airport Ltd.
- Developments planned for the near future:
  - Rabaul Rd/ HLD upgrade by Transport in Georges Hall.
  - Riverlands Subdivision by Mirvac.
  - Tower Road/ HLD intersection upgrade by Bankstown Airport Ltd.
  - Murray Jones Drive/ Milperra Road intersection upgrade by Bankstown Airport Ltd.

Potential cumulative impacts of the beforementioned developments with the proposal includes water quality impacts and therefore, impacts to coastal wetlands of the Georges River and Milperra Drain.

During construction, potential negative impacts to water quality of the sensitive receiving environments could arise if construction of future developments were to occur concurrently with the proposal. Potential impacts would likely include increases in water quality parameters such as TSS, TDS and turbidity due to the disturbance or removal of groundcover and bulk earthworks. However, the safeguards and mitigation measures provided in section 6.3 would be sufficient to avoid and manage potential negative impacts to water quality. As such, no cumulative impacts on coastal wetlands as a result of construction of the proposal are expected.

During operation, potential negative impacts to water quality of the sensitive receiving environments could arise during construction and operation of future developments occurring concurrently with the proposal. Potential impacts would likely include increases in stormwater quality pollutants such as TSS, gross pollutants, total nitrogen, and total phosphorus. The safeguards and mitigation measures provided in section 7.4 would be sufficient to avoid and manage potential negative impacts to water quality for all pollutants except total nitrogen. Cumulative total nitrogen impacts on coastal wetlands could result of operation of the proposal. Further investigations for stormwater quality controls in the broader sub-catchments would be explored to address this potential cumulative impact.

Ongoing monitoring would occur during construction, and inspection and maintenance of stormwater quality controls would occur during operation to maintain their performance. Monitoring would occur at locations upstream and downstream of the proposal to determine if water quality impacts are occurring as a result of construction or site stabilisation issues. Details of the monitoring program are provided in section 6.3.3, and inspection and maintenance activities for operation are described in section 7.4.1. WQM would ensure any exceedances to baseline water quality data is rectified immediately, reducing potential cumulative impacts to coastal wetlands.

The safeguards and mitigation measures in the concept strategies are sufficient and would be further investigated and defined during detailed design. No additional safeguards are proposed.

9. CONCLUSION

Transport is proposing to upgrade Henry Lawson Drive between Keys Parade, Milperra, to Tower Road, Bankstown Aerodrome (known as the Henry Lawson Drive Upgrade Stage 1A). The proposal is adjacent to mapped Coastal Wetlands, which is protected under the SEPP Coastal Management.

This assessment has been prepared to assess the potential water quality impacts of the proposal during the construction phase and Stage 1A operation phase, and to address SEARs from the DPIE for the EIS proposal areas. The assessment also provides, in conjunction with Lyall & Associates, water quality objectives, pre-construction monitoring data, and an avoidance, management, mitigation and monitoring approach. Mitigation strategies for water quality for construction and operation have been provided.

The ANZG (2018) water quality guidelines for estuaries, Water Quality Objectives of the Georges River Estuary (DECCW 2006), the Blue Book (Landcom 2004), Managing Urban Stormwater V2D (DECC 2008) and water quality monitoring data have been used to define the water quality objectives. The proposal was given a high protection level for conserving ecological value systems (ANZG 2018). The ecological values of the receiving environment are based around the TECs under the EPBC Act and the BC Act, which represent the mapped protected Coastal Wetland ecosystems.

Construction impacts of the proposal include a risk to the degradation of adjacent and downstream water quality if mitigation measures are not implemented, monitored and maintained. Risks to surface water quality could result from spills and leaks, earthworks, bridge development and disruption to ASS, stockpiling, removal of vegetation and ground disturbance. Without appropriate erosion and sediment controls, soil loss and contaminants in runoff from the proposal would increase sedimentation, turbidity and nutrient loads of the receiving waters.

The proposal has been divided into 33 control areas where annual average soil loss would be less than 150 m^2 and therefore, no sediment basins are required. Controls would include staging of project works, separation of clean and dirty water using clean water diversion drains or banks, drainage culverts to control runoff through the site, shaker grids, scour protection in drainages and progressive site rehabilitation. The concept construction erosion and sediment control strategy (Lyall & Associates 2021) would be updated during the detailed design phase.

Operation impacts to the net annual average weight of gross pollutants, total nitrogen, total phosphorous and total suspended solids increase as a result of increased pavement areas (i.e. impervious surfaces). However, modelling using the MUSIC modelling software has shown that the net annual average weight of beforementioned pollutants, except total nitrogen, would be reduced with the configuration of stormwater quality controls as presented in the Concept Operational Stage 1 Strategy (Lyall & Associates 2021). Controls would include bioretention basins and vegetated swales where space and topography are not constrained. Key risks to water quality include soil loss from recently rehabilitated areas, accidental spills and leaks from vehicles and litter.

Erosion and sediment controls during construction and water quality controls during operation are expected to address the impacts from spills/ leaks, litter and pollutant loads in runoff. The concept strategies for construction and operation should address these potential impacts and meet the adopted approach for water quality that has been assigned to the proposal to protect and maintain the adjacent sensitive receiving environments. Both strategies are concept only and would be further defined during the detailed design phase with detailed contour information, construction staging plans and additional ground survey and in consultation with stakeholders and other required information.

It is likely that ASS would be encountered during proposed works and therefore, an ASSMP would be required to manage ASS during construction.

9.1. Surface Water Summary for the EIS Proposal Areas

9.1.1. Construction Surface Water Impacts

Construction activities within the EIS proposal areas could have negative impacts on surface water quality. Transportation of soils into receiving waters would lead to increased TSS, increased nutrient loads and increases of other potential contaminants. Increased in-channel sediment accumulation could lead to smothering of aquatic flora and fauna. Impacts would be to the immediate area of coastal wetland and could continue downstream. Other potential impacts include pollution of receiving waters and downstream environments from accidental spills and leaks of petroleum hydrocarbons, oil and grease, heavy metals or chemicals.

Proposed safeguards and mitigation measures at concept design stage are provided in section 9.1.3.

9.1.2. Operation Surface Water Impacts

Operation of Stage 1 activities within the EIS proposal areas could have negative impacts on surface water quality. The contaminants likely to impact surface water quality from road runoff within the EIS proposal areas include TSS from areas undergoing rehabilitation following disturbance and from paved surfaces, drainages and control outlets. Heavy metals attached to particulates from paved surfaces and hydrocarbons, oils and grease from spills/leaks also have the potential to impact water quality adjacent coastal wetlands to the EIS proposal areas. Gross pollutants from the road corridor and nutrients from organic material and any potential spills during transportation would also potentially impact water quality and adjacent coastal wetlands of EIS proposal areas.

Proposed safeguards and mitigation measures at concept design stage are provided in section 9.1.3.

9.1.3. Safeguards and Mitigation Measures of EIS Proposal Areas

Construction and operation safeguards and mitigation measures for the EIS proposal areas are provided in Table 9-1. These measures would be further defined during the detailed design phase.

Table 9-1 Construction and operation safeguards and mitigation measures for the EIS Proposal Areas.

EIS Proposal Area	Safeguard / Mitigation Measure	C	O
EIS proposal area 1	Utilisation of the existing outlet to transverse drainage (EXD01) would minimise the extent of disturbance within EIS Proposal Area 1 to carry out permanent drainage works.	C	
	Temporary diversion drains and/or sediment fencing would be provided along the toe of the fill embankment, constructed as part of proposed works, to collect runoff from the disturbed areas. Runoff would be treated through a series of sediment sumps and/or inline sediment control measures.	C	
	Depending on the extent of temporary sediment sumps and in-line controls additional erosion controls could be implemented. For example,	C	

EIS Proposal Area	Safeguard / Mitigation Measure	C	O
	stabilisation of the fill batter with a cover such as temporary ground cover or spray-on soil binder prior to forecast rainfall.		
	Works within tidal areas of the Georges River would need to include measures to control the dispersion of sediment, such as the provision of turbidity barriers.	C	
	A stormwater drainage system would divert stormwater runoff along the north-eastern boundary into a vegetated swale.		O
EIS proposal area 2	Extension of the existing drainage systems to accommodate the widening of Milperra Road along its southern boundary, which would require the construction of a series of relocated drainage outlets within EIS proposal area 2. These drainage outlets would be implemented during the initial stages of construction to allow for the control of clean water through the site.	C	
	Temporary diversion drains and/or sediment fencing would be provided along the toe of the fill embankment, constructed as part of proposed works, to collect runoff from the disturbed areas. Runoff would be treated through a series of sediment sumps and/or inline sediment control measures.	C	
	Depending on the extent of temporary sediment sumps and in-line controls additional erosion controls could be implemented. For example, stabilisation of the fill batter with a cover such as temporary ground cover or spray-on soil binder prior to forecast rainfall.	C	
	Stormwater drainage systems to divert water along the southern boundary of Milperra Road to discharge points.		O
EIS proposal area 3	Coastal wetland mapping encroaches along the boundary of the ancillary site. There is an opportunity for the construction contractor to utilise sediment fencing as a measure to exclude ancillary work from the coastal wetlands in this area.	C	

C: Construction; O: Operation.

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APPENDIX A SOIL LANDSCAPES

Landscape—Quaternary terraces of the Nepean and Georges Rivers. Mainly flat (slopes <1%). Splays and levees provide local relief (<3 m). Tree cover, now almost completely cleared, was formerly a low open-woodland (dry sclerophyll).

Soils—poorly structured orange to red clay loams, clays and sands. Texture may increase with depth. Ironstone nodules may be present. Plastic Clays (U46.12) in drainage lines. Deep acid non-Calcic Brown Soils (Gn3.14, Gn4.34), Red Earths (Gn2.11) and Red Podzolic Soils (Dr2.41), occur on terrace surfaces with Earthy Sands (Uc5.21, Uc1.23) on terrace edges.

Limitations—localised flood hazard, localised seasonal waterlogging, localised water erosion hazard on terrace edges.

LOCATION

This soil landscape occurs on the higher Quaternary terraces of the Hawkesbury, Nepean and Georges Rivers. There is an extensive area from Richmond east to Rickabys Creek; another large occurrence is on the west bank of the Nepean at Emu Plains. Further examples are found on both banks of the Nepean south of Wallacia. Smaller pockets of this landscape are found on the Georges River both up and down-stream from Liverpool.

LANDSCAPE

Geology

Quaternary alluvium consisting of sand, silt and gravels derived from sandstone and shale.

Topography

Mostly flat (slope <1%) terrace tops; terrace edges and levees provide low relief of up to 10 m.

Vegetation

Extensively cleared open forest. Original tree species included *Toona ciliata* (red cedar), *Ceratopetalum apetulum* (coachwood), *Melaleuca* spp. (paperbarks) and aquatic plants such as *Typha orientalis* (cumbungi), *Cyperus* spp. and *Phragmites australis* (common reed) (Neil Dusty pers. comm.). Regrowth vegetation is dominated by *Acacia* spp. (wattles). *Eucalyptus piperita* (Sydney peppermint) is the most usual Eucalypt.

The grass understorey is commonly *Paspalum* sp. (paspalum), with abundant weeds e.g., *Senecio* sp. (groundsel).

Landuse

In the Richmond and Liverpool areas this unit is now extensively urbanised. Along the Nepean River some areas remain as pasture, small hobby farms and some citrus orchards. Native vegetation has been extensively cleared.

SOILS

Dominant Soil Materials

ri1—Loose reddish brown loamy sand.

This is a reddish brown loamy sand with apedal single-grained structure and porous sandy fabric. It occurs as topsoil (A horizon).

Texture may range to sandy loam when organic matter content is high. Colour has a narrow range between brown (7.5YR 4/4) and very dark reddish brown (5YR 4/2). This material varies from moderately acid (pH 5.5) to slightly acid (pH 6.5). Roots are common near the surface but rare at depth. Stones and charcoal are absent.

ri2—Brown sandy clay loam.

This is a brown sandy clay loam to fine sandy clay loam with apedal massive structure and earthy fabric. It occurs as topsoil (A horizon).

Structure often increases with depth to moderately pedal subangular blocky peds which are porous rough-faced and range in size from 50–100 mm. Colour is brown (7.5YR 4/4, 4/6) but varies from dull reddish brown (2.5YR 4/3) to bright brown (7.5YR 5/8). This material is typically slightly acid (pH 6.0) with few roots and no stones or charcoal fragments.

ri3—Brown mottled light day.

This is a reddish to yellowish brown light or light medium clay with apedal massive structure, an earthy fabric increasing to moderate structure, with porous rough-faced ped fabric at depth. It occurs as subsoil (B horizon).

At depth peds are large (50–100 mm) and angular blocky in shape. There is a wide colour range from dark reddish brown (2.5YR 3/6) to greyish yellow brown (10YR 5/2). Yellow or orange mottles often occur. This material varies from strongly acid (pH 4.0) to slightly alkaline (pH 8.0). Small (2–20 mm) iron-indurated gravels may occur in concentrated bands or dispersed throughout this material. There are few roots, and charcoal and other inclusions are rare.

ri4—Brown mottled stiff medium-heavy clay.

This is a reddish brown to yellowish brown, mottled, occasionally subplastic medium to heavy clay with variable structure and dense smooth-faced ped fabric. It occurs as subsoil (B horizon).

Structure increases with depth from weak small (<2 mm) crumb structure to strong subangular blocky with ped size range of 20–100 mm. Colour ranges from dark reddish brown (2.5YR 3/4) to yellowish brown (10YR 5/8). Light grey mottles are common, especially at depth. This material has a pH range of strongly acid (pH 4.5) to neutral (pH 7.0). Stones, roots, charcoal and other inclusions are generally absent.

Associated Soil Materials

Reddish brown sandy (occasionally silty) clay. This material is a sandy clay with weak or moderate structure.It occurs in stratified layers or lenses to a maximum thickness of 220 cm. Ironstone nodules and lateritic bands are also associated with this material.

Occurrence and Relationships

Near terrace edge. Up to 40 cm of reddish brown loamy sand (**ri1**) occurs as a surface layer. This overlies 40–100 cm brown sandy clay loam (**ri2**). The underlying layers are stratified with alternating layers of **ri3** and heavier **ri4** clays with occasional lenses of reddish brown sandy clay [Red Earths (Gn2.11) and red podzolic soils (Dr2.41)]. Boundaries between soil materials are gradual to sharp. Total soil depth is >200 cm.

Back of terrace. Up to 100 cm brown sandy clay loam (**ri2**) can overlie up to 150 cm of light clay (**ri3**) and >100 cm medium or heavy clay (**ri4**) [deep acid Non-calcic Brown Soil (Gn3.14, Gn4.34)]. Total soil depth is >300 cm. **ri2** is occasionally absent. Boundaries between soil materials are gradual.

Drainage lines incise into both front and back of terrace and sedimentary deposition can cause interspersing of the layers within the channel and on the immediate floodplain. Boundaries and soil depth vary [Structured Plastic Clays (Uf5.12)].

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ri1 High erodibility
Very high aluminium toxicity
Very low fertility
Low available water capacity
Salinity (localised)

ri2 High erodibility (localised)

ri3 Stoniness (localised)
Sodic
Very high erodibility
Very high aluminium toxicity
Very low fertility
Low to moderate shrink swell

ri4 High erodibility (localised)
Low to moderate shrink swell

Fertility

The general fertility of this soil landscape is low to very low. The materials have very low CEC, low nutrient storage capacity, and high levels of aluminium which gives a high potential for toxicity should the pH become lower.

Erodibility

The surface soils are moderately erodible. They have a high fine sand fraction and have low organic matter content. They are, however, not dispersible. The subsoils have very high erodibility due to very low organic matter and a high fine sand and silt content. They are also moderately dispersible.

Erosion Hazard

Due to low slopes and generally good vegetation cover the erosion hazard for non-concentrated flows on the Richmond soil landscape is low. During periods of drought or dry seasons this may increase in some areas. The calculated soil loss on the terrace surface in the first twelve months of urban development is low at 29 t/ha for topsoil and 49 t/ha for exposed subsoil. The erosion hazard for concentrated flows is moderate to high.

Surface Movement Potential

These materials are generally slightly to moderately reactive although the surface sand is stable.

Landscape Limitations

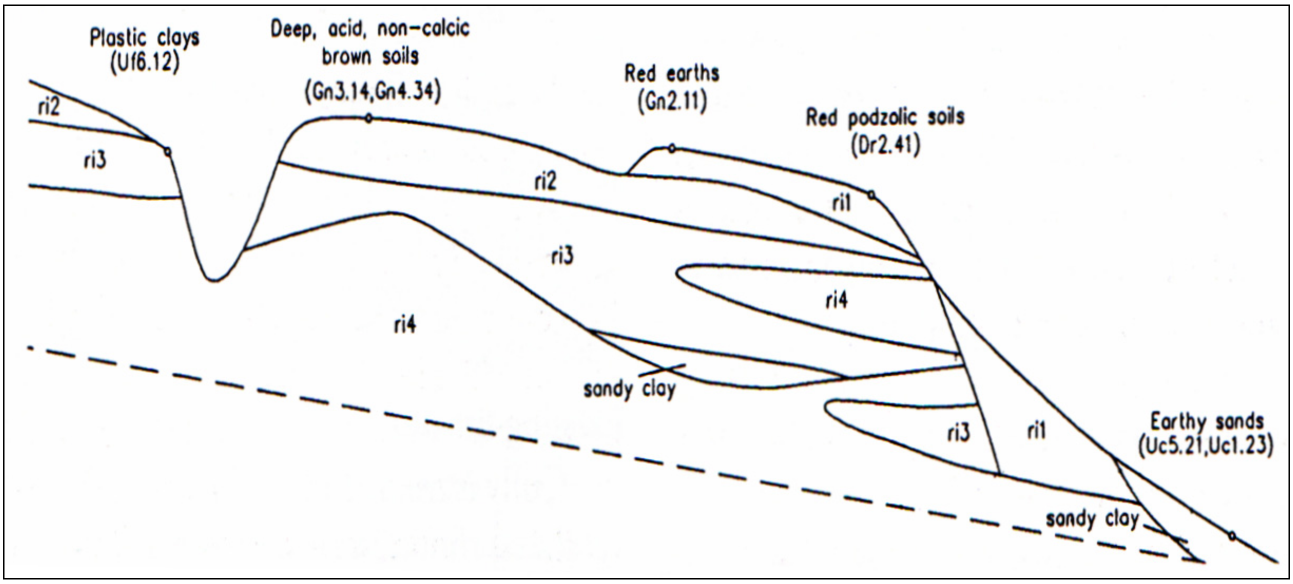
Flood hazard (localised), seasonal waterlogging (localised), water erosion hazard (localised).

Urban Capability

High capability for urban development in flood free areas.

Rural Capability

Capable of regular cultivation and grazing.



Distribution diagram of the Richmond soil landscape showing the occurrence and relationship of dominant soil materials.

xx	DISTURBED TERRAIN	Disturbed

Landscape—occurs within other landscapes and is mapped as **xx**. The topography varies from level plains to undulating terrain, and has been disturbed by human activity to a depth of at least 100 cm. Most of these areas have been levelled to slopes of <5%. The original vegetation has been completely cleared.

Soils—the original soil has been removed, greatly disturbed or buried. Landfill includes soil, rock, building and waste material.

Limitations—dependent on nature of fill material and include subsidence resulting in a mass, movement hazard, soil impermeability leading to poor drainage, and low fertility. Care must be taken when these sites are developed. A survey at a suitable scale as well as geotechnical analysis should be undertaken because of variability of materials throughout the sites. Advice from local councils should be sought concerning localised areas of disturbed terrain.

LOCATION

Numerous areas of disturbed terrain occur throughout the Penrith region. Geologically, most of these are underlain by alluvial and volcanic materials. Large areas of landfill include Penrith Lakes Scheme (Nepean River), Georges River Basin near Liverpool (e.g., Chipping Norton) and areas west of Bankstown including Bankstown Airport.

Quarried areas include Prospect, Erskine Park and Berkshire Park.

There are also numerous areas of disturbed terrain too small to represent at a scale of 1:100 000.

Underlying Material

Artificial fill. This can be dredged sand or mud, rocks and local soil materials. It can also include demolition rubble, industrial and household waste. In pits or quarries bedrock is usually exposed (e.g., dolerite at Prospect).

Landuse

Landuse is varied and includes commercial and industrial complexes, sporting or recreational areas, quarries, airports and waste disposal sites. Local parks are underlain by compacted waste.

In quarries bedrock is exposed. Most disturbed sites are eventually artificially topsoiled and revegetated or covered by concrete and bitumen.

Historical Information

Many of these disturbed sites were surveyed prior to their disturbance, e.g., Prospect and Penrith Lakes (see previous surveys).

Additional information is provided in Appendix 7.9.

APPENDIX B GEORGES RIVERKEEPER WQM DATA

CATCHMEN	Stream Ord	SITE NUMB	SITE	DATE	Dissolved oxygen (% saturation)	Salinity	pH	Turbidity (NTU)	Temperature	TDS (ppk)	Chorophyll-a (µg/l) MIN=<1
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-01	62.5		6.94	14.5			2
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-02	58.1		7.5	19.5			2
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-03	70.8		6.86	43.4			<1
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-04	64		6.89	20.9			2
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-05	71.4		7.82	83.8			<1
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-06	81.6		6.98	16.9			11
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-07	81.1		7.52	8			9
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-08	52.3		6.98	13.4			4
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-09	59.8		7.77	15.7			4
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-10	77.5		7.36	13			3
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-11	88.1		7.54	9.7			5
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-12	116.8		7.33	9.2			14
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-13	89.3		7.64	8.9			1
GEORGES	7	GR102	Chipping Norton Lake	2011-2012-14	80.2		6.94	15.9			4
GEORGES	7	GR102	Chipping Norton Lake	1/04/2012	58.1		7.5	21.4			2
GEORGES	7	GR102	Chipping Norton Lake	18/05/2012	62.5		6.94	14.5		2.52	2
GEORGES	7	GR102	Chipping Norton Lake	19/06/2012	69.5		7.12	40.8		0.699	3
GEORGES	7	GR102	Chipping Norton Lake	18/07/2012	12.7		7.78	7.1		2.44	64
GEORGES	7	GR102	Chipping Norton Lake	15/08/2012	107.3		6.39	3.1		7.25	<1
GEORGES	7	GR102	Chipping Norton Lake	20/09/2012	71			1.8		9.57	54
GEORGES	7	GR102	Chipping Norton Lake	15/10/2012	69.7		7.37	6.9		9.78	7
GEORGES	7	GR102	Chipping Norton Lake	25/10/2012	81.3		7.52	4.2		10.56	8
GEORGES	7	GR102	Chipping Norton Lake	6/11/2012	67.2		7.34	3.6		11.6	2
GEORGES	7	GR102	Chipping Norton Lake	20/11/2012	84.3		7.46	3.9		15.4	11
GEORGES	7	GR102	Chipping Norton Lake	4/12/2012	80.7		7.2	3.2		11.23	6
GEORGES	7	GR102	Chipping Norton Lake	18/12/2012	80.4		7.49	2.7		13.65	5
GEORGES	7	GR102	Chipping Norton Lake	9/01/2013	73.4		7.48	2.1		17.1	1
GEORGES	7	GR102	Chipping Norton Lake	22/01/2013	56		7.33	2		16.6	<1
GEORGES	7	GR102	Chipping Norton Lake	5/02/2013	49.8		7.08	15.8		0.708	<1
GEORGES	7	GR102	Chipping Norton Lake	19/02/2013	44.2		7.1	7		1.023	2
GEORGES	7	GR102	Chipping Norton Lake	5/03/2013	59		7.03	27.3		0.193	<1
GEORGES	7	GR102	Chipping Norton Lake	19/03/2013	52.7		7.28	14.3		0.481	1
GEORGES	7	GR102	Chipping Norton Lake	15/04/2013	65.2		7.39	6.1		3.15	5
GEORGES	7	GR102	Chipping Norton Lake	15/05/2013	117.8		7.5	8.4		5.12	8
GEORGES	7	GR102	Chipping Norton Lake	12/06/2013	81.1		7.05	9.4		2.04	7
GEORGES	7	GR102	Chipping Norton Lake	16/07/2013	78		6.88	17.8		0.289	<1
GEORGES	7	GR102	Chipping Norton Lake	20/08/2013	105.6		7.01	6.2		6.59	4
GEORGES	7	GR102	Chipping Norton Lake	24/09/2013	83.7		7.39	7.3		7.5	5
GEORGES	7	GR102	Chipping Norton Lake	17/10/2013	104.7		7.47	5.8		12.36	2
GEORGES	7	GR102	Chipping Norton Lake	14/11/2013	66.9		7.35	7.1		9.88	3
GEORGES	7	GR102	Chipping Norton Lake	3/12/2013	56.9		7.17	21.5		0.187	3
GEORGES	7	GR102	Chipping Norton Lake	17/12/2013	96.4		7.29	11.7		7.13	9
GEORGES	7	GR102	Chipping Norton Lake	15/01/2014			7.88	5.2		9.52	5
GEORGES	7	GR102	Chipping Norton Lake	30/01/2014	91.1		7.73	7.3		9.05	9
GEORGES	7	GR102	Chipping Norton Lake	11/02/2014	56.9		7.34	6.5		14.55	2
GEORGES	7	GR102	Chipping Norton Lake	25/02/2014	58.3		7.29	5.2		9.8	9
GEORGES	7	GR102	Chipping Norton Lake	11/03/2014	76.9		7.6	3		6.76	2
GEORGES	7	GR102	Chipping Norton Lake	18/03/2015							18.6
GEORGES	7	GR102	Chipping Norton Lake	25/03/2014	70.5			16.9		4.89	7
GEORGES	7	GR102	Chipping Norton Lake	29/04/2014	80.7		7.83	8.4		4.3	9
GEORGES	7	GR102	Chipping Norton Lake	10/06/2014			7.73			9.16	7
GEORGES	7	GR102	Chipping Norton Lake	8/07/2014	82.9		7.91	0.8	10.5	12.13	<1
GEORGES	7	GR102	Chipping Norton Lake	17/10/2014	65		7.02	15.1	19.5	3.13	4
GEORGES	7	GR102	Chipping Norton Lake	12/11/2014	77.5		7.25	10	24.5	4.07	7
GEORGES	7	GR102	Chipping Norton Lake	10/12/2014	74.5		7.45	5.2	23.4	3.22	4
GEORGES	7	GR102	Chipping Norton Lake	25/02/2105	69.5		7.36	6.2	24.95	3.53	9
GEORGES	7	GR102	Chipping Norton Lake	12/03/2015							14.5
GEORGES	7	GR102	Chipping Norton Lake	8/05/2015				15.1	16.7	0.9	1.2
GEORGES	7	GR102	Chipping Norton Lake	12/06/2015				6.5	13.4	2.8	10.9
GEORGES	7	GR102	Chipping Norton Lake	24/07/2015					11		39.4
GEORGES	7	GR102	Chipping Norton Lake	19/08/2015		5.14		1.43	13.4		13.8
GEORGES	7	GR102	Chipping Norton Lake	17/09/2015		4.22		7.02	17.35		19.3
GEORGES	7	GR102	Chipping Norton Lake	6/10/2015		5.42		8.67	19.44		6.4
GEORGES	7	GR102	Chipping Norton Lake	18/11/2015		2.12		4.41	23.7		10.9
GEORGES	7	GR102	Chipping Norton Lake	20/01/2016		0.87		7.21	25.8		21.3
GEORGES	7	GR102	Chipping Norton Lake	18/02/2016		1.3		21.36	26.9		5.6
GEORGES	7	GR102	Chipping Norton Lake	8/03/2016		6.04		8.03	27.84		10.6
GEORGES	7	GR102	Chipping Norton Lake	12/04/2016		8.02		4.32	22.86		21.2
GEORGES	7	GR102	Chipping Norton Lake	10/05/2016		10.71		4.5	19.76		14.3
GEORGES	7	GR102	Chipping Norton Lake	7/09/2016		0.57		15	16.53		
GEORGES	7	GR102	Chipping Norton Lake	8/12/2016		10.19		8.6	26.39		13.2
GEORGES	7	GR102	Chipping Norton Lake	25/01/2017							10.9
GEORGES	7	GR102	Chipping Norton Lake	15/02/2017		8.97		2.6	26.99		28.1
GEORGES	7	GR102	Chipping Norton Lake	23/03/2017		0.16		27.9	22.8		0.9
GEORGES	7	GR102	Chipping Norton Lake	5/04/2017		0.22		22.2	20.53		1.7
GEORGES	7	GR102	Chipping Norton Lake	19/10/2017				4.2	23.5		2
GEORGES	7	GR102	Chipping Norton Lake	8/11/2017				6	20.7		4
GEORGES	7	GR102	Chipping Norton Lake	19/12/2017				4.5			2
GEORGES	7	GR102	Chipping Norton Lake	25/01/2018				2.2	24.5		4
GEORGES	7	GR102	Chipping Norton Lake	15/02/2018				1.6	34.5		5
GEORGES	7	GR102	Chipping Norton Lake	15/03/2018				4.5			1
GEORGES	7	GR102	Chipping Norton Lake	24/10/2018				12.5	19.4		4.3
GEORGES	7	GR102	Chipping Norton Lake	6/12/2018				7.6	28.6		7.2
GEORGES	7	GR102	Chipping Norton Lake	19/02/2019				11.5	28.4		21.6
GEORGES	7	GR102	Chipping Norton Lake	20/03/2019				24	22.3		1.8
GEORGES	7	GR102	Chipping Norton Lake	11/12/2019				5.2	23.2		7
GEORGES	7	GR102	Chipping Norton Lake	21/01/2020				3.4	31.1		2
GEORGES	7	GR102	Chipping Norton Lake	24/02/2020				12.5	26.4		<1
GEORGES	7	GR102	Chipping Norton Lake	25/03/2020				7.6	22.3		8

APPENDIX C WATER QUALITY MONITORING DATA

Sample Location	Date	Time	Sampler	Weather	Rainfall, previous 24hours	Tide (m)	GPS Coordinates	Water quality description	Oil and grease presence / absence	Dissolved Oxygen (mg/L)	pH (field)	Temperature (°C)	Oxidation Reduction Potential (mV)	Conductivity (S/m)	Total Suspended Solids (ppt)	Specific Conductance (µS/cm at 25 °C)	Salinity (µS/cm)	(Laboratory) Turbidity (NTU)	(Laboratory) Total Dissolved Solids (mg/L)	(Laboratory) Total Suspended Solids (mg/L)	Comments
SW01			Martin Kim																		
	6/04/2021	12:10pm	Martin Kim	Fine, partly cloudy	Yes	0.5	-33.921199, 150.975305	Very murky	absent	3.59	8.11	23	176.8	0.0717		745	0.36	31.67	487.5		Mid-low tide, murky water, mangrove crabs numerous
	4/03/2021	11:40am	Martin Kim	Fine, sunny	nil	0.8	-33.921199, 150.975305	Clear to slightly murky	absent	6.01	7.86	24.5	176.2	0.5222		5275	2.84	3.6	3432	14	Mid-low tide, calm sediment
	10/02/2021	11:30am	Martin Kim	Mostly cloudy	nil	1.8	-33.921199, 150.975305	Clear to murky	absent	4.07	7.26	24.9	148.5	1.0898		11008	6.24		7080	6	Small fish present, high tide
	13/01/2021	2:05pm	Martin Kim	Fine, sunny	nil	1.4	-33.921199, 150.975305	Slightly murky, small fish within	absent	10.54	8.1	26.5	181.6	0.6066		6642	3.19		3940	24	Mid tide level, watercraft activities causign ripples that disurb foreshore sediment
	1/12/2020	12:15pm	Martin Kim	Sunny	nil	1.75	-33.921199, 150.975305	Slightly murky	absent	0.12	7.2	24.6	146.3	0.015126		15246	machine error		98	5>	Georges River, High tide flowing south, Small-medium sized fish
	4/11/2020	3:50pm	Martin Kim	Clear, slight wind	nil	1.3	-33.923041, 150.976309	Murky brown, strong water movement with tide	absent	2.86	7.33	20.5	115.2	0.00135		1476	0.74		9	44	Boats and Jet skis creating ripples on embankment, rubbish floating in river downstream
SW01 Mean										4.531666667	7.643333333	24	157.4333333	0.384462667		6732	2.674	17.635	2507.75	22	
SW02			Martin Kim																		
	6/04/2021	11:40am	Martin Kim	Fine, partly cloudy	Yes		-33.931079, 150.988305	Murky, top 3cm clear	absent	2.81	8.37	22.9	229.8	0.0648		675	0.33	9.73	435.5		Sediment fence moved approx. 10m east, birds actively foraging (Eurasian Coot, Dusky Moorhen)
	4/03/2021	11:15am	Martin Kim	Fine, sunny	nil		-33.930556, 150.987003	Clear to slightly murky	absent	16.04	8.1	23.4	162.4	0.1864		1935	0.98	2.9	1254.5	7	Small fish present, silt fence back up, aggregated debris on surface
	10/02/2021	11:00am	Martin Kim	Mostly cloudy	nil	-	-33.930556, 150.987003	Very murky. Oily	present	9.39	7.69	23	143.6	0.1257		1309	0.65		1210	11	Vegetation death along southern bank, small to large fish present, spoil dumped within creek
	13/01/2021	1:20pm	Martin Kim	Fine, sunny	nil	-	-33.930556, 150.986837	Clear/slightly murky, large fish within	absent	15.13	8.17	28.6	198.5	0.1089		1019	0.5		708	8	Downstream of previous WQM site is partially filled – existing creek is still maintained
	1/12/2020	11:15am	Martin Kim	Sunny	nil	-	-33.930556, 150.986837	Relatively clear. Murky when disturbed, reeds near embankment, strong odour, no water movement	absent	7.8	7.05	25.3	124.4	0.00236		2352.4	machine error		16	22	Bankstown Golf Club, Large quantity of small fish
	4/11/2020	3:05pm	Martin Kim	Clear, slight wind	nil	-	-33.930534, 150.986788	Murky when disturbed, reeds near embankment, strong odour, no water movement	absent	5.55	7.37	27	6.2	0.00111		1124	0.55		7	1420	Rubbish floating on water surface, council construction works within Milperra Drain occurring downstream
	SW02 mean							**SW02 Mean**		9.453333333	7.791666667	25.03333333	144.15	0.081545		1402.4	0.602	6.315	605.1666667	12	

APPENDIX D EROSION AND SEDIMENT CONTROL STRATEGY (LYALL & ASSOCIATES)

TECHNICAL NOTE 1
HENRY LAWSON DRIVE UPGRADE STAGE 1A - CONCEPT DESIGN AND ENVIRONMENTAL ASSESSMENT – EROSION AND SEDIMENT CONTROL STRATEGY

1. Introduction

This technical note presents the findings of an investigation into the requirements for controlling the impact of the construction phase of Stage 1A of the proposed Henry Lawson Drive Upgrade project (**proposal**) on water quality in the existing downstream drainage lines and watercourses.

Figure 1 (3 sheets) shows the erosion and sediment control strategy (**strategy**) for the construction of the proposal and should be referred to when reading the following sections of this Technical Note. The strategy addresses the increase in potential for both erosion and sediment mobilisation within the proposed construction footprint, and transport of this sediment into downstream watercourses via sediment-laden runoff (herein referred to as 'dirty water') leaving areas disturbed by the road works.

The strategy for the control of erosion and sediment during the construction of the proposal has been developed based on a review of the concept design together with an assessment of existing site conditions and erosion potential. Background information relating to the existing environment (including climate, soils, geology and topography) is contained in Section 4.1 of the *Surface Water Assessment*. Details of the concept strategy to manage the operational related impacts of the proposal on water quality in the existing downstream drainage lines and watercourses is presented in **Technical Note 2** that is contained in Appendix E of the *Surface Water Assessment*.

It is recommended that the strategy that is presented in this technical note be used as the starting point for the preparation of a *"Construction Soil and Water Management Plan"* (**SWMP**) (or similar) that will need to be developed as part of the Construction Environmental Management Plan (**CEMP**) for the construction of the proposal. However, it should be recognised that ultimate requirements for controlling erosion and sediment during construction will be dictated by the final design of the road upgrade works, as well as construction staging plans and site management practices that would be developed by the contractor. To this end, the strategy presented in this Technical Note provides a suitable basis for the development of the SWMP and associated erosion sediment control plans, construction work method statements and procedures that would be developed by the contractor.

The strategy has been developed based on the principles and design guidelines set out in the following documents:

- *Soils and Construction – Managing Urban Stormwater* series (collectively referred to herein as the **'Blue Book'**), comprising:
  - Volume 1 (Landcom, 2004)
  - Volume 2D – Main Roads (Department of Environment and Climate Change (**DECC**), 2008)
- *Transport for NSW QA Specification G38* (Transport for NSW (**TfNSW**), 2020)
- *RTA Procedure PN 143P Erosion and Sedimentation Management Procedure* (Roads and Traffic Authority (**RTA**), 2008).

2. Assessment of erosion potential

An assessment of the erosion potential from areas that will be disturbed during the construction of the proposal was carried using the procedure set out in Appendix A of the Blue Book. The procedure involves the estimation of the soil loss from disturbed areas using the Revised Universal Soil Loss Equation (**RUSLE**), the formula for which is as follows:

A = R x K x LS x P x C

where,	A =	computed soil loss (tonnes/ha/year)
	R =	rainfall erosivity factor
	K =	soil erodibility factor
	LS =	slope length / gradient factor
	P =	erosion control practice factor
	C =	ground cover and management factor

Table 1 contains a summary of the adopted values for the RUSLE calculations together with an estimate of the area of disturbance that would trigger the need for the installation of a sediment basin in accordance with the recommendations set out in the Blue Book.[1]

While the estimated soil loss based on the RUSLE correlates to Soil Loss Class 2 and a Low Erosion Hazard, the Blue Book recommends that waterfront land be always classified as a minimum Soil Loss Class 6 which corresponds to Very High Erosion Hazard. This would apply to areas of the proposal that are located within 40 m of the Georges River and Milperra Drain, where additional measures would need to be applied to limit the discharge of sediment into these water bodies. It is noted that waterfront land where these additional measures would apply would include, but not be limited to, areas within or adjacent to wetlands mapped as 'Coastal Wetlands' under the State Environmental Planning Policy (Coastal Management) 2018 (**SEPP (CM) 18**). The areas of coastal wetland that are mapped under SEPP (CM) 2018 correspond to the extent of the EIS proposal area that is shown on **Figure 1**.

3. Key elements of the strategy

The primary principles for effective erosion and sediment control are firstly to minimise erosion, and to then capture sediment from disturbed areas where erosion cannot be prevented.

Whilst this present investigation deals primarily with the control of sediment, and the structural measures that will be required to capture dirty water and bypass clean water through the construction site, a range of erosion control principles will need to be incorporated into the future SWMP or similar including:

- staging the proposal works to ensure that clean water diversion drains and/or diversion banks upslope of the proposal are implemented during the initial stages of construction to control runoff which presently discharges onto the proposal
- staging the construction of drainage culverts and channels to control runoff through the site, including the provision of temporary drainage diversions for new culverts

[1] The Blue Book recommends that sediment basins be installed to control erosion and sedimentation where the average annual soil loss from a disturbed area, as derived by application of the RUSLE, is greater than or equal to 150 m^3 per year.

- minimisation of disturbed areas and extent of vegetation removal, particularly on waterfront land
- preparing and implementing progressive erosion and sediment controls applicable to each stage of construction
- locating site accesses, and use of shaker grids and surface treatments to control the risk of sediment being tracked onto surrounding roads
- locating stockpiled material that is erodible away from drainage paths and flood prone areas and stabilising stockpiles to minimise the risk of erosion
- conservation of existing topsoil for later site rehabilitation, including appropriate amelioration and fertilisation where required
- stabilisation of batters using blanketing, surface mulching or vegetation
- managing the extent of exposed surfaces based on their flood potential and the duration that the areas would be left exposed
- scour protection along drainage lines through the site
- separation of clean and dirty water wherever possible
- monitoring of forecast rainfall and developing wet weather procedures to protect or stabilise areas of construction susceptible to erosion
- implementing procedures for the routine inspection and maintenance of erosion and sediment controls measures, and following rainfall events
- progressive site rehabilitation and monitoring of the condition of permanent drainage measures to ensure that temporary erosion controls are only removed once permanent measures have been established.

As noted in the preceding section, the Blue Book allows for localised erosion and sediment control measures to be used in lieu of sediment basins where the average annual soil loss from a disturbed area, as derived by application of the RUSLE, is less than 150 m^3.

Figure 1 (3 sheets) shows the extent of land which will be disturbed during the construction phase of the proposal. For the purpose of undertaking an initial assessment of the erosion and sediment control requirements, the total area of disturbance was divided into thirty three (33) control areas based on the likely staging of construction and nominated locations for the controlled discharge of runoff from the site. As it will be necessary to maintain traffic flow along Henry Lawson Drive, Milperra Road and Newbridge Road during construction it was assumed that earthworks would be limited to a maximum of one half of the road width at any one time, with the disturbed areas stabilised before traffic is switched over and work is undertaken along the other half of the road.

Based on the layout of control areas shown on **Figure 1** (3 sheets), it is estimated that the average annual soil loss from each area will not exceed the threshold value of 150 m^3. The implementation of effective localised erosion and sediment control measures aimed at minimising the volume of sediment which is transported from disturbed areas will therefore be key to the control of sediment from the proposal corridor in the absence of any large-scale sediment retention basins. Key structural elements of the strategy for control of dirty water are outlined below.

<u>Temporary diversion of dirty water</u>

A combination of diversion drains, sediment fencing and bunding would be used to control dirty water along the downslope side of disturbed areas and direct this water towards temporary sediment retention sumps which may be supplemented or replaced with a series of inline controls such as straw bales and gravel filters where space is limited. The location of the proposed dirty water diversions and sediment control measures are shown on **Figure 1** (3 sheets). The combination of sediment retention sumps and inline controls would be subject to further development of the erosion and sediment control strategy during the preparation of the CEMP and SWMP by the contractor. However, areas CA09, CA13, CA23 and CA24 would be prioritised for application of temporary sediment sumps due to their larger predicted soil losses.

Due to the constrained nature of the site and the proximity of the construction to adjoining residential and commercial properties it is likely that diversion drains will be required to control both on- and off-site water along sections of Henry Lawson Drive. Temporary sediment sumps and in-line controls along these combined diversion drains will need to be sized to cater for the additional runoff from upslope areas. Temporary access crossings will be required across the diversion drains to maintain access to the adjoining properties during construction.

It is envisaged that the temporary sediment sumps would comprise geotextile lined storage bays, temporary sump pits (lined or unlined) or a series of check dams along the diversion drains which would act to slow the flow of runoff sufficient to allow the heavier sediment to drop out of suspension.

Annexure A of this Technical Note contains a series of typical details that are presented in the Blue Book of the types of measures that would be used to control the discharge of sediment from the construction site.

<u>Local erosion and sediment control measures</u>

Localised erosion and sediment control measures may be provided to augment or replace the temporary sediment retention sumps, particularly where there is limited space within the construction footprint or where additional controls are required given the proximity of the proposed works to the Georges River and Milperra Drain. Localised erosion and sediment control measures would include use of the following smaller scale elements:

- staging of works to minimise the extent of disturbance at any one time
- temporary catch drains and earth bunding to divert on-site and off-site water toward receiving drainage lines
- temporary stabilisation or revegetation/rehabilitation works to reduce the extent of disturbed surfaces
- application of temporary surface treatments or blanketing on exposed earth surfaces
- sediment barriers in series using sediment fencing or silt bags
- filtration barriers in series using strawbales across flowpaths or gravel filters around pit inlets
- drainage channels incorporating rock check dams at regular intervals
- vegetative buffer strips.

Discharge of runoff during the construction of the proposal

A construction work method statement (**WMS**) would be prepared that sets out the procedures for the discharge of surface water runoff that is retained in sediment controls (e.g. sediment sumps) and exposed excavations. The WMS would be prepared in accordance with the *"Technical Guideline – Environmental Management of Construction Site Dewatering"* (TfNSW, 2011) based on the process set out in **Diagram 1** and would include consideration of the following:

- methods for achieving water quality objectives for any site discharge through best practice erosion and sediment controls and/or treatment of water through flocculation prior to discharge from sediment retention sumps
- reuse of stormwater for dust suppression, earthworks compaction, vegetation establishment or plant wash down where feasible within the scope of construction activities
- suitable discharge locations utilising existing drainage paths and implementing appropriate energy dissipation and scour protection, which should be integrated with operational measures
- procedures for monitoring and maintenance of sump capacity taking into consideration forecast rainfall events
- identification of water quality criteria for the discharge of on-site water and the treatment techniques required to meet these criteria
- water sampling and testing requirements to ensure the water quality objectives are met.

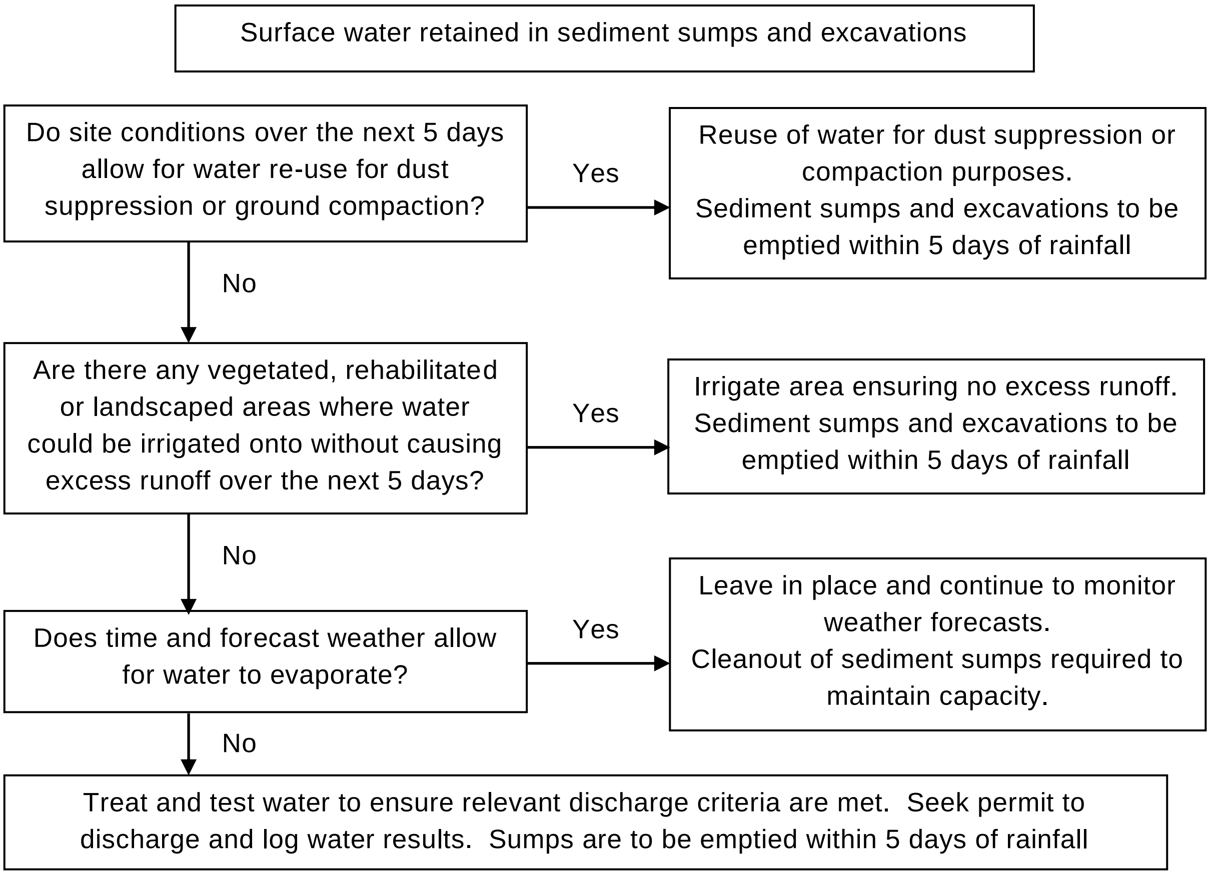


Diagram 1 – Flow chart showing the process for managing the discharge of runoff from sediment sumps and excavations

<u>Control of clean water</u>

Permanent catch and toe drains would be installed during the initial stages of the construction and would be augmented with temporary diversion drains in order to direct clean water runoff around the disturbed areas. The location of proposed clean water diversion drains is shown on **Figure 1** (3 sheets).

Transverse drainage works would be carried out during the initial stages of the construction in order to allow the passage of clean water through the construction site. The locations of existing transverse drainage structures is shown on **Figure 1** (3 sheets).

<u>Works associated with the construction of the Auld Avenue bridge</u>

Piling works for the proposed duplication of the existing bridge to the south of Auld Avenue will require the implementation of erosion controls in order to manage impacts on the Milperra Drain, which will include:

- the installation of working pads and access roads using clean rock material;
- preparing and implementing procedures for the removal or stabilisation of works in flood affected areas and the monitoring of weather forecasts for periods of heavy rain;
- temporary diversions and protection; and
- progressive stabilisation of affected areas with suitable landscaping.

<u>Works within EIS proposal areas</u>

EIS proposal area 1:

- Based on the concept design it is proposed to maintain the existing outlet to transverse drainage EXD01 which will minimise the extent of disturbance within EIS proposal area 1 to carry out permanent drainage works.
- Proposed works within EIS proposal area 1 would involve the construction of a fill embankment to accommodate the widening of Henry Lawson Drive. Temporary diversion drains and/or sediment fencing would be provided along the toe of the fill embankment to collect runoff from the disturbed areas which would be treated through a series of sediment sumps and/or inline sediment control measures.
- Depending on the extent of temporary sediment sumps and in-line controls it may also be necessary to implement additional erosion controls such as the stabilisation of the fill batter with temporary ground cover or sprayed with soil binder prior to forecast rainfall.
- Works within tidal areas of the Georges River will need to include measures to control the dispersion of sediment, such as the provision of turbidity barriers.

EIS proposal area 2:

- Based on the concept design it is proposed to extend the existing drainage systems to accommodate the widening of Milperra Road along its southern side which will require the construction of a series of relocated drainage outlets within EIS proposal area 2. It will be necessary to implement these drainage outlet works during the initial stages of construction to allow for the control of clean water through the site.
- In addition to the extension of existing drainage systems, the works within EIS proposal area 2 would also comprise the construction of a fill embankment to accommodate the widening of Henry Lawson Drive. Temporary diversion drains and/or sediment fencing would be provided along the toe of the fill embankment to collect runoff from the disturbed

areas which would be treated through a series of sediment sumps and/or inline sediment control measures.

- Depending on the extent of temporary sediment sumps and in-line controls, it may also be necessary to implement additional erosion controls such as the stabilisation of the fill batter with temporary ground cover or sprayed with soil binder prior to forecast rainfall.

EIS proposal area 3:

- The southern portion of the Henry Lawson Drive construction ancillary site is located within EIS proposal area 3. Sediment fencing would be installed along the perimeter of the site and erosion and sediment controls would be integrated with the layout of the site to control sediment from disturbed areas and stockpiled material.
- Coastal wetland mapping encroaches along the boundary of the ancillary site. In these areas, there is an opportunity for the construction contractor to utilise sediment fencing as a measure to exclude ancillary work from the coastal wetlands in this area.

<u>Wet weather procedures</u>

Wet weather event procedures would be developed as part of the SWMP for the proposal, which would include:

- monitoring of weather forecasts for wet weather (rain) events
- inspection of disturbed areas to ensure that all erosion, sedimentation and stabilisation controls are in place and in effective working order prior to, during and following forecast rainfall events
- ceasing work and protecting exposed surfaces in flood prone areas
- rescheduling of construction activities that may lead to erosion and sedimentation until after a forecast rainfall event
- limiting of vehicle movements from the site during rainfall if tracking of mud becomes an issue
- the identification of additional controls such as protection of batters in sensitive areas that are to be implemented prior to forecast rainfall events.

3.1. Concluding remark

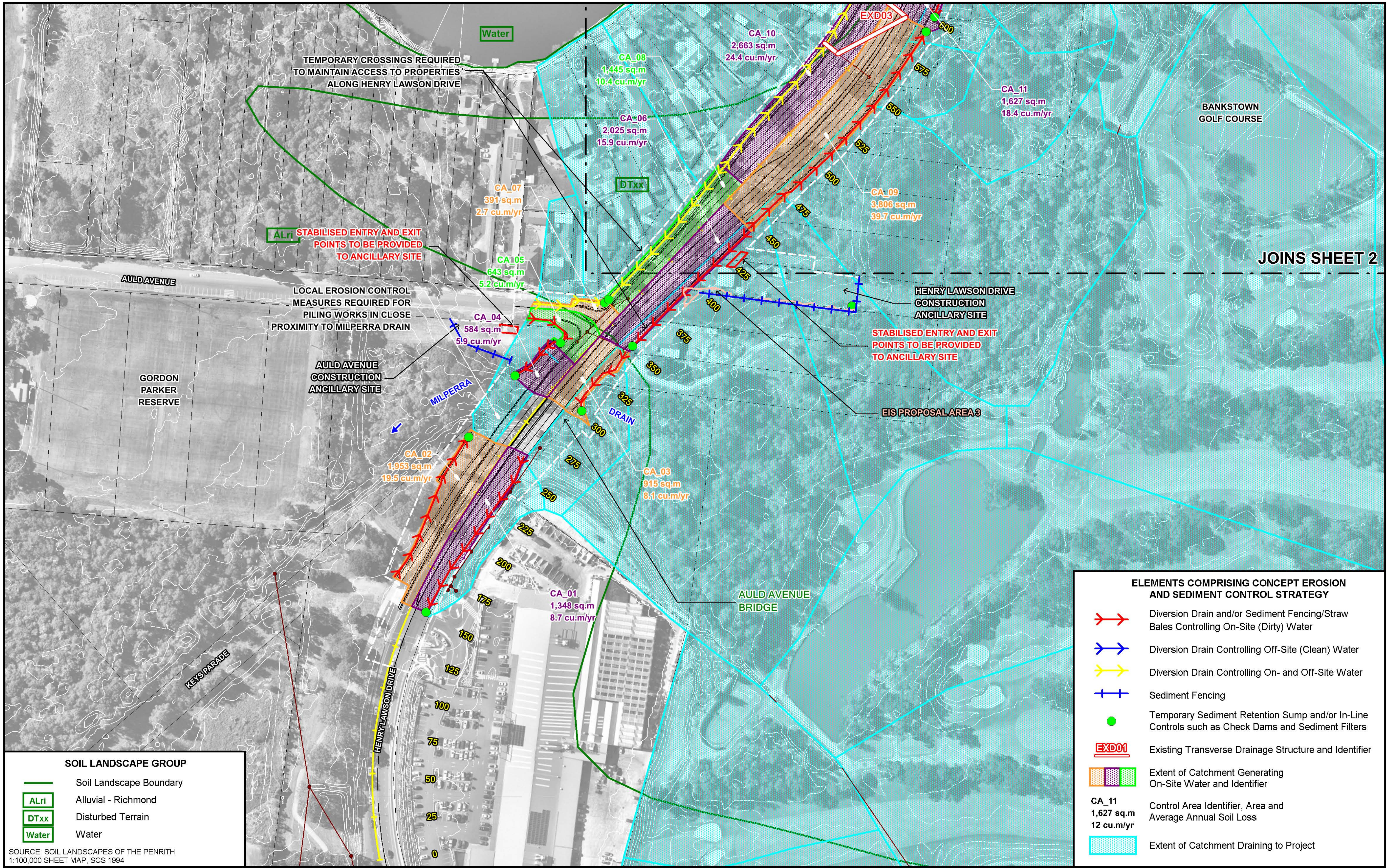
The erosion and sediment control strategy set out in this chapter of the report does not constitute a detailed SWMP, but rather provides an initial guidance on the measures which will need to be implemented during construction of the road works. Additional erosion and sediment control measures, as well as standard maintenance measures which should be implemented during construction are outlined in Volumes 1 and 2D of the Blue Book. A detailed SWMP inclusive of erosion and sediment control plans (**ESCPs**) will therefore need to be prepared by the contractor prior to the commencement of construction activities.

ESCPs would be progressively updated by the contractor, the implementation of which would ensure adequate controls are in place as ground conditions change during each construction stage and that provisions are made for wet weather.

TABLE 1
RUSLE INPUT PARAMETERS AND ESTIMATION OF ANNUAL SOIL LOSS

Parameter	Value	Comment
R (rainfall erosivity factor)	3,000	A rainfall erosivity factor of 1,620 was derived using the 2 year Average Recurrence Interval, 6 hour design storm intensity that was obtained from the Bureau of Meteorology website, compared with a value of 3,000 based on Map 10 in Appendix B of Landcom, 2004. The higher value has been adopted in the RUSLE calculations.
K (soil erodibility factor)	0.059	The mapping contained in the *Soil Landscapes of the Penrith 1:100,000* (Bannerman & Hazelton, 2010) shows that the proposal is located on land that is mapped as either Richmond Soil Landscape or “Disturbed Area”. Richmond Soil Landscape is identified as having a high soil erosion hazard, which is reflected in the recommended K value of 0.059 in Table 19 of Appendix C of Landcom, 2004. In the absence of soil characteristics for “Disturbed Area”, the K value for the Richmond Soil Landscape has also been applied to these areas. It is recommended that the soil erodibility within areas of the proposal that are classified in Bannerman & Hazelton, 2010 as “Disturbed Area” be confirmed based on site specific soil testing.
LS (slope length / gradient factor)	0.91	Based on a slope of 5% and length of 50 m, which is the upper value of slope and length across the proposed areas of disturbance.
P (erosion control practice factor)	1.3	Assumed maximum value based on compacted and smooth surface conditions.
C (ground cover management factor)	1.0	Assumed maximum value based on worst case scenario with zero ground cover.
A (total calculated soil loss)	209 tonnes / ha / yr	Representative soil loss for the proposal.
Erosion Hazard	Low (Soil Loss Class 2)	Based on Table 4.2 of Landcom, 2004.
Minimum catchment size requiring a sediment basin	0.94 Ha	Based on a threshold of 150 m^3 and a typical density of saturated sediment of 1.3 tonnes / m^3.

FIGURES



N

20 0 20 40 60 m

Scale: 1:2,000

LEGEND

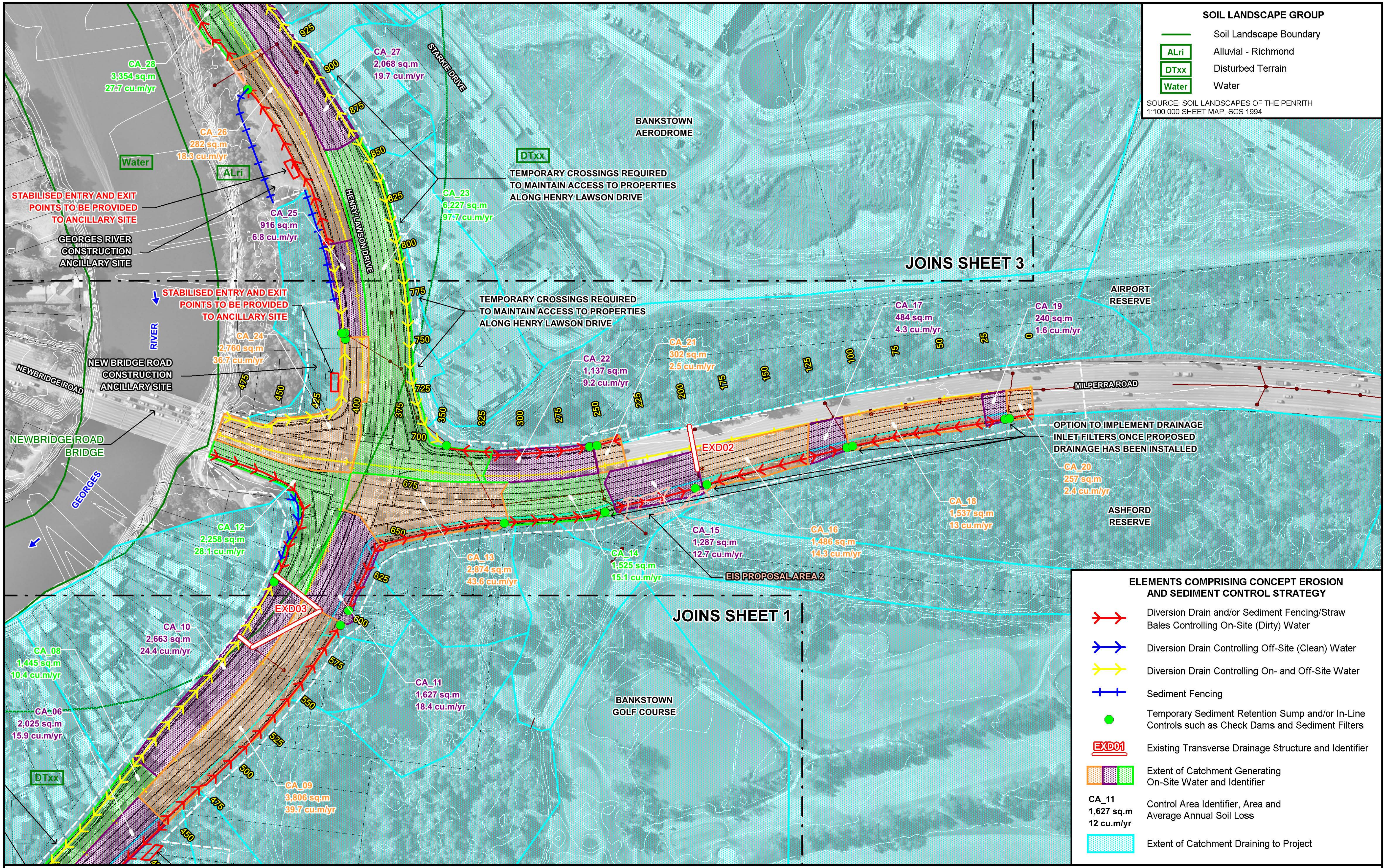
Road Design Strings	Construction Footprint
Road Alignment and Chainage (250, 500)	Existing Stormwater Drainage System
	EIS Proposal Area

Lyall & Associates

HENRY LAWSON DRIVE UPGRADE STAGE 1

Figure 1
(Sheet 1 of 3)

EROSION AND SEDIMENT CONTROL STRATEGY



N

20 0 20 40 60 m

Scale: 1:2,000

LEGEND

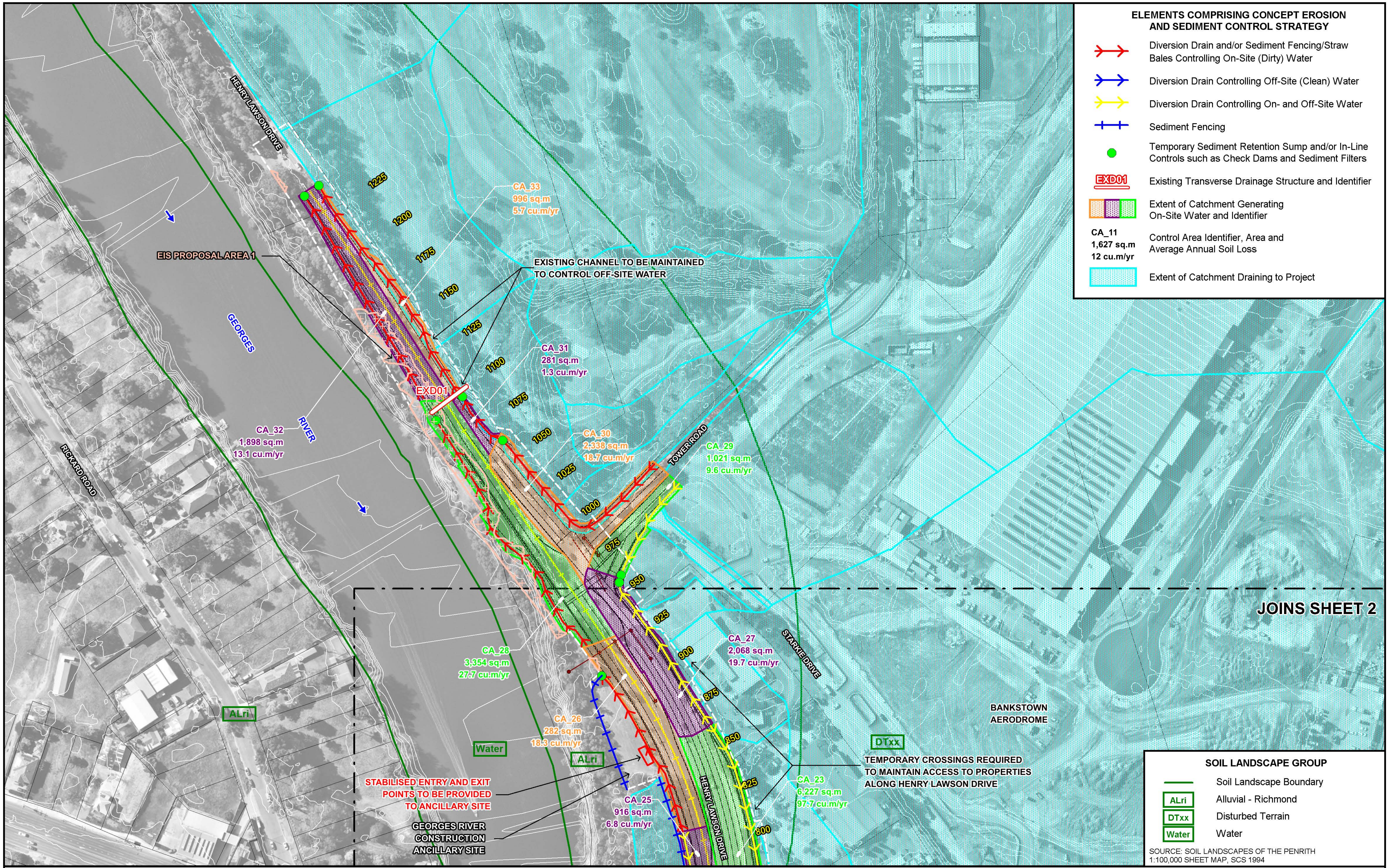
- Road Design Strings
- Road Alignment and Chainage
- Construction Footprint
- Existing Stormwater Drainage System
- EIS Proposal Area

Lyall & Associates

HENRY LAWSON DRIVE UPGRADE STAGE 1

Figure 1
(Sheet 2 of 3)

EROSION AND SEDIMENT CONTROL STRATEGY



N
20 0 20 40 60 m
Scale: 1:2,000

Lyall & Associates

LEGEND

- Road Design Strings
- Road Alignment and Chainage (250, 500)
- Construction Footprint
- Existing Stormwater Drainage System
- EIS Proposal Area

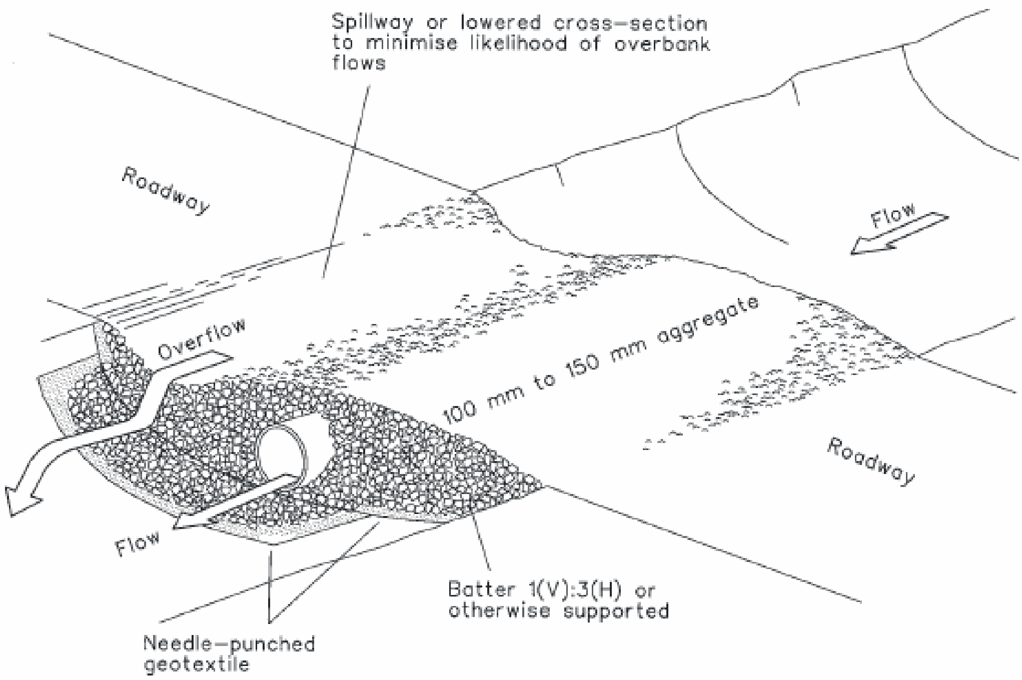
HENRY LAWSON DRIVE UPGRADE STAGE 1

Figure 1
(Sheet 3 of 3)

EROSION AND SEDIMENT CONTROL STRATEGY

ANNEXURE A
TYPICAL EXAMPLES OF SEDIMENT CONTROL MEASURES

(Source: *Soils and Construction – Managing Urban Stormwater Volume 1* (Landcom, 2004)

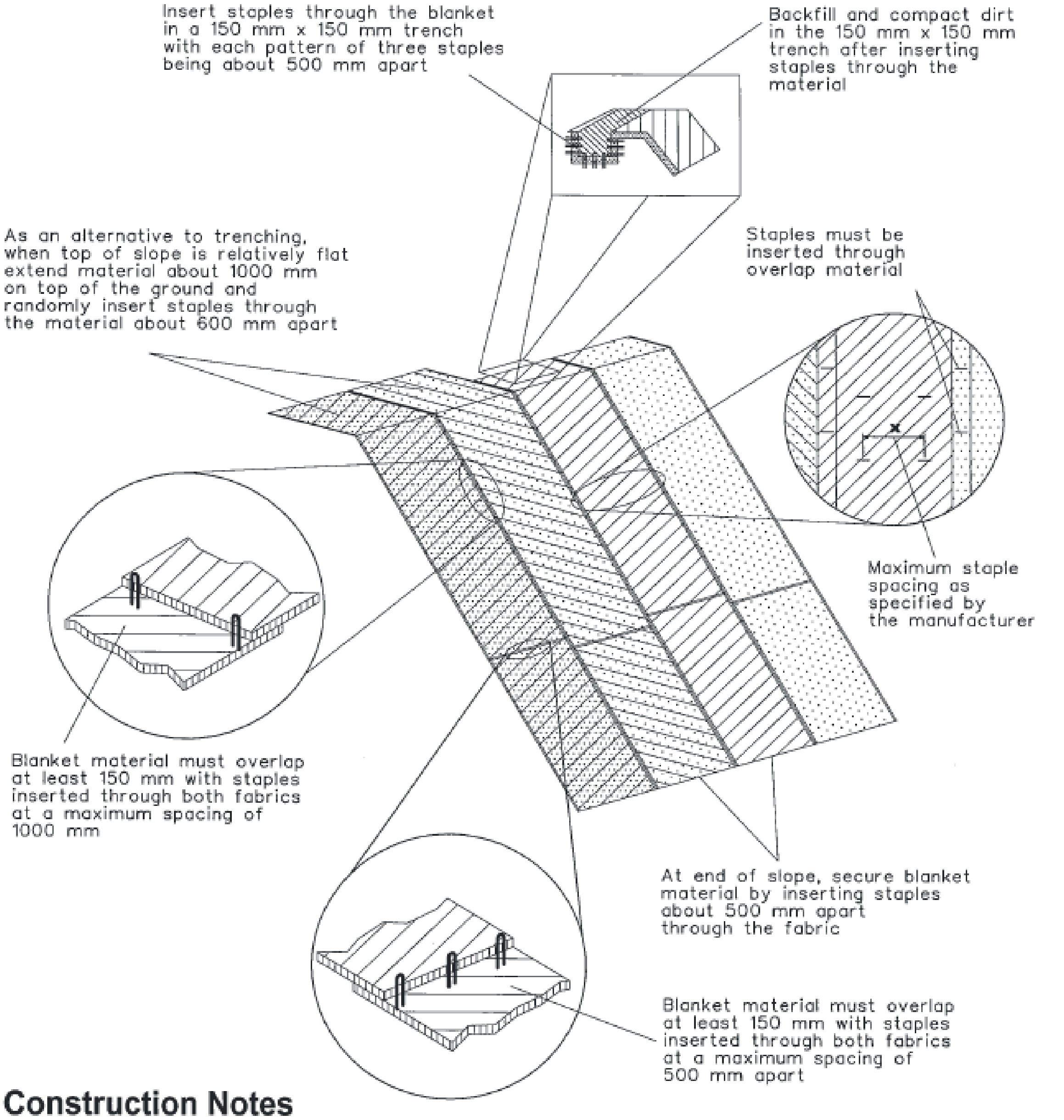


Construction Notes

1. Prohibit all traffic until the access way is constructed.
2. Strip any topsoil and place a needle-punched textile over the base of the crossing.
3. Place clean, rigid, non polluting aggregate or gravel in the 100 mm to 150 mm size class over the fabric to a minimum depth of 200 mm.
4. Provide a 3-metre wide carriageway with sufficient length of culvert pipe to allow less than a 3(H): 1 (V) slope on side batters.
5. Install a lower section to act as an emergency spillway in greater than design storm events.
6. Ensure that culvert outlets extend beyond the toe of fill embankments.

TEMPORARY WATERWAY CROSSING

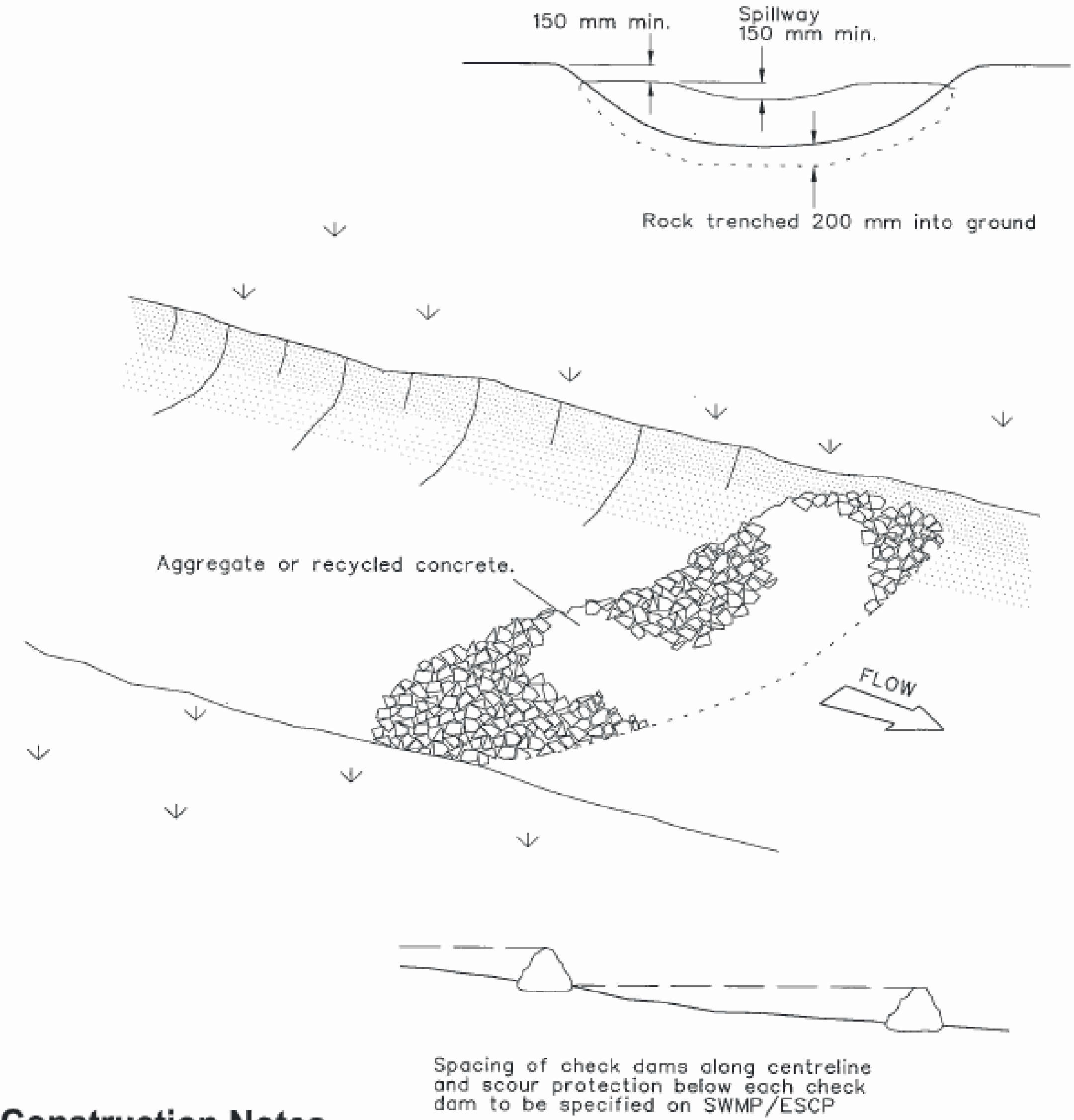
SD 5-1



Construction Notes

1. Remove any rocks, clods, sticks or grass from the ground surface before laying the matting.
2. Spread topsoil to at least 75 mm depth.
3. Where appropriate, complete fertilising and seeding on a properly prepared seedbed (Standard Drawing 7-1) before laying the matting.
4. Ensure the fabric can be continuously in contact with the soil by grading the surface carefully first.
5. Lay the matting in "shingle-fashion" with the ends of each upstream roll overlapping the next roll downslope.
6. Ensure sufficient staples are used to maintain a good contact between the soil and the matting.

RECP : SHEET FLOW **SD 5-2**

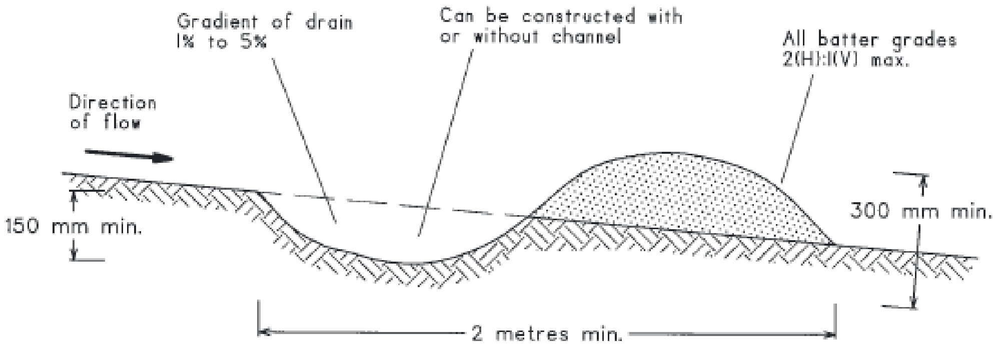


Construction Notes

1. Check dams can be built with various materials, including rocks, logs, sandbags and straw bales. The maintenance program should ensure their integrity is retained, especially where constructed with straw bales. In the case of bales, this might require their replacement each two to four months.
2. Trench the check dam 200 mm into the ground across its whole width. Where rock is used, fill the trenches to at least 100 mm above the ground surface to reduce the risk of undercutting.
3. Normally, their maximum height should not exceed 600 mm above the gully floor. The centre should act as a spillway, being at least 150 mm lower than the outer edges.
4. Space the dams so the toe of the upstream dam is level with the spillway of the next downstream dam.

ROCK CHECK DAM

SD 5-4

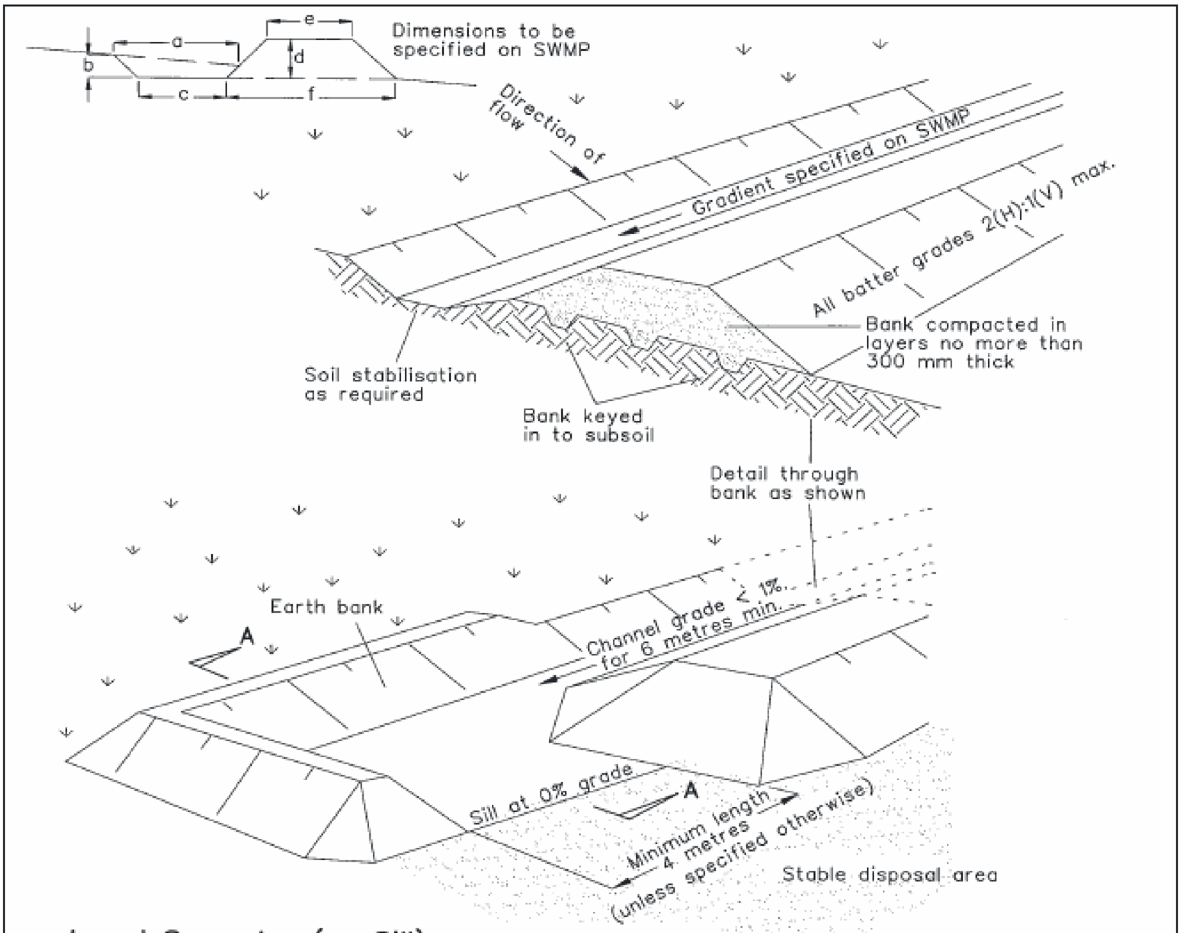


NOTE: Only to be used as temporary bank where maximum upslope length is 80 metres.

Construction Notes

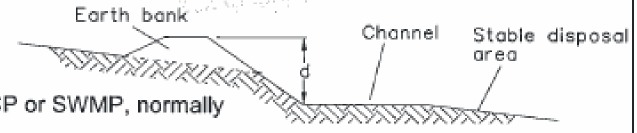
1. Build with gradients between 1 percent and 5 percent.
2. Avoid removing trees and shrubs if possible - work around them.
3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V shaped.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction.

EARTH BANK (LOW FLOW) **SD 5-5**



Level Spreader (or Sill)

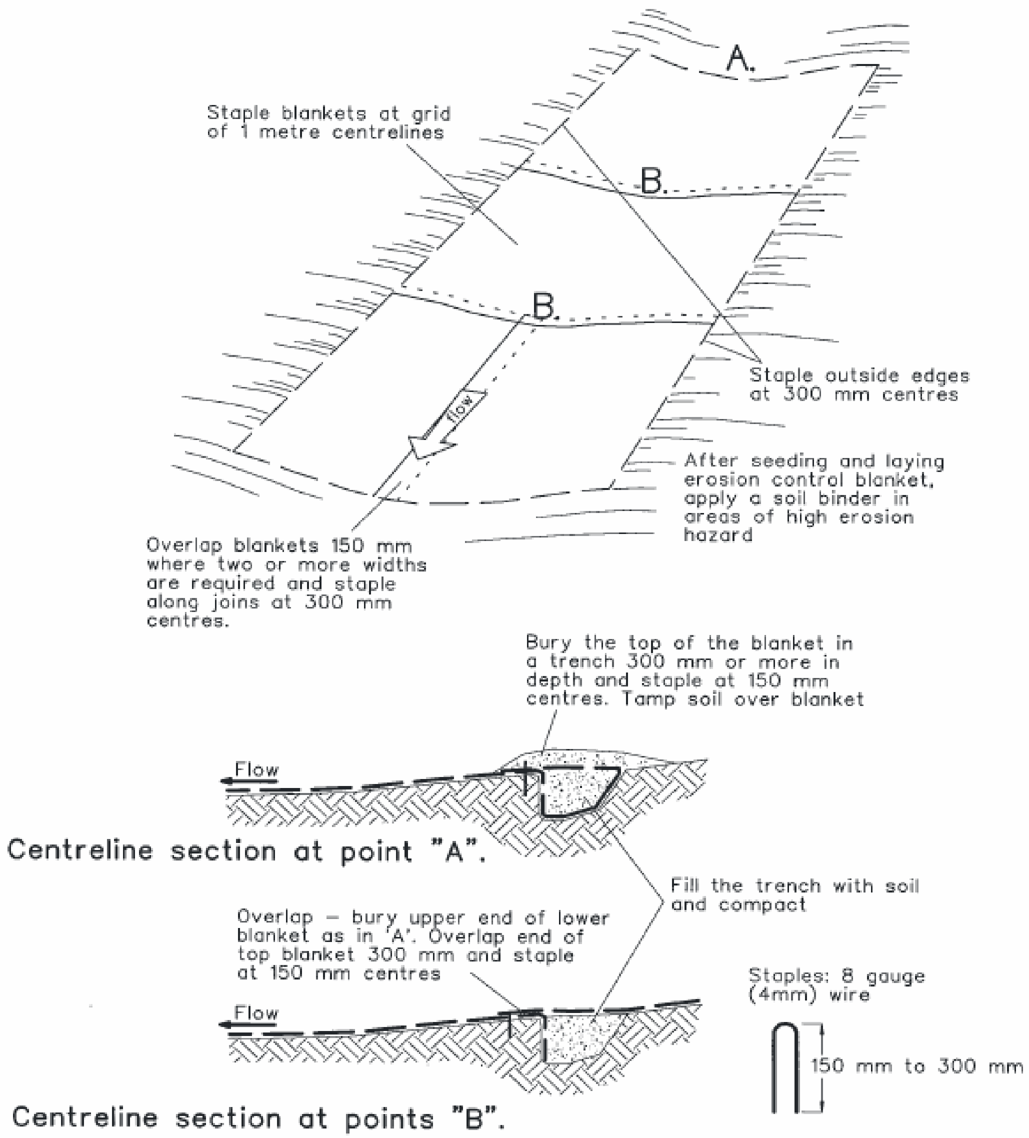
Construction Notes



Section AA

1. Construct at the gradient specified on the ESCP or SWMP, normally between 1 and 5 percent
2. Avoid removing trees and shrubs if possible - work around them.
3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V-shaped, at the dimensions shown on the SWMP.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction following Table 5.2 in Landcom (2004).
7. Where discharging to erodible lands, ensure they outlet through a properly constructed level spreader.
8. Construct the level spreader at the gradient specified on the ESCP or SWMP, normally less than 1 percent or level.
9. Where possible, ensure they discharge waters onto either stabilised or undisturbed disposal sites within the same subcatchment area from which the water originated. Approval might be required to discharge into other subcatchments.

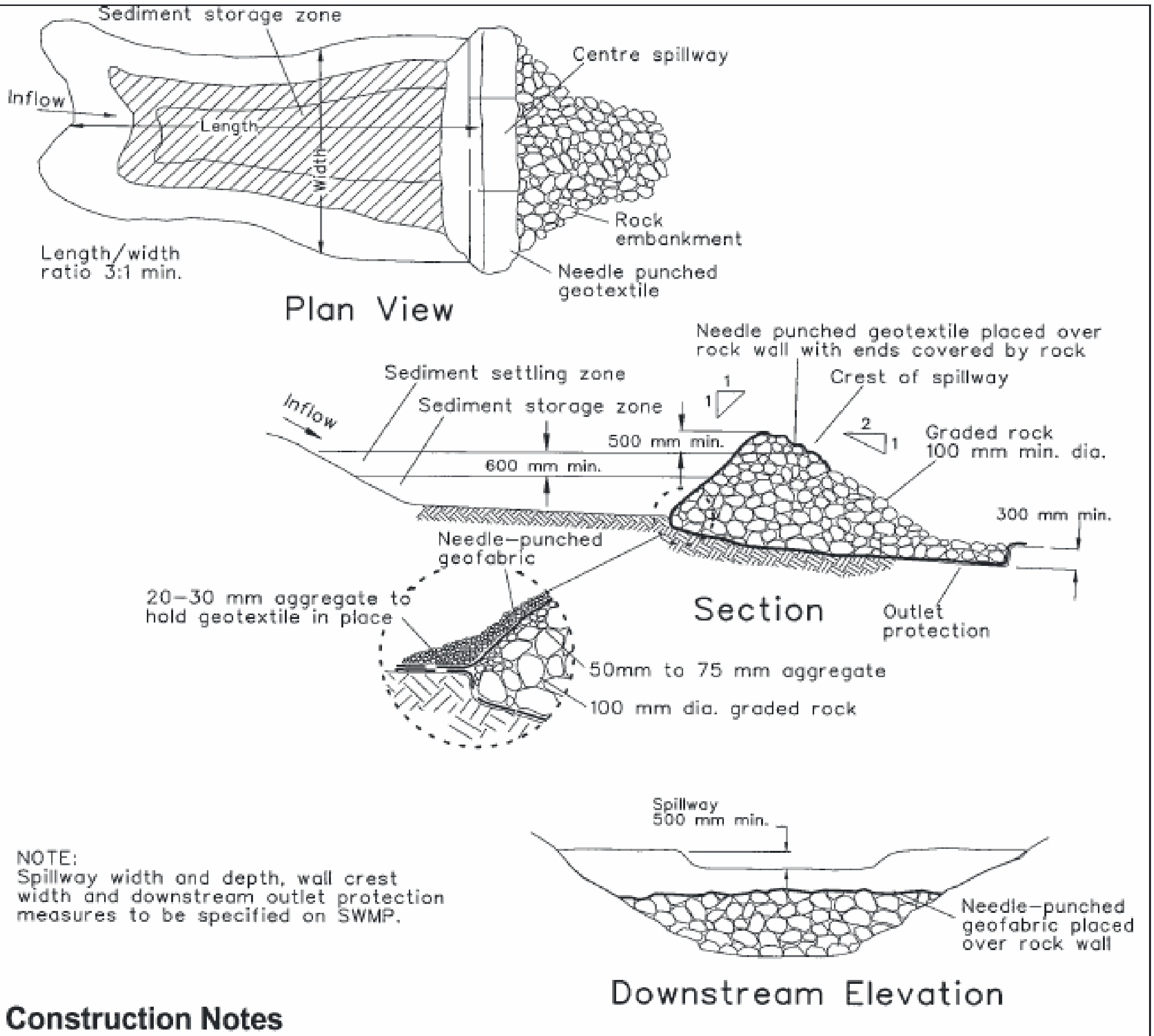
EARTH BANK (HIGH FLOWS) SD 5-6



Construction Notes

1. Remove any rocks, clods, sticks or grass from the surface before laying matting
2. Ensure that topsoil is at least 75 mm deep.
3. Complete fertilising and seeding before laying the matting.
4. Ensure fabric will be continuously in contact with the soil by grading the surface carefully first.
5. Lay the fabric in "shingle-fashion", with the end of each upstream roll overlapping those downstream. Ensure each roll is anchored properly at its upslope end (Standard Drawing 5-7b).
6. Ensure that the full width of flow in the channel is covered by the matting up to the design storm event, usually in the 10-year ARI time of concentration storm event.
7. Divert water from the structure until vegetation is stabilised properly.

RECP : CONCENTRATED FLOW **SD 5-7**



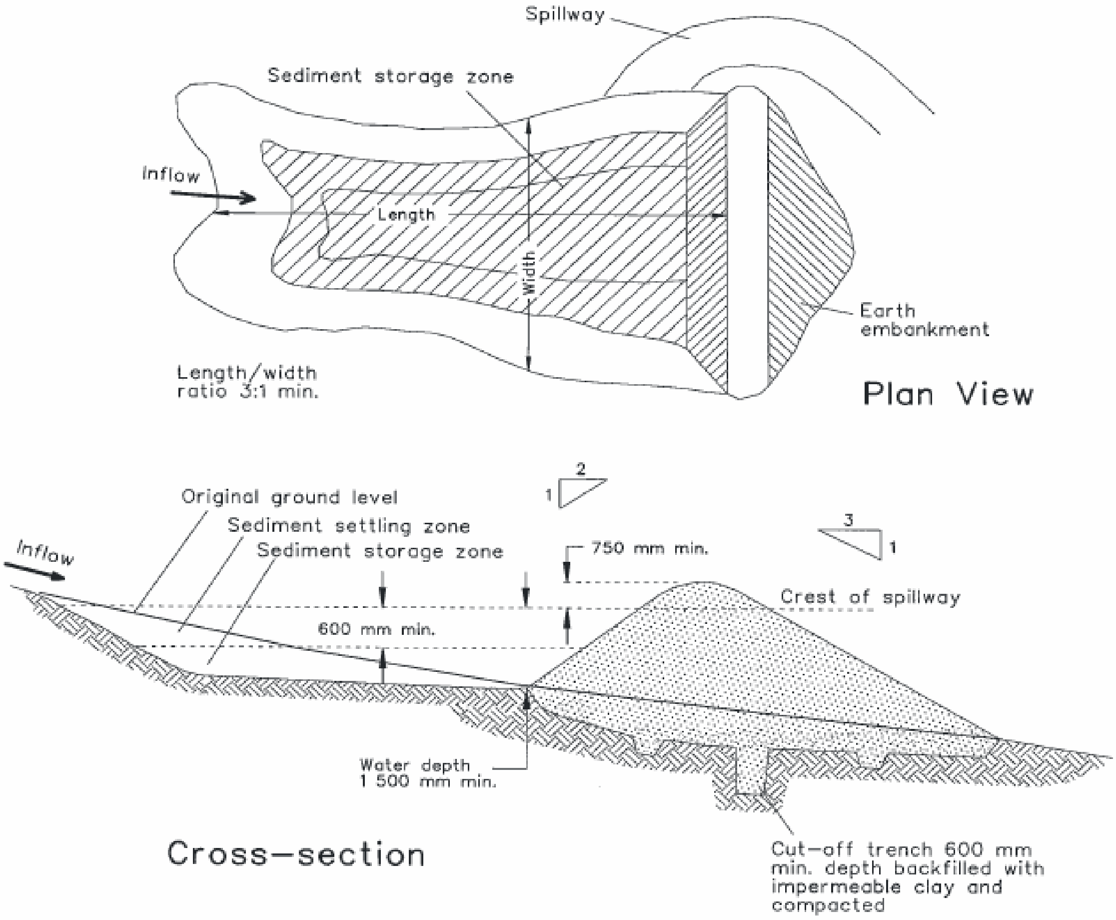
Construction Notes

1. Remove all vegetation and topsoil from under the dam wall and from within the storage area.
2. Excavate to 300 mm depth for base of the dam wall.
3. Line the excavation with a needle-punched geotextile allowing sufficient to line below the wall, and over the upstream rock and the spillway to 500 mm below the spillway exit on the downstream face.
4. Make up the wall profile and outlet protection with100 mm (min.) diameter graded rock. Spread a layer of 50 mm to 75 mm diameter aggregate over the upstream batter for a more even surface, and add 100 mm to 150 mm of 20 mm to 30 mm gravel over the 50 mm to 75 mm diameter aggregate.
5. Lay geotextile over the upstream batter and through the spillway, fixing in place with 100 mm rock.
6. Place a "Full of Sediment" marker to show when less than design capacity occurs and sediment removal is required.
7. Replace the upstream geotextile layer each time sediment is removed

ROCK SEDIMENT BASIN

(APPLIES TO 'TYPE C' SOILS ONLY)

SD 6-1



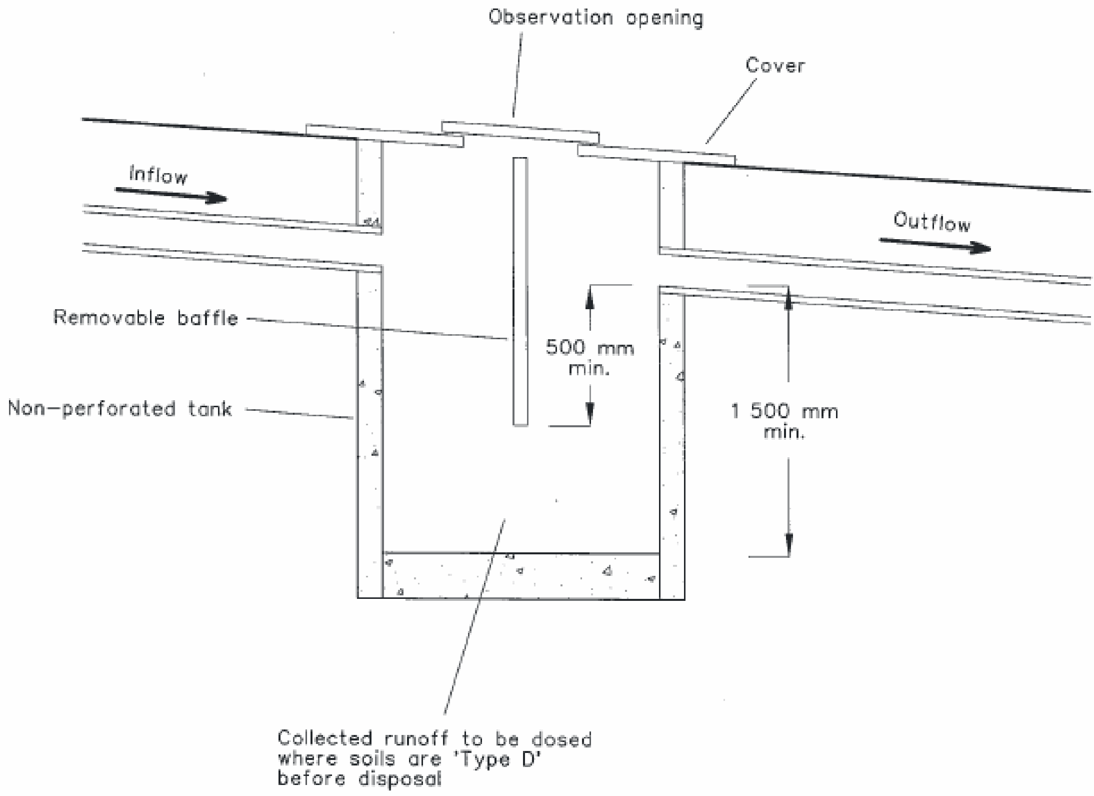
Construction Notes

1. Remove all vegetation and topsoil from under the dam wall and from within the storage area.
2. Construct a cut-off trench 500 mm deep and 1,200 mm wide along the centreline of the embankment extending to a point on the gully wall level with the riser crest.
3. Maintain the trench free of water and recompact the materials with equipment as specified in the SWMP to 95 per cent Standard Proctor Density.
4. Select fill following the SWMP that is free of roots, wood, rock, large stone or foreign material.
5. Prepare the site under the embankment by ripping to at least 100 mm to help bond compacted fill to the existing substrate.
6. Spread the fill in 100 mm to 150 mm layers and compact it at optimum moisture content following the SWMP.
7. Construct the emergency spillway.
8. Rehabilitate the structure following the SWMP.

EARTH BASIN - WET

(APPLIES TO 'TYPE D' AND 'TYPE F' SOILS ONLY)

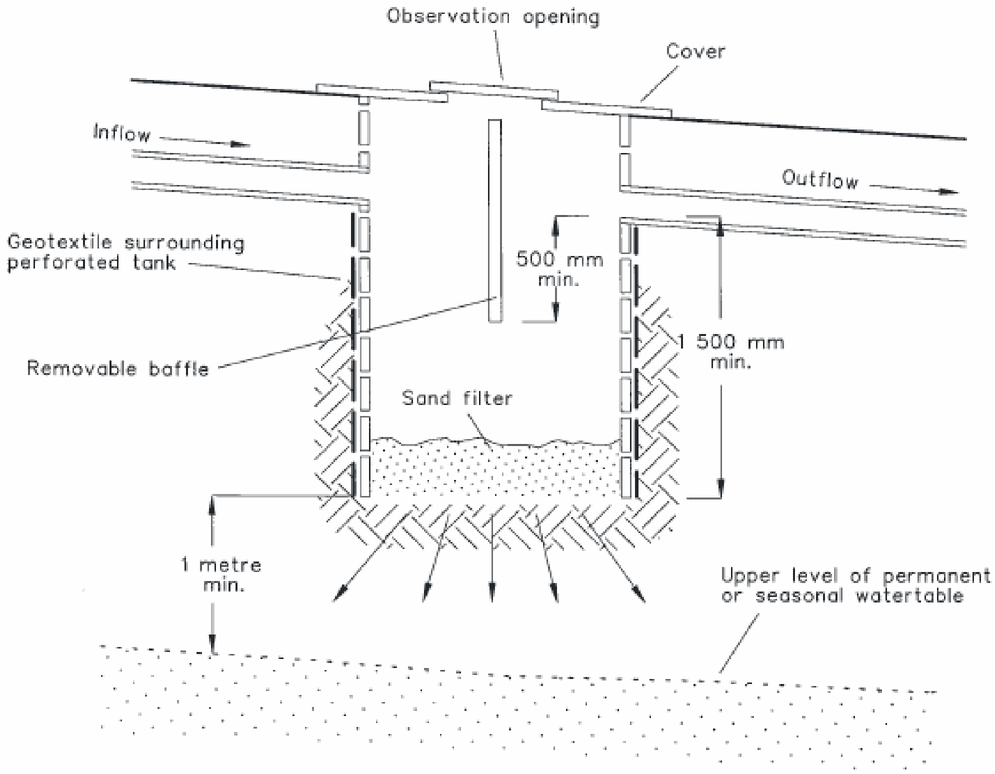
SD 6-4



Construction Notes

1. Join the inlet to the stormwater, taking any suitable steps to remove bulky or coarse material before it can enter the tank.
2. Connect the outlet to a safe disposal area following the SWMP.
3. Install a removable baffle, central to the inflow/outflow and normal to the direction of flow, ensuring that it reaches 500 mm below the invert of the outlet pipe.
4. Install a cover over the pit with an observation port and access cover.

LINED TANK **SD 6-5**

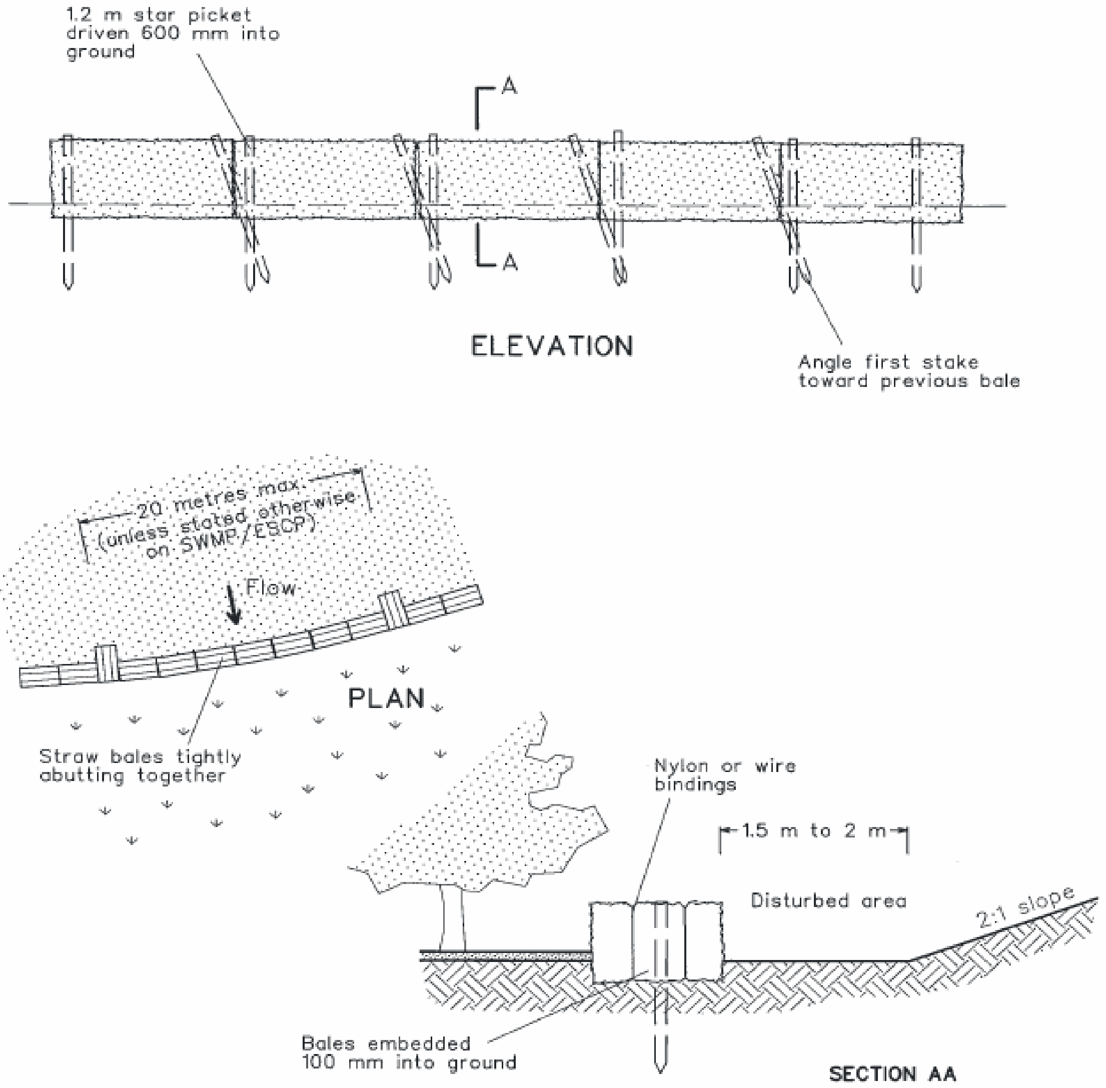


Construction Notes

1. Join the inlet to the polluted supply taking any suitable step to remove bulky material before it can enter the sump.
2. Connect the outlet to a safe disposal area following the ESCP/SWMP.
3. Place a geotextile liner on the outside of the pit.
4. Install a removable baffle, central to the inflow/outflow and normal to the direction of flow, ensuring that it reaches 500 mm below the invert of the outlet pipe.
5. Install a cover over the pit with an observation port and access cover.

INFILTRATION SUMP

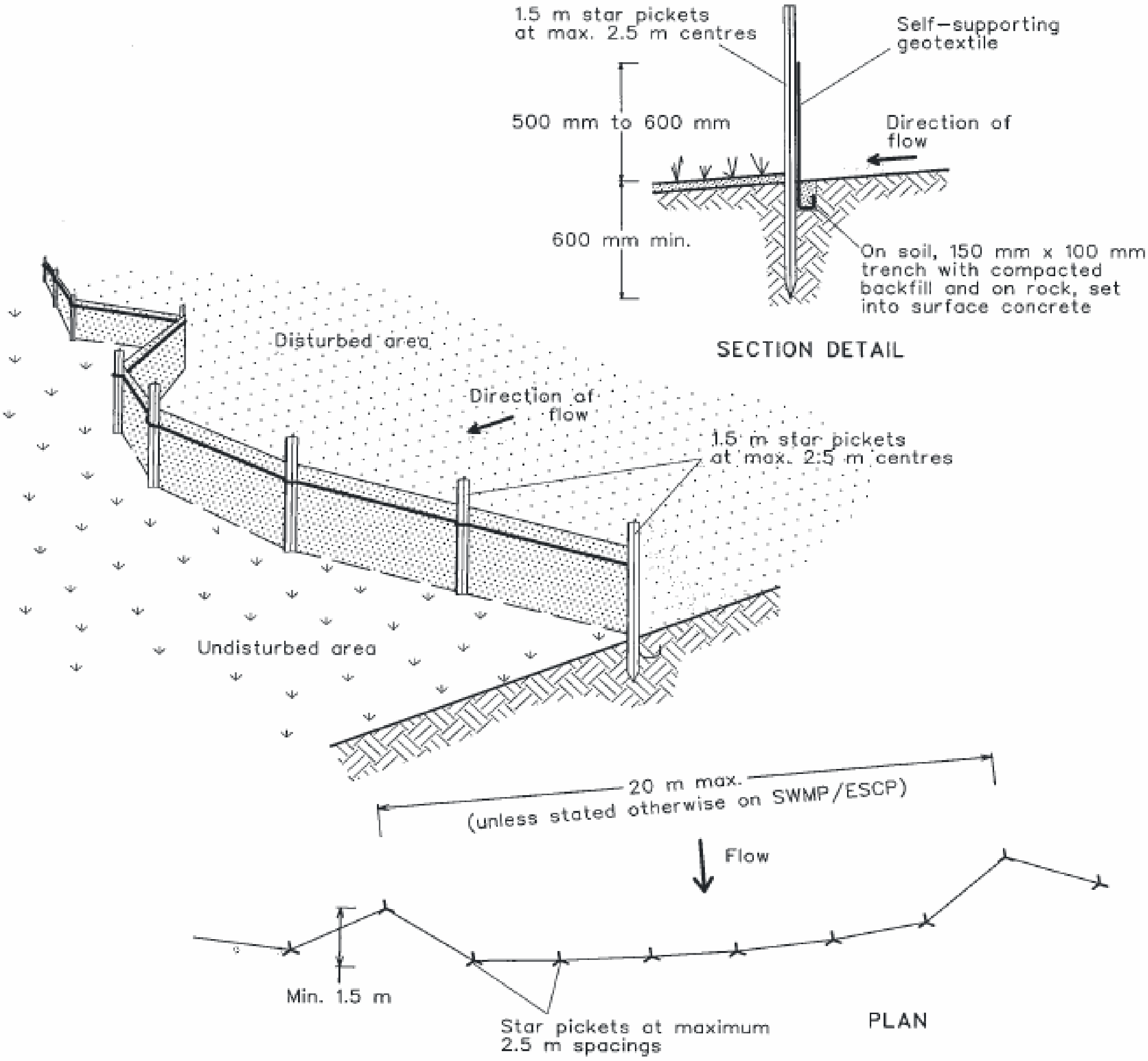
SD 6-6



Construction Notes

1. Construct the straw bale filter as close as possible to being parallel to the contours of the site.
2. Place bales lengthwise in a row with ends tightly abutting. Use straw to fill any gaps between bales. Straws are to be placed parallel to ground.
3. Ensure that the maximum height of the filter is one bale.
4. Embed each bale in the ground 75 mm to 100 mm and anchor with two 1.2 metre star pickets or stakes. Angle the first star picket or stake in each bale towards the previously laid bale. Drive them 600 mm into the ground and, if possible, flush with the top of the bales. Where star pickets are used and they protrude above the bales, ensure they are fitted with safety caps.
5. Where a straw bale filter is constructed downslope from a disturbed batter, ensure the bales are placed 1 to 2 metres downslope from the toe.
6. Establish a maintenance program that ensures the integrity of the bales is retained - they could require replacement each two to four months.

STRAW BALE FILTER **SD 6-7**

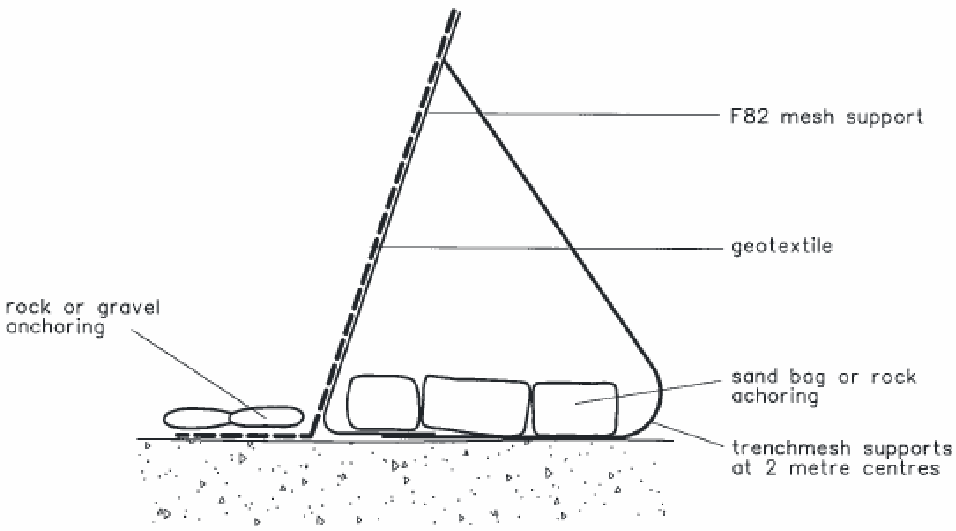


Construction Notes

1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

SEDIMENT FENCE

SD 6-8

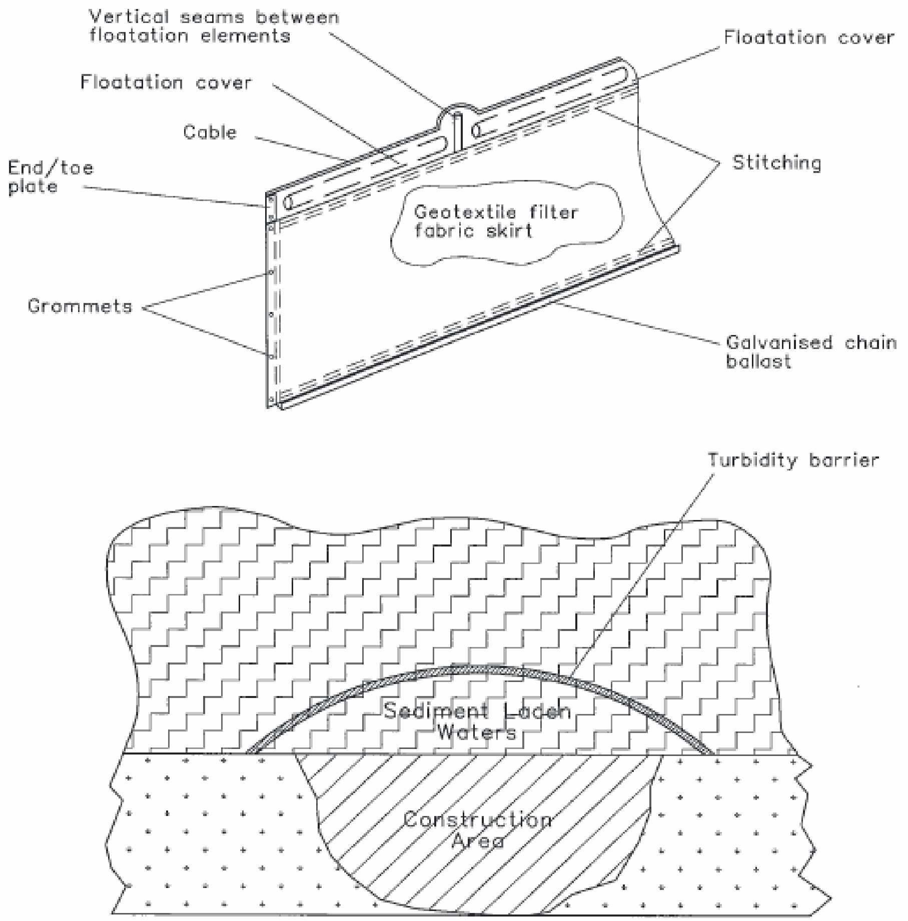


Construction Notes

1. Install this type of sediment fence when use of support posts is not desirable or not possible. Such conditions might apply, for example, where approval is granted from the appropriate authorities to place these fences in highly sensitive estuarine areas.
2. Use bent trench mesh to support the F82 welded mesh facing as shown on the drawing above. Attach the geotextile to the welded mesh facing using UV resistant cable ties.
3. Stabilise the whole structure with sandbag or rock anchoring over the trench mesh and the leading edge of the geotextile. The anchoring should be sufficiently large to ensure stability of the structure in the design storm event, usually the 10 year event.

ALTERNATIVE SEDIMENT FENCE

SD 6-9

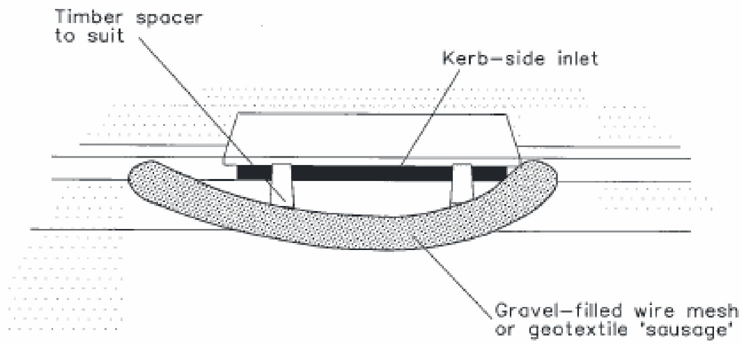


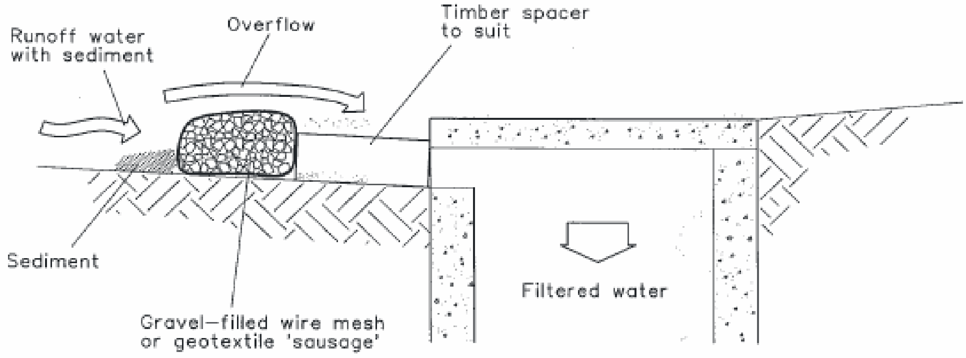
Construction Notes

1. Use turbidity barriers only where high flows are unlikely to remove accumulated sediment and/or move the curtain significantly.
2. Where the barrier is to remain in place for more than one month, ensure the floatation cover is a UV-resistant, durable material.
3. Use only closed cell foam or foam-filled PVC piping as floatation elements. Do not use unfilled pipes.
4. Use only woven or heat-set non woven geotextiles. Needle-punched, non woven geotextiles can become fouled with debris that fray and delaminate them as they move with the waves or currents.
5. Remove captured sediment before the barrier is decommissioned.
6. In tidal areas, ensure the barrier can rise and fall without being moved from its position.

TURBIDITY BARRIER

SD 6-10





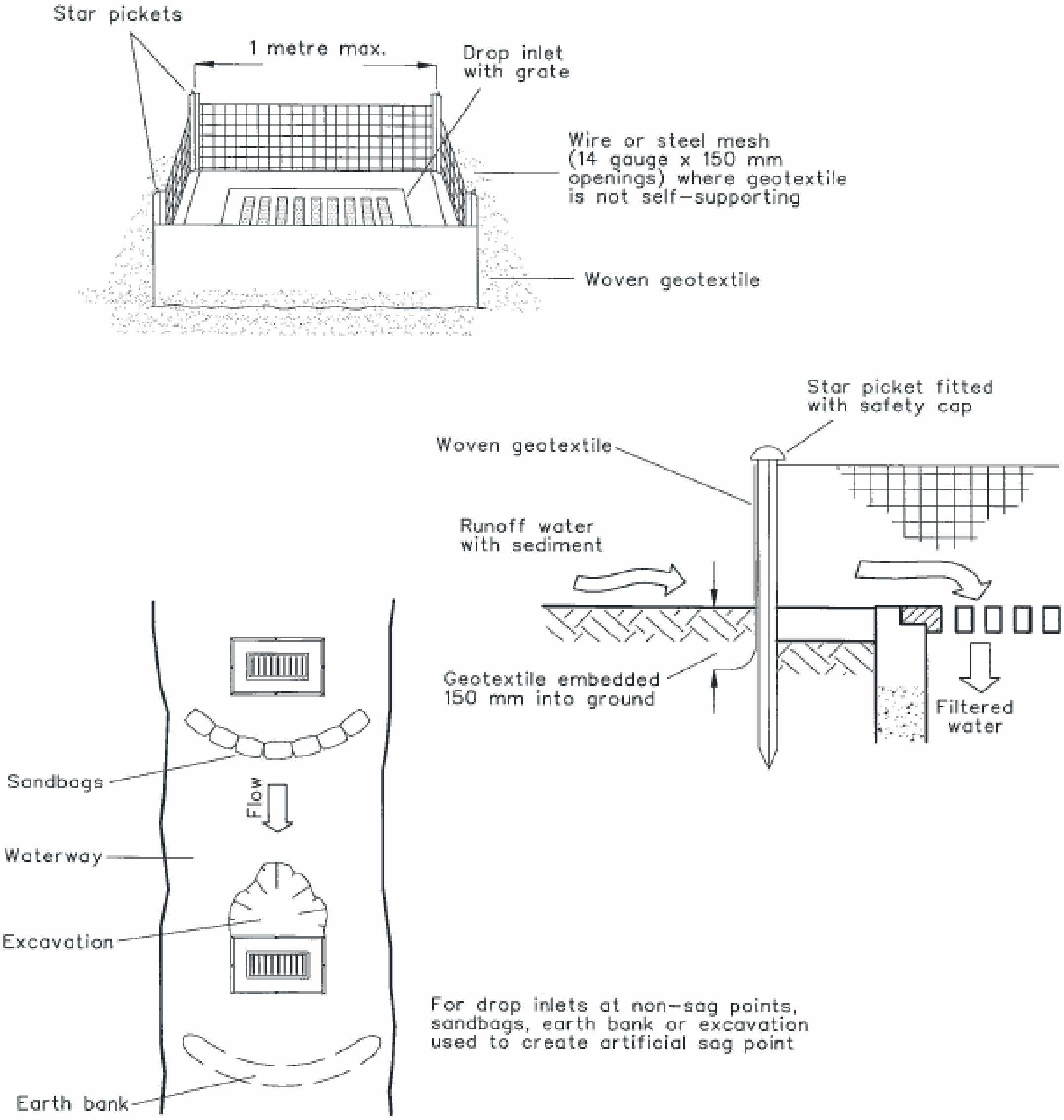
NOTE: This practice only to be used where specified in an approved SWMP/ESCP.

Construction Notes

1. Install filters to kerb inlets only at sag points.
2. Fabricate a sleeve made from geotextile or wire mesh longer than the length of the inlet pit and fill it with 25 mm to 50 mm gravel.
3. Form an elliptical cross-section about 150 mm high x 400 mm wide.
4. Place the filter at the opening leaving at least a 100-mm space between it and the kerb inlet. Maintain the opening with spacer blocks.
5. Form a seal with the kerb to prevent sediment bypassing the filter.
6. Sandbags filled with gravel can substitute for the mesh or geotextile providing they are placed so that they firmly abut each other and sediment-laden waters cannot pass between.

MESH AND GRAVEL INLET FILTER

SD 6-11

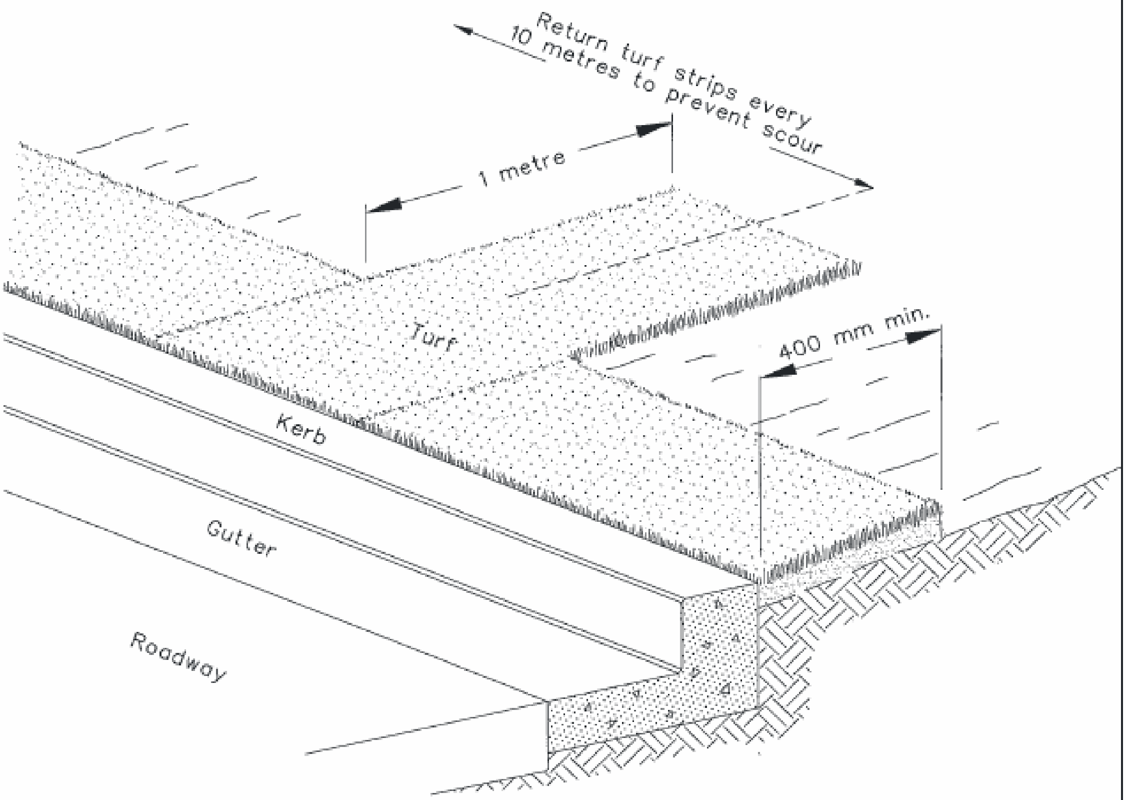


Construction Notes

1. Fabricate a sediment barrier made from geotextile or straw bales.
2. Follow Standard Drawing 6-7 and Standard Drawing 6-8 for installation procedures for the straw bales or geofabric. Reduce the picket spacing to 1 metre centres.
3. In waterways, artificial sag points can be created with sandbags or earth banks as shown in the drawing.
4. Do not cover the inlet with geotextile unless the design is adequate to allow for all waters to bypass it.

GEOTEXTILE INLET FILTER

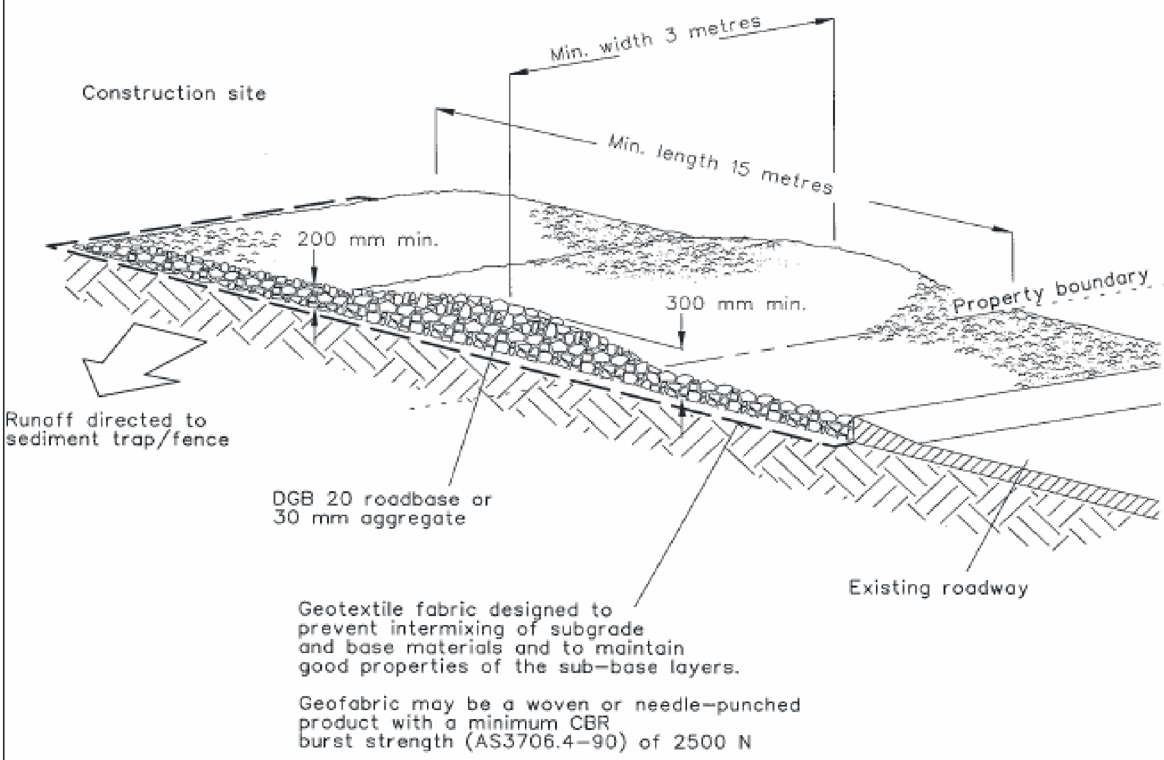
SD 6-12



Construction Notes

1. Install a 400-mm minimum wide roll of turf on the footpath next to the kerb and at the same level as the top of the kerb.
2. Lay 1.4 metre long turf strips normal to the kerb every 10 metres.
3. Rehabilitate disturbed soil behind the

KERBSIDE TURF STRIP **SD 6-13**



Construction Notes

1. Strip the topsoil, level the site and compact the subgrade.
2. Cover the area with needle-punched geotextile.
3. Construct a 200-mm thick pad over the geotextile using road base or 30-mm aggregate.
4. Ensure the structure is at least 15 metres long or to building alignment and at least 3 metres wide.
5. Where a sediment fence joins onto the stabilised access, construct a hump in the stabilised access to divert water to the sediment fence

STABILISED SITE ACCESS

SD 6-14

APPENDIX E CONCEPT OPERATIONAL WATER QUALITY STRATEGY (LYALL & ASSOCIATES)

TECHNICAL NOTE 2
HENRY LAWSON DRIVE UPGRADE STAGE 1A – SURFACE WATER ASSESSMENT
OPERATIONAL WATER QUALITY STRATEGY

1. Introduction

This technical note presents the findings of an investigation into the requirements for controlling the impact of the operational phase of Stage 1A of the proposed Henry Lawson Drive Upgrade project (**proposal**) on water quality in the Georges River and Milperra Drain.

Figure 1 (3 sheets) shows the concept operational water quality strategy (**strategy**) for the proposal and should be referred to when reading the following sections of this technical note. The strategy is aimed at meeting the water quality objectives that have been established for the proposal of limiting the discharge of pollutant loads from the proposal corridor to no greater than those under present day conditions.

The strategy has been developed based on the concept road design for the proposed upgrade and will form part of the overall flood and stormwater management strategy for the operational phase of the proposal.

2. Assessment of stormwater quality impacts

2.1. Background to development of MUSIC models

Contaminants that are typically associated with road runoff include suspended sediments, heavy metals, litter, nutrients such as nitrogen and phosphorus, oils and greases. These contaminants build up on the road surface during dry weather and are then washed off during rainfall events. The proposed road upgrade has the potential to increase the volume of contaminants discharging to the receiving drainage lines unless appropriate measures are incorporated into the design. It is noted that the increase in pollutant loads is due to an increase in paved area in combination with an increase in vehicle movements attributable to the proposal.

To demonstrate the level of impact that the proposed road upgrade works would have on the quality of water in the receiving drainage lines, an investigation was carried out using the MUSIC rainfall runoff modelling software. The first step in the process involved the development of a MUSIC model to reflect the contributing areas of the road corridor discharging to the receiving drainage lines under present day (i.e. pre-upgrade) conditions (**Pre-Upgrade MUSIC Model**). **Figure A1** in **Annexure A** shows the layout of the sub-catchments which comprise the Pre-Upgrade MUSIC Model.

Rainfall records from the Bankstown Airport AWS pluviograph recorder (Station Number 66137) for the period 1968 to 1992 were selected for use in the Pre-Upgrade MUSIC Model. The recorder is located less than 1 km to the north east of the proposal and therefore provides the most location specific rainfall data for the study area. Rainfall losses, as well as base and stormwater flow pollutant concentrations were based on values recommended in the publication entitled *"Using MUSIC in Sydney's Drinking Water Catchment"* (SCA, 2012).

The Pre-Upgrade MUSIC Model was then adjusted to reflect post-upgrade conditions in order to assess the impact of the proposed road works on the weight of pollutants entering the receiving drainage lines (**Post-Upgrade MUSIC Model**). This was done by adjusting sub-catchment boundaries, drainage paths and per cent imperviousness based on the concept road and drainage designs. **Figure A2** in **Annexure A** shows the layout of the sub-catchments which comprise the Post-Upgrade MUSIC Model.

2.2. Pre-proposal analysis and impact of road upgrade on stormwater quality

Columns 3 to **6** of **Table 1** show the average annual pollutant loads in the drainage lines downstream of the proposal corridor, while **Columns 8** to **11** of **Table 1** show the changes that would occur in average annual pollutant loads as a result of the road upgrade works if stormwater quality measures are not incorporated into its design. Results are presented in terms of changes in annual pollutant loads in the individual drainage lines that control runoff from the proposal corridor and discharge to the Georges River and Milperra Drain, as well as the net change in average annual pollutant loads discharging to the two water bodies.

In regards to the Georges River, it was found that if appropriate stormwater quality measures are not incorporated into the design of the drainage system then the increase in paved surfaces would result in the following net increase in the average annual weight of pollutants:

- gross pollutants - 72 kg
- total suspended solids (TSS) - 745 kg
- total phosphorus (TP) - 1.4 kg
- total nitrogen (TN) - 5.5 kg

As the majority of the roadworks are located within the Milperra Drain catchment a larger increase in pollutant loads is predicted. If appropriate stormwater quality measures are not incorporated into the design of the drainage system then the increase in paved surfaces would result in the following net increase in the average annual weight of pollutants:

- gross pollutants - 302 kg
- TSS - 2,880 kg
- TP - 5.3 kg
- TN - 20.9 kg

3. Concept stormwater quality strategy

A concept stormwater quality strategy was developed that is aimed at, as far as is practical, offsetting the increase in pollutant load attributable to the proposed road upgrade within the available site constraints. The strategy was developed using the result of the MUSIC modelling together with a review of the proposed road upgrade and site conditions to identify opportunities to incorporate suitable stormwater quality measures into the concept drainage design. The layout of the concept stormwater quality strategy is shown on **Figure 1** (3 sheets), while details of the potential measures are summarised in **Table 2**.

The concept stormwater quality strategy that is shown on **Figure 1** (3 sheets) will be developed further during detailed design. Subject to consultation with Canterbury Bankstown City Council and other stakeholders it is proposed that this further design development consider opportunities to implement alternative stormwater treatment measures throughout the broader catchment. This would enable the identification of more suitable locations within the broader catchment for stormwater quality measures given the confined nature of the proposal corridor. To this end, the layout of stormwater quality measures that is presented on **Figure 1** (3 sheets) is indicative only and would be subject to change during detailed design whilst maintaining the stormwater quality objectives established for the proposal.

The strategy comprises a series of vegetated swales and bio-retention basins to treat runoff from the paved areas. While bio-retention basins are the most effective means of treating road runoff, their use at all drainage outlets is limited by their space requirements relative to the confined nature of the proposal corridor. Similarly, vegetated swales are also restricted to areas where space and topography allows.

The strategy includes two bio-retention basins (denoted **MD_WQ3** on **Figure 1**, sheet 2 and **MD_WQ5** on **Figure** 1, sheet 3), both of which would treat runoff discharging to Milperra Drain. Bio-retention basins provide treatment of stormwater runoff through filtration, extended retention and biological uptake. The basins typically comprise a retention zone overlaying a filtration media that is drained via a slotted pipe. The surface of the filtration media is planted with vegetation that promotes nutrient uptake and denitrification. The bio-retention basins would require a level of pre-treatment to remove gross pollutants and coarse material from the stormwater runoff that would be prone to clog the filtration media. The arrangement for pre-treatment would be developed during detailed design and may involve the use of a pollutant control device, litter baskets on inlet pits, or a screening chamber at the outlet of the pipes discharging to the bio-retention basins.

Vegetated swales are proposed to treat stormwater runoff from drainage outlets that are located along Henry Lawson Drive. Vegetated swales to the north of the intersection with Milperra Road would treat runoff discharging to the Georges River (denoted **GR_WQ01**, **GR_WQ2** and **GR_WQ03** on **Figure 1**, sheet 3), while the vegetated swales to the south would treat stormwater runoff discharging to Milperra Drain (denoted **MD_WQ1, MD_WQ2** and **MD_WQ3** on **Figure 1**, sheet 2).

Space and topography constraints limit the ability to include stormwater quality measures at the drainage outlets that are located along the section of Milperra Road within the proposal corridor. While consideration was given to incorporating a series of pollutant control devices at the outlet to each of the pipe drainage lines they have not been incorporated in the concept stormwater quality strategy due to restricted access for maintenance and the presence of a high pressure gas main along the southern side of Milperra Road.

The Post-Upgrade MUSIC Model was updated to incorporate the proposed measures identified in the concept water quality strategy in order to assess their effectiveness at offsetting the increase in pollutant load that is attributable to the proposed road upgrade. **Columns 13** to **16** of **Table 1** show the changes in average annual pollutant loads with the implementation of the proposed stormwater quality measures, while **Table 2** contains a summary of the pollutant retention performance of each individual measure.

In regards to the Georges River, **Table 1** shows that with the inclusion of the aforementioned stormwater quality measures there would be a net reduction in the average annual weight of gross pollutants, TSS and TP[1] when compared to present day conditions. However, there would be an increase in the average annual weight of TN by 3.8 kg due to space and topography constraints that limit the ability to implement additional bio-retention basins or swales. For example, an area of about 70 m^2 of bio-retention basin would be required to fully offset the increase in TN in the Georges River, which is not considered to be feasible given the limited availability of suitably graded land.

[1] While there would be a net reduction in the total weight of TP discharging to the Georges River catchment, there would be a localised increase at comparison location **GR1** on **Figure 1**, sheet 3.

In regards to Milperra Drain it was also found that the inclusion of the aforementioned stormwater quality measures would provide a net reduction in the average annual weight of gross pollutants, TSS and TP[2] when compared to present day conditions, but there would still be an increase in the average annual weight of TN by 7.4 kg. Again space and topography constraints limit the ability to implement additional area bio-retention swales or basins at the drainage outlets that discharge to Milperra Drain. For example, an area of about 100 m^2 of bio-retention basin would be required to fully offset the increase in TN in Milperra Drain, which is not considered to be feasible given the limited availability of suitably graded land.

4. Concluding remarks

The assessment presented in this technical note has demonstrated that it would be feasible to implement a range of stormwater quality measures that generally provide a reduction in the average annual weight of pollutants discharging from the road corridor when compared to present day conditions. The exception is the average annual weight of TN discharging to both the Georges River and Milperra Drain which would increase by 3.8 kg and 7.4 kg, respectively following the construction of the proposed road works.

While it has been identified that in order to fully offset the predicted increase in TN it would be necessary to implement an additional area of about 70 m^2 of bio-retention basin at the drainage outlets that drain to the Georges River, and about 100 m^2 at the drainage outlets that discharge to Milperra Drain, there is limited ability to implement such measures due to space and topography constraints within the proposal corridor. It is therefore proposed that during detailed design, and subject to consultation with Council and other stakeholders, opportunities are investigated to implement stormwater quality measures within the broader catchments within which the proposal is located.

[2] While there would be a net reduction in the total weight of gross pollutants, TSS and TP discharging to the Milperra Drain catchment there would be a localised increase in all three pollutants at comparison location **MD3** on **Figure 1**, sheet 3).

TABLE 1
AVERAGE ANNUAL RUNOFF CHARACTERISTICS IN THE RECEIVING DRAINAGE LINES

Stormwater Quality Comparison Location & Identifier[(1)]	**Pre-Upgrade Conditions**					**Post-Upgrade Conditions**					**Post-Upgrade Conditions with Mitigation**				
	Runoff Volume (ML/year)	**Gross Pollutants (kg/year)**	**TSS (kg/year)**	**TP (kg/year)**	**TN (kg/year)**	**Runoff Volume (ML/year)**	**Gross Pollutants (kg/year)**	**TSS (kg/year)**	**TP (kg/year)**	**TN (kg/year)**	**Runoff Volume (ML/year)**	**Gross Pollutants (kg/year)**	**TSS (kg/year)**	**TP (kg/year)**	**TN (kg/year)**
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**	**[11]**	**[12]**	**[13]**	**[14]**	**[15]**	**[16]**
GEORGES RIVER															
GR1	2.5	65.9	463	0.9	4.9	3.4 *[0.9]*	93.8 *[27.9]*	788 *[325]*	1.5 *[0.6]*	7.2 *[2.3]*	3.4 *[0.9]*	55.3 *[-10.6]*	445 *[-18]*	1.0 *[0.1]*	6.7 *[1.8]*
GR2	6.0	140	1340	2.5	12.1	7.2 *[1.2]*	184 *[44]*	1,760 *[420]*	3.3 *[0.8]*	15.3 *[3.2]*	7.2 *[1.2]*	22.4 *[-117.6]*	563 *[-777]*	1.7 *[-0.9]*	14.1 *[2.0]*
TOTAL	**8.5**	**206**	**1,803**	**3.4**	**17.0**	**10.6** ***[2.1]***	**278** ***[72]***	**2,548** ***[745]***	**4.8** ***[1.4]***	**22.5** ***[5.5]***	**10.6** ***[2.1]***	77.7 *[-128.3]*	1008 *[-795]*	2.7 *[-0.7]*	20.8 *[3.8]*
MILPERRA DRAIN															
MD1	9.3	175	1,280	2.6	16.6	12.1 *[2.8]*	286 *[111]*	2,270 *[990]*	4.4 *[1.8]*	23.5 *[6.9]*	11.8 *[2.5]*	58.7 *[-116]*	701 *[-579]*	2.0 *[-0.6]*	16.8 *[0.2]*
MD2	9.8	215	1,570	3.0	17.4	12.8 *[3.0]*	318 *[103]*	2,560 *[990]*	4.9 *[1.8]*	25.0 *[7.6]*	12.8 *[3.0]*	0.0 *[-215]*	785 *[-785]*	2.5 *[-0.5]*	23.2 *[5.8]*
MD3	13.3	185	2,030	3.9	19.3	13.9 *[0.6]*	212 *[27]*	2,280] *[250]*	4.3 *[0.5]*	21.0 *[1.7]*	13.9 *[0.6]*	212 *[27]*	2280 *[250]*	4.3 *[0.5]*	21.0 *[1.7]*
MD4	15.5	393	3,060	5.7	31.8	17.5 *[2.0]*	454 *[61]*	3,710 *[650]*	6.9 *[1.2]*	36.5 *[4.7]*	17.0 *[1.5]*	376 *[-17]*	2930 *[-130]*	5.6 *[-0.1]*	31.5 *[-0.3]*
TOTAL	**47.9**	**968**	**7,940**	**15.2**	**85.1**	**56.3** ***[8.4]***	**1,270** ***[302]***	**10,820** ***[2,880]***	**20.5** ***[5.3]***	**106.0** ***[20.9]***	**55.5** ***[7.6]***	**647** ***[-321]***	**6,696** ***[-1,244]***	**14.4** ***[-0.8]***	**92.5** ***[7.4]***

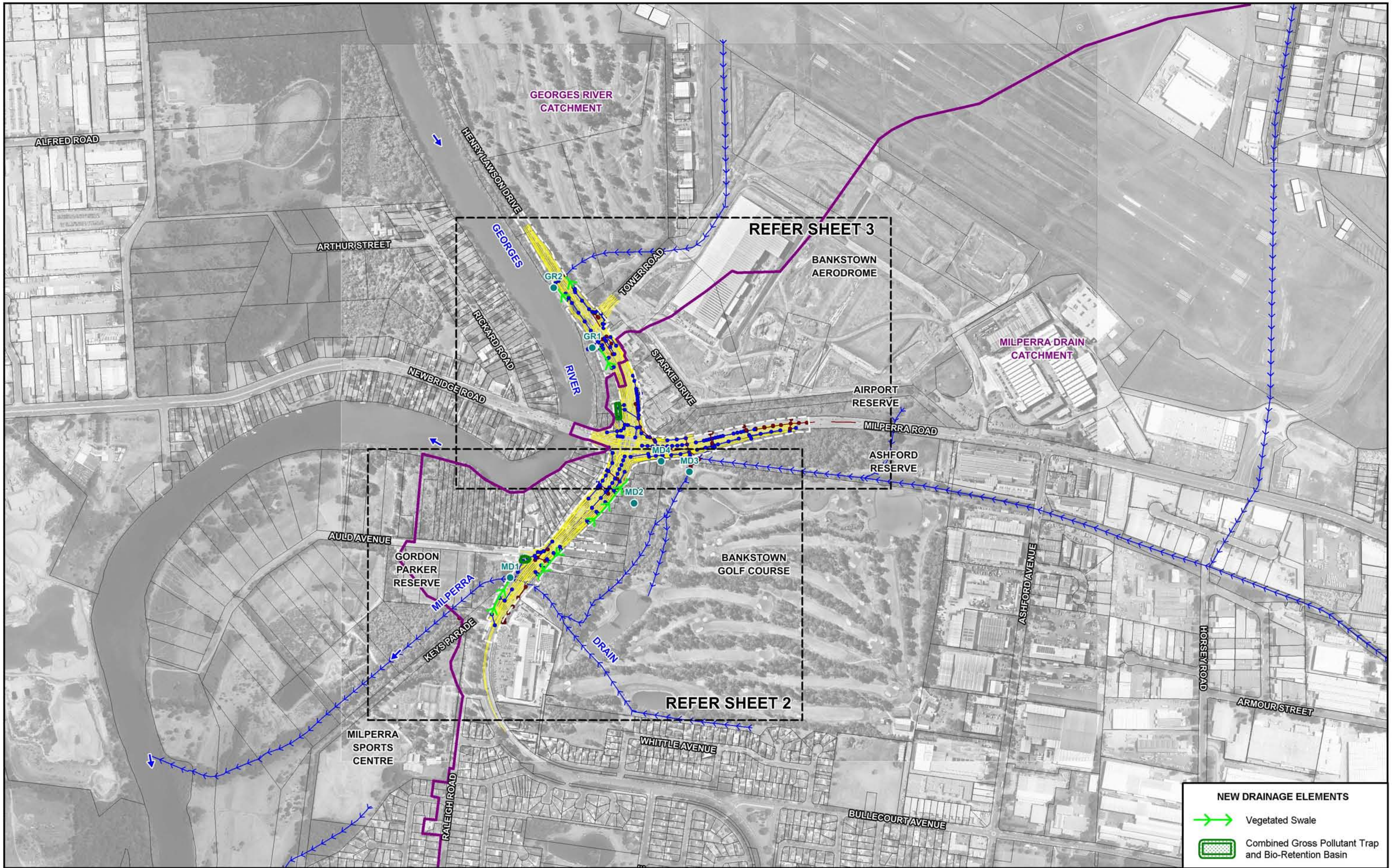
1. Refer **Figure 1** (3 sheets) for Stormwater Quality Comparison Location & Identifiers.
2. Values in *[brackets]* represent the change in average annual runoff volume and pollutant load compared to present day conditions. A positive value represents an increase, while conversely a negative value represents a decrease compared to present day conditions.

TABLE 2
SUMMARY OF ASSESSED STORMWATER QUALITY MEASURES

Stormwater Quality Measure & Identifier[(1)]	Stormwater Quality Arrangement		Average Annual Retention Performance of Stormwater Quality Arrangement				
	Vegetated Swale Length (m)	Bio-Retention Basin Area (m^2)	Runoff Volume (ML/year)	Gross Pollutants (kg/year)	TSS (kg/year)	TP (kg/year)	TN (kg/year)
GEORGES RIVER							
GR_WQ1	50	-	0.0	38.5	342.6	0.5	0.5
GR_WQ2	30	-	0.0	120.0	827.0	1.1	0.7
GR_WQ4	30	-	0.0	41.5	363.7	0.5	0.5
TOTAL	**110**	**0**	**0.0**	**200.0**	**1,533**	**2.1**	**1.7**
MILPERRA DRAIN							
MD_WQ1	85	-	0.8	69.8	620.6	1.0	2.5
MD_WQ2	75	-	0.0	55.9	469.9	0.7	0.7
MD_WQ3	-	120	0.3	122.0	706.1	1.1	5.3
MD_WQ4	135	-	0.0	318.2	1,775.0	2.6	1.8
MD_WQ5	-	280	0.6	78.1	783.0	1.3	5.0
TOTAL	**330**	**400**	**1.7**	**1,196**	**7,900**	**9.4**	**15.3**

1. Refer **Figure 1** (3 sheets) for locations of Stormwater Quality Measure & Identifiers.

FIGURES



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

LEGEND

Road Design Strings

Major Overland Flowpath

Project Boundary

Existing Stormwater Drainage System to be Retained

Proposed Stormwater Drainage System

MD1 Stormwater Quality Comparison Location and Identifier

HENRY LAWSON DRIVE UPGRADE STAGE 1A

Figure 1
(Sheet 1 of 3)

CONCEPT STORMWATER QUALITY STRATEGY

N

25 0 25 50 75 m

Scale: 1:2,500

Lyall & Associates

LEGEND

Road Design Strings

Major Overland Flowpath

Project Boundary

Existing Stormwater Drainage System to be Retained

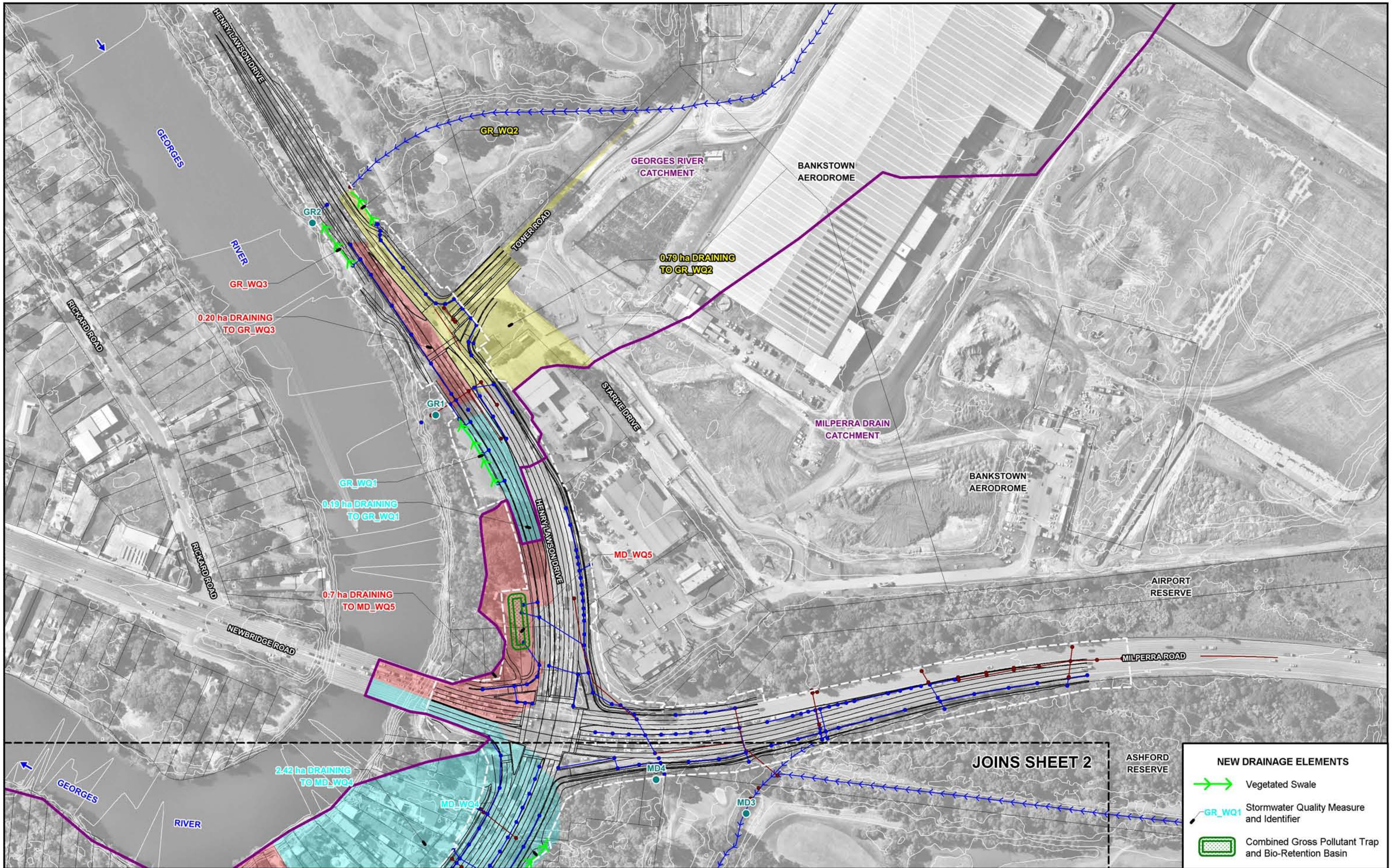
Proposed Stormwater Drainage System

MD1 Stormwater Quality Comparison Location and Identifier

HENRY LAWSON DRIVE UPGRADE STAGE 1A

Figure 1
(Sheet 2 of 3)

CONCEPT STORMWATER QUALITY STRATEGY



N

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Scale: 1:2,500

Lyall & Associates

LEGEND

- Road Design Strings
- Major Overland Flowpath
- Project Boundary
- Existing Stormwater Drainage System to be Retained
- Proposed Stormwater Drainage System
- MD1 Stormwater Quality Comparison Location and Identifier

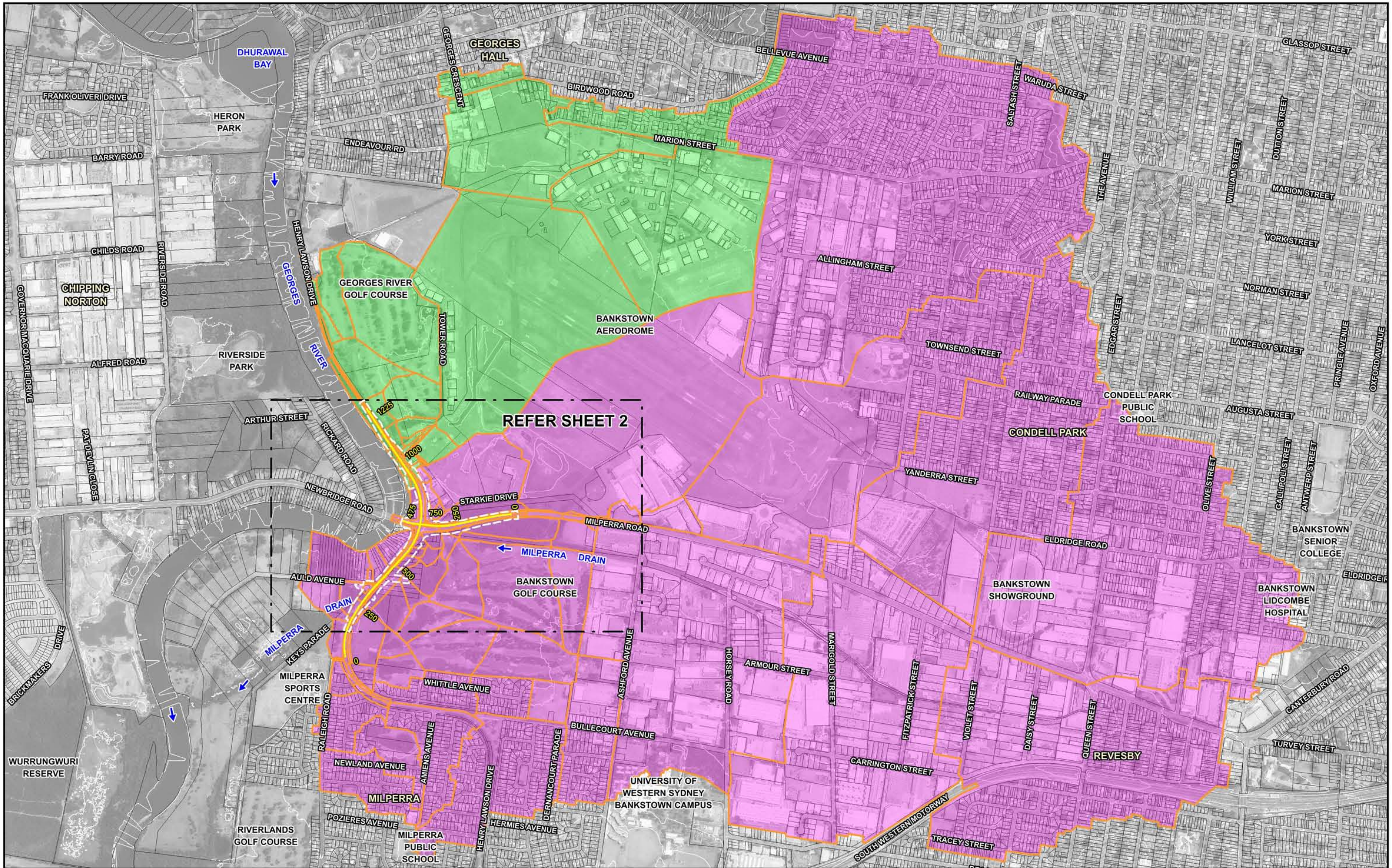
HENRY LAWSON DRIVE UPGRADE STAGE 1A

Figure 1
(Sheet 3 of 3)

CONCEPT STORMWATER QUALITY STRATEGY

ANNEXURE A

FIGURES SHOWING LAYOUT OF PRE- AND POST-UPGRADE MUSIC MODELS



N

150 0 150 300 450 m

Scale: 1:15,000

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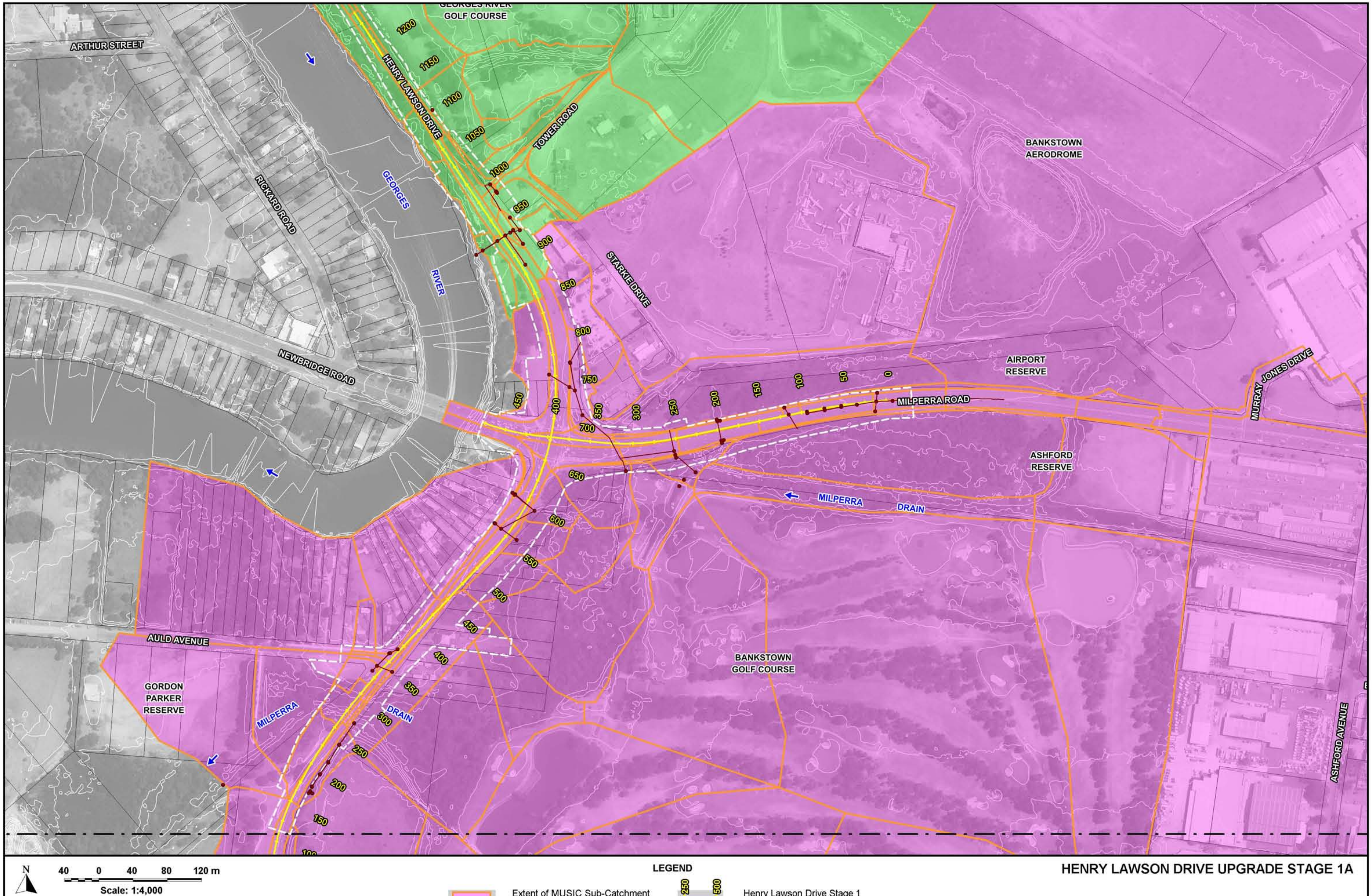
LEGEND

Extent of MUSIC Sub-Catchment Draining to Milperra Drain	250 500 Henry Lawson Drive Stage 1 Alignment and Chainage
Extent of MUSIC Sub-Catchment Draining to Georges River	Overall Proposal Boundary

HENRY LAWSON DRIVE UPGRADE STAGE 1A

Figure A1
(Sheet 1 of 2)

EXTENT OF SUB-CATCHMENTS COMPRISING PRE-UPGRADE MUSIC MODEL



LEGEND

Extent of MUSIC Sub-Catchment Draining to Milperra Drain

Extent of MUSIC Sub-Catchment Draining to Georges River

Henry Lawson Drive Stage 1 Alignment and Chainage

Overall Proposal Boundary

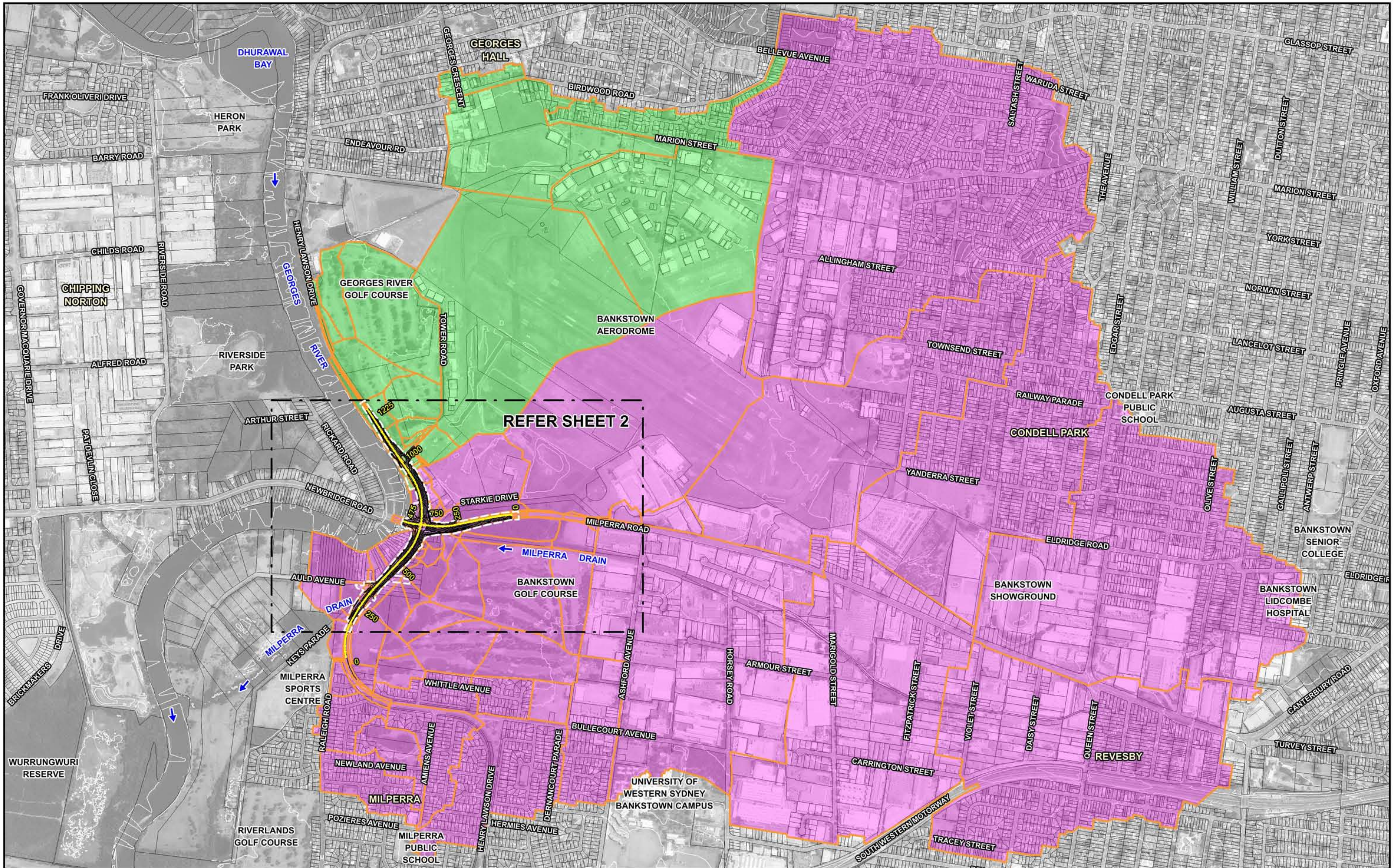
Existing Stormwater Drainage System

Lyall & Associates

HENRY LAWSON DRIVE UPGRADE STAGE 1A

Figure A1
(Sheet 2 of 2)

EXTENT OF SUB-CATCHMENTS COMPRISING PRE-UPGRADE MUSIC MODEL



LEGEND

Extent of MUSIC Sub-Catchment Draining to Milperra Drain	Henry Lawson Drive Stage 1 Alignment and Chainage
Extent of MUSIC Sub-Catchment Draining to Georges River	Overall Proposal Boundary
	Henry Lawson Drive Stage 1 Road Design Strings

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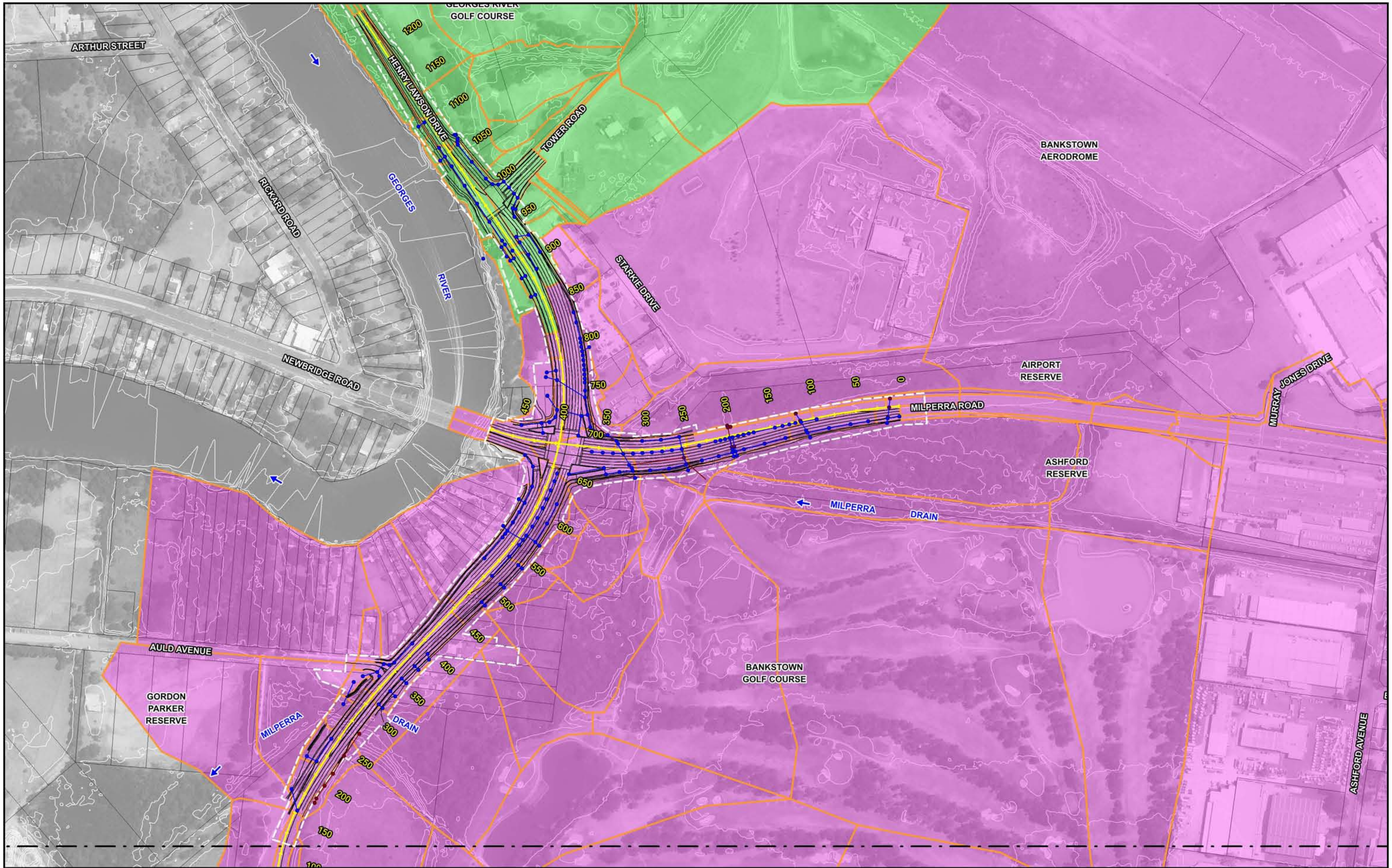
HENRY LAWSON DRIVE UPGRADE STAGE 1A

Figure A2
(Sheet 1 of 2)

EXTENT OF SUB-CATCHMENTS COMPRISING POST-UPGRADE MUSIC MODEL



N

40 0 40 80 120 m

Scale: 1:4,000

Lyall & Associates

LEGEND

Extent of MUSIC Sub-Catchment Draining to Milperra Drain

Extent of MUSIC Sub-Catchment Draining to Georges River

Henry Lawson Drive Stage 1 Alignment and Chainage

Overall Proposal Boundary

Henry Lawson Drive Stage 1 Road Design Strings

Existing Stormwater Drainage System to be Retained

Proposed Stormwater Drainage System

HENRY LAWSON DRIVE UPGRADE STAGE 1A

Figure A2
(Sheet 2 of 2)

EXTENT OF SUB-CATCHMENTS COMPRISING POST-UPGRADE MUSIC MODEL