Mamre Road Upgrade Stage 1- Concept Design, REF and Detailed Design

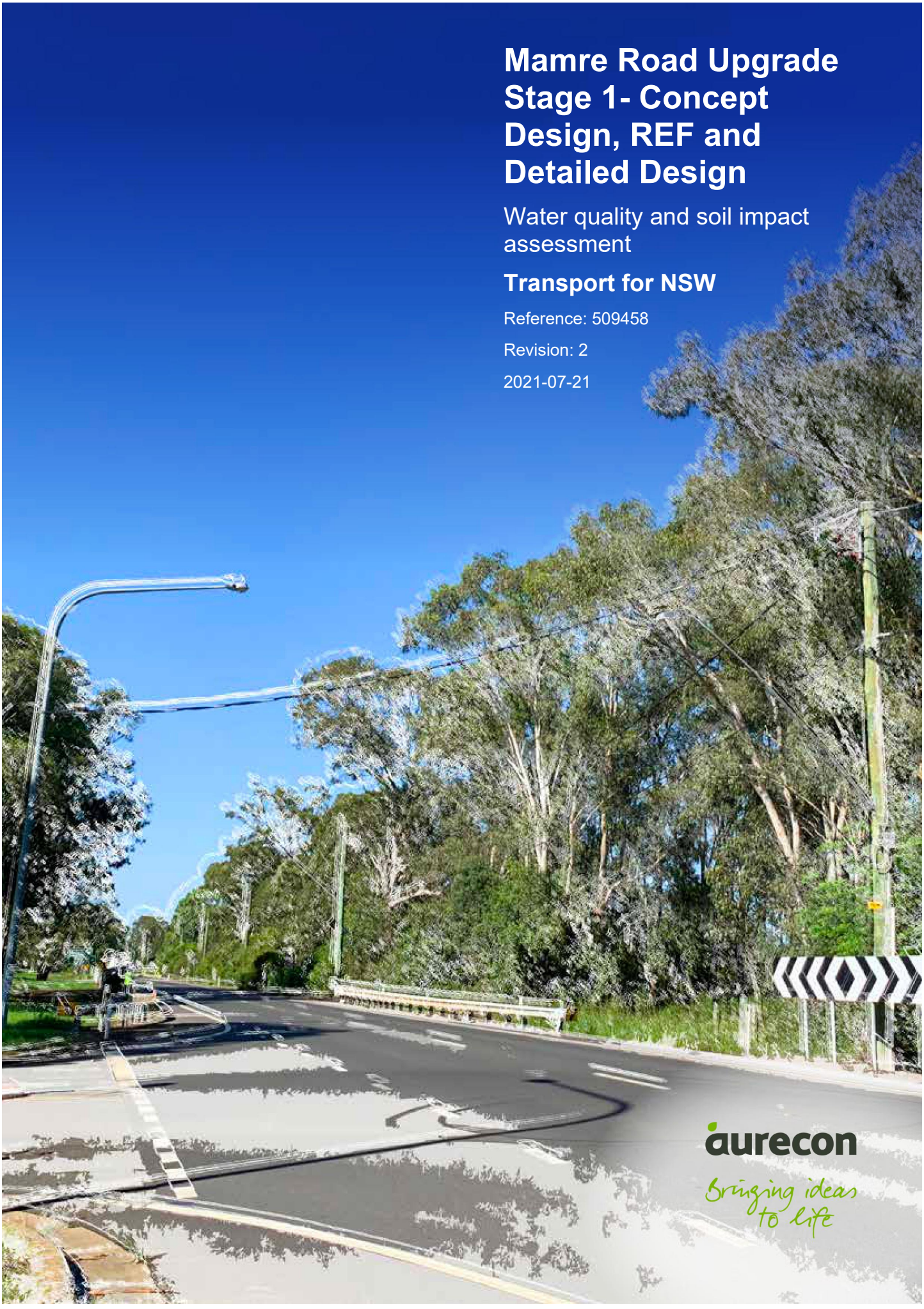
Water quality and soil impact assessment

Transport for NSW

Reference: 509458

Revision: 2

2021-07-21



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Figures

Tables

Glossary and abbreviations

ACM	Asbestos containing material
ANZECC & ARMCANZ	Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), 2000
ANZG	Australian and New Zealand Guidelines
ARI	Average reoccurrence interval
ARQ	Australian Runoff Quality
Aurecon	Aurecon Australasia Pty Ltd
BoM	Bureau of Meteorology
BTEXN	benzene, ethylbenzene, xylenes and naphthalene
CEMP	Construction Environmental Management Plan
CLM Act	*Contaminated Land Management Act 1997*
Coastal Management SEPP 2018	*State Environmental Planning Policy (Coastal Management) 2018*
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
DO	Dissolved Oxygen
DECCW	NSW Department of Environment, Climate Change and Water
DLWC	Department of Land and Water Conservation
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment
DVGs	Default Value Guidelines
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPL	Environmental Protection Licence
eSpade	Online Mapping providing access to soil profile and soil map information published by the NSW Department of Planning, Industry and Environment.
FM Act	*Fisheries Management Act 1991*
GIS	Geographic Information Systems
HGL	Hydrogeological Landscapes
HRC	Healthy Rivers Commission
KFH	Key Fish Habitat
LGA	local government area
LiDAR	Light Detection and Ranging
mAHD	Metres Australian height datum
MAP	Mean Annual Precipitation
mBGL	Metres below ground level

NEPM	National Environmental Protection Measures
NH_3-N	Ammonia
NO_x	Oxidised Nitrogen
NSW	New South Wales
NTU	Turbidity
NWQMS	National Water Quality Management Strategy
OEH	Office of Environmental and Heritage
PAH	Polycyclic aromatic hydrocarbons
POEO Act	Protection of the Environment Operations Act
proposal area	proposal area of Mamre Road Upgrade Stage 1 as defined in the figures
RAP	Remediation Action Plan
REF	review of environmental factors
SEED	SEED is the NSW Government's central resource for Sharing and Enabling Environmental Data.
SILO	SILO is a database of Australian climate data from 1889 to the present
SWMP	Soil and Water Management Plan
TfNSW	Transport for NSW
the proposal	Mamre Road Upgrade Stage 1
TN	Total Nitrogen
TP	Total Phosphorus
TRH	Total recoverable hydrocarbons
TSS	Total Suspended Solids
UFP	Unexpected Find Protocol
WDE	Water Dependent Ecosystems
WQO	Water quality objectives

Executive Summary

Transport for NSW (TfNSW) propose to upgrade about 3.8 kilometres of Mamre Road between the M4 Motorway, St Clair and Erskine Park Road, Erskine Park to a four-lane divided road (the proposal). Aurecon Australasia Pty Ltd (Aurecon) has been commissioned by TfNSW to prepare a water and soil technical assessment of the proposal (this report).

The proposal is located within the flood plains of South Creek. South Creek is a main tributary of the Nepean-Hawkesbury catchment, and is also a key fish habitat. There are three unnamed tributaries that intersect the proposal area and flow into South Creek after crossing the proposal area.

Groundwater is assumed to be between 0.6 and 6 metres below ground level. Based on the hydrogeological landscapes of the area it is assumed groundwater flows towards South Creek to the west of the proposal. The groundwater residence time is in the order of years. There are a number of groundwater dependent ecosystems (GDEs) located west of the proposal, including South Creek (Aquatic GDE) and Cumberland Shale Plains Woodlands and the Cumberland River Flat Forests (terrestrial GDEs).

The geology consists of sedimentary rocks from the Middle Triassic Mesozoic Wianamatta Group (major Bringelly Shale with minor Ashfield Shale and Minchinbury Sandstone). Quaternary fine grain sands, silt and clays derived from the surrounding rocks are present along South Creek and current streams. The hydrological soil group of the soils within the proposal area are group D soils which have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted.

The key potential impacts of the proposal on surface water, groundwater and soils are as follows:

- Surface water quality impacts due to sediment laden runoff being released to waterways during construction activities such as earthworks, stockpiling, dewatering, waterway crossing construction, channel and outlet works and transportation of materials
- Surface water quality, groundwater quality and soil impacts during construction as a result of accidental spills
- Direct disturbance of channel form and stability during construction of transverse drainage structures / waterway crossings, channel tail in and tail out work and outlet work
- The proposal would increase the impervious surface area of the local catchment, which would increase the runoff volume, frequency, flow rate and pollutant load being discharged to receiving waterways including South Creek. This may have a minor impact on water quality, waterway stability and aquatic habitat in the receiving waterways.
- Increased scour at newly proposed stormwater outlet locations

The key measures proposed to avoid, manage and/or mitigate impacts to surface water, groundwater and soils include:

- Preparation of a Soil and Water Management Plan as part of the Construction Environmental Management Plan to manage water quality impacts during construction of the proposal
- Incorporating swales and water quality basins with spill containment for water quality treatment during the design of the proposal to minimise operational water quality impacts
- Preparation of a Remediation Action Plan and Unexpected Finds Protocol to manage the potential for soil or water quality contamination during construction of the proposal
- Appropriately designed scour protection at new stormwater outlets

With the proposed management measures in place impacts, are expected to be negligible to minor.

1 Introduction

1.1 Proposal overview

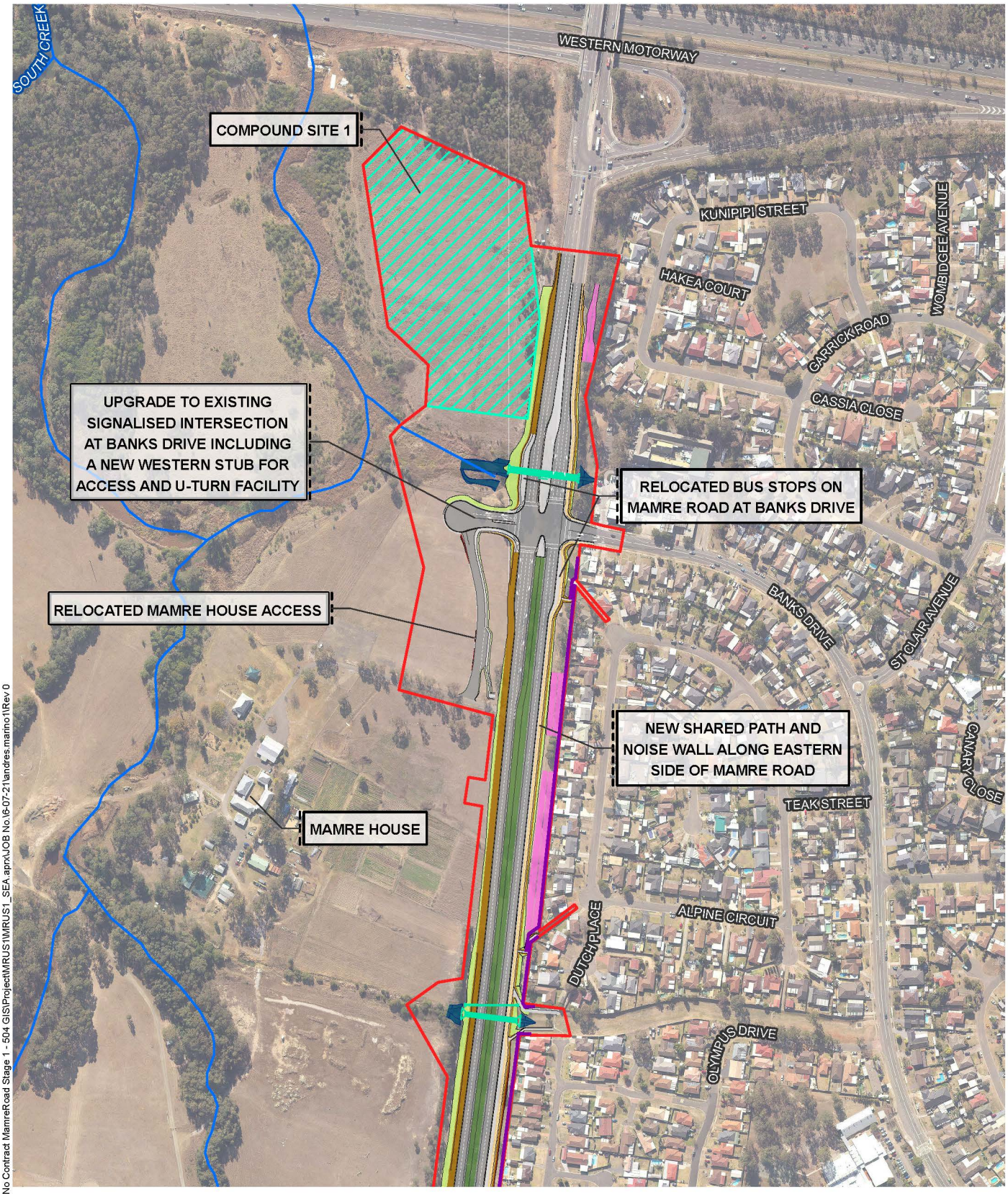
Transport for NSW (TfNSW) propose to upgrade about 3.8 kilometres of Mamre Road between the M4 Motorway, St Clair and Erskine Park Road, Erskine Park to a four-lane divided road (the proposal). The proposal is located within the City of Penrith local government area (LGA) in Sydney, New South Wales (NSW). The proposal forms Stage 1 of the larger Mamre Road Upgrade Project, which is proposed to be delivered by TfNSW in two stages. Overall, the Mamre Road Upgrade Project would upgrade a 10 kilometre long section of Mamre Road between the M4 Motorway, St Clair and Kerrs Road.

Mamre Road is a key transport corridor, which provides connections to the Western Sydney Employment Area and the proposed Western Sydney Aerotropolis. The proposal is required to support future growth in Western Sydney by increasing the capacity of Mamre Road and improving road safety and movement between the M4 Motorway and Erskine Park Road.

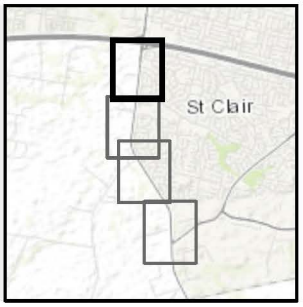
Key features of the proposal would include (refer to **Figure 1-1**):

- an upgrade of Mamre Road to a four-lane divided road with a wide central median that would allow for widening to six lanes in the future, if required
- changes to intersections with Mamre Road including:
  - an upgrade to the existing signalised intersection at Banks Drive including a new western stub for access and a U-turn facility
  - a new signalised intersection at Solander Drive including a new western stub for access and a U-turn facility
  - a new signalised intersection at Luddenham Road with new turning lanes
  - an upgrade to the existing signalised intersection at Erskine Park Road with new turning lanes
  - modified intersection arrangements (left in, left out only) at McIntyre Avenue and Mandalong Close
- a new shared path along the eastern side of Mamre Road and provision for a future shared path on the western side
- reinstatement of bus stops near Banks Drive with provision for additional bus infrastructure in the future
- changes to property access to Mamre House, Erskine Park Rural Fire Service and other private properties
- drainage and flooding infrastructure upgrades including culvert crossings, water quality basins, grass swales and channel tail-out work
- new traffic control facilities including new traffic signals and relocation of existing electronic variable message signage
- roadside furniture and street lighting
- noise walls along the eastern side of Mamre Road at St Clair
- utility relocations
- establishment of temporary ancillary facilities to support construction including compound sites, stockpile and laydown locations, temporary access tracks, temporary waterway crossings and concrete batching plants

Construction of the proposal is expected to start in 2022 and be completed in late 2025. Construction of the proposal is planned to be carried out in two stages: early work and main construction work. Early work would involve utility relocations, site establishment activities, property adjustments and other low impact work required to facilitate construction.



Waterways
Indicative noise wall
Culverts
REF proposal area
Compound site options
Basin
Shared user path
Channel work
Concrete
Fill
Median
Road
Swale
Cut
Verge



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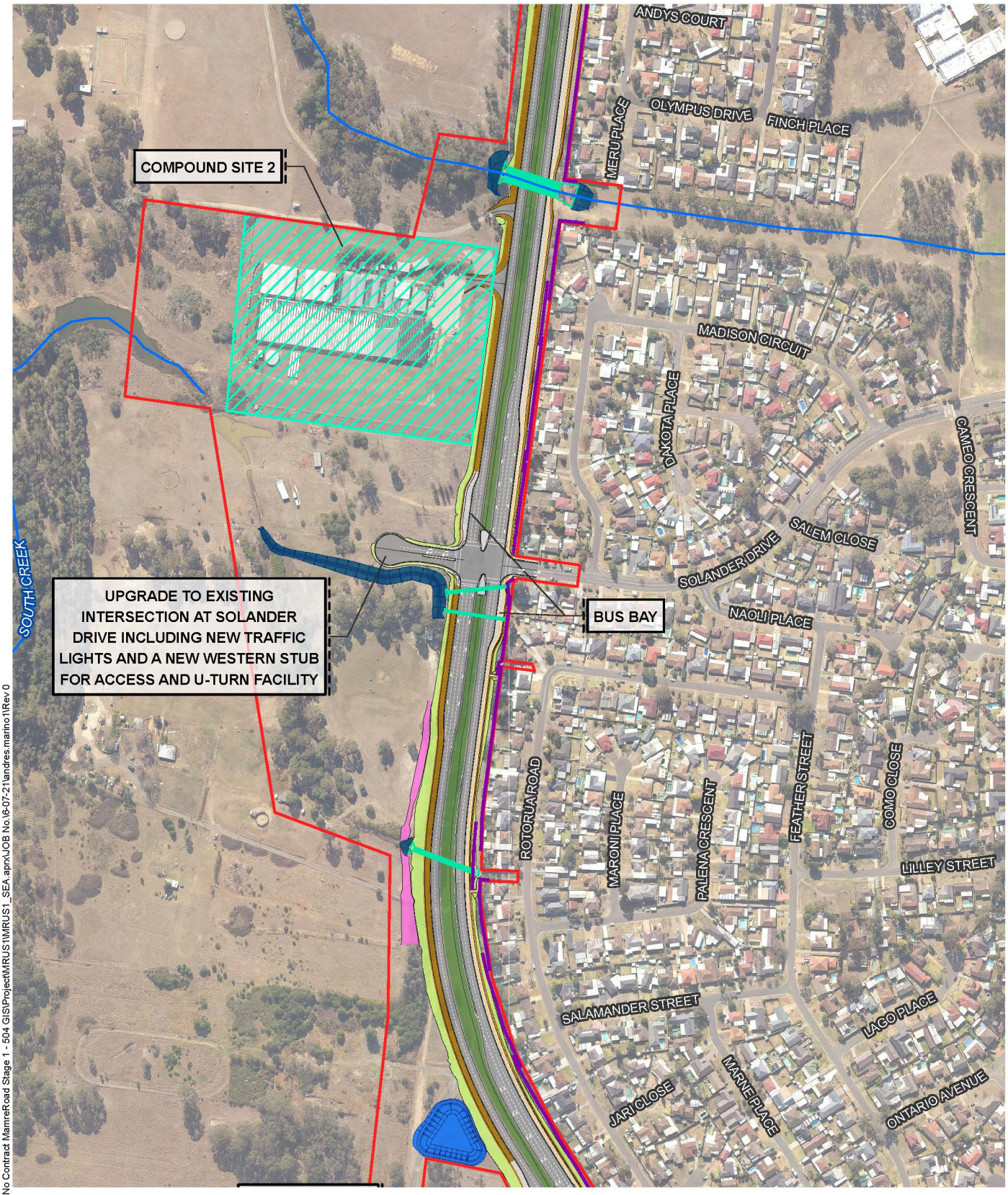
Mamre Road Upgrade Stage 1

Figure 1-1a: Key features of the proposal



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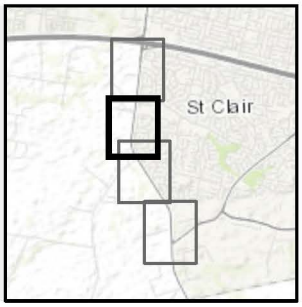

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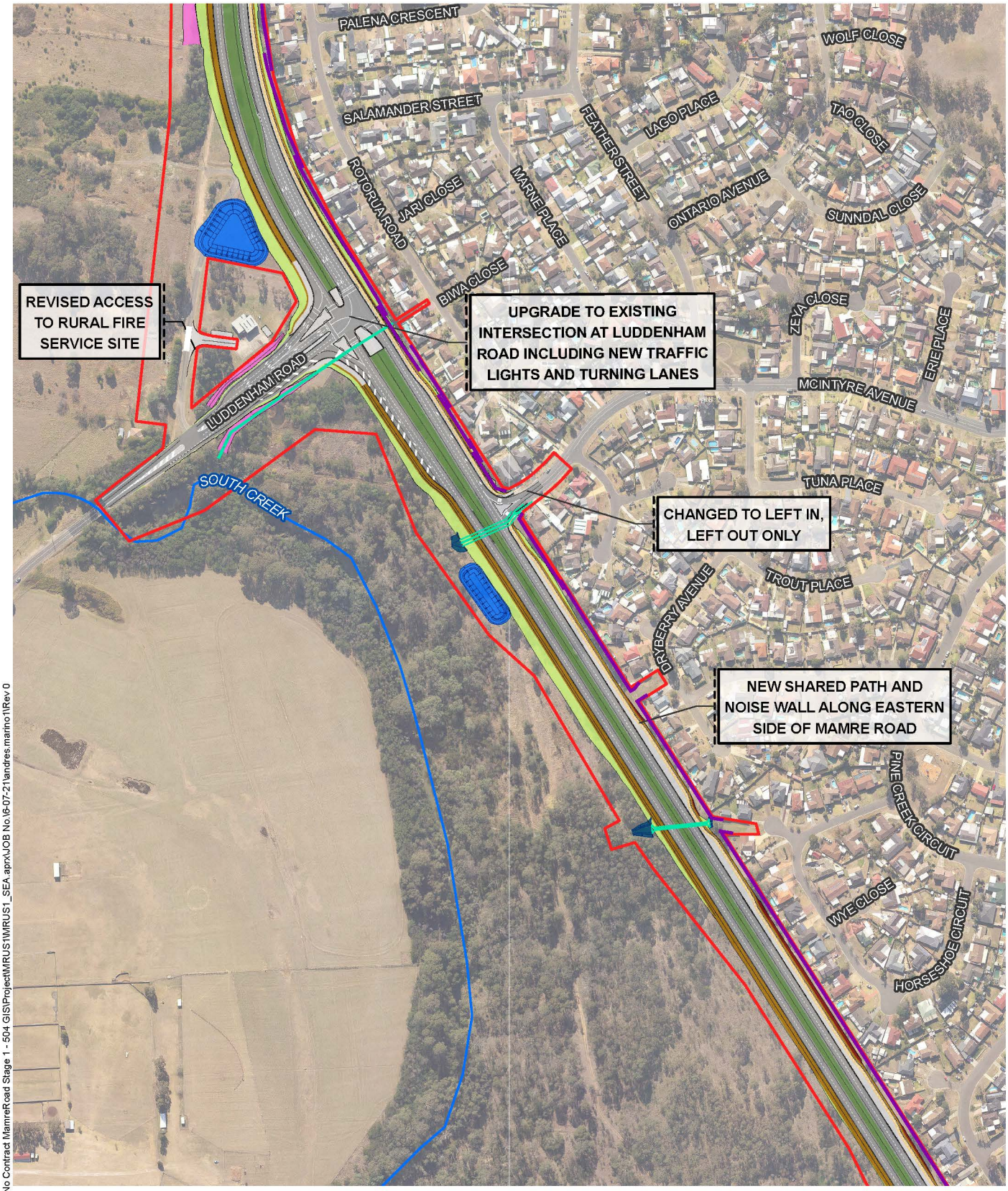
Mamre Road Upgrade Stage 1

Figure 1-1b: Key features of the proposal



Waterways
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Compound site options

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Shared user path
Channel work
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Fill

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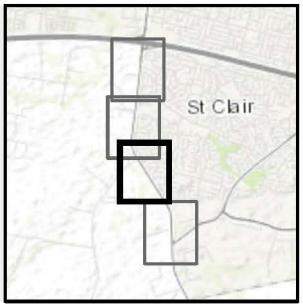
Road
Swale
Cut
Verge



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Source: Aurecon, Spatial Services, Nearmap, Esri

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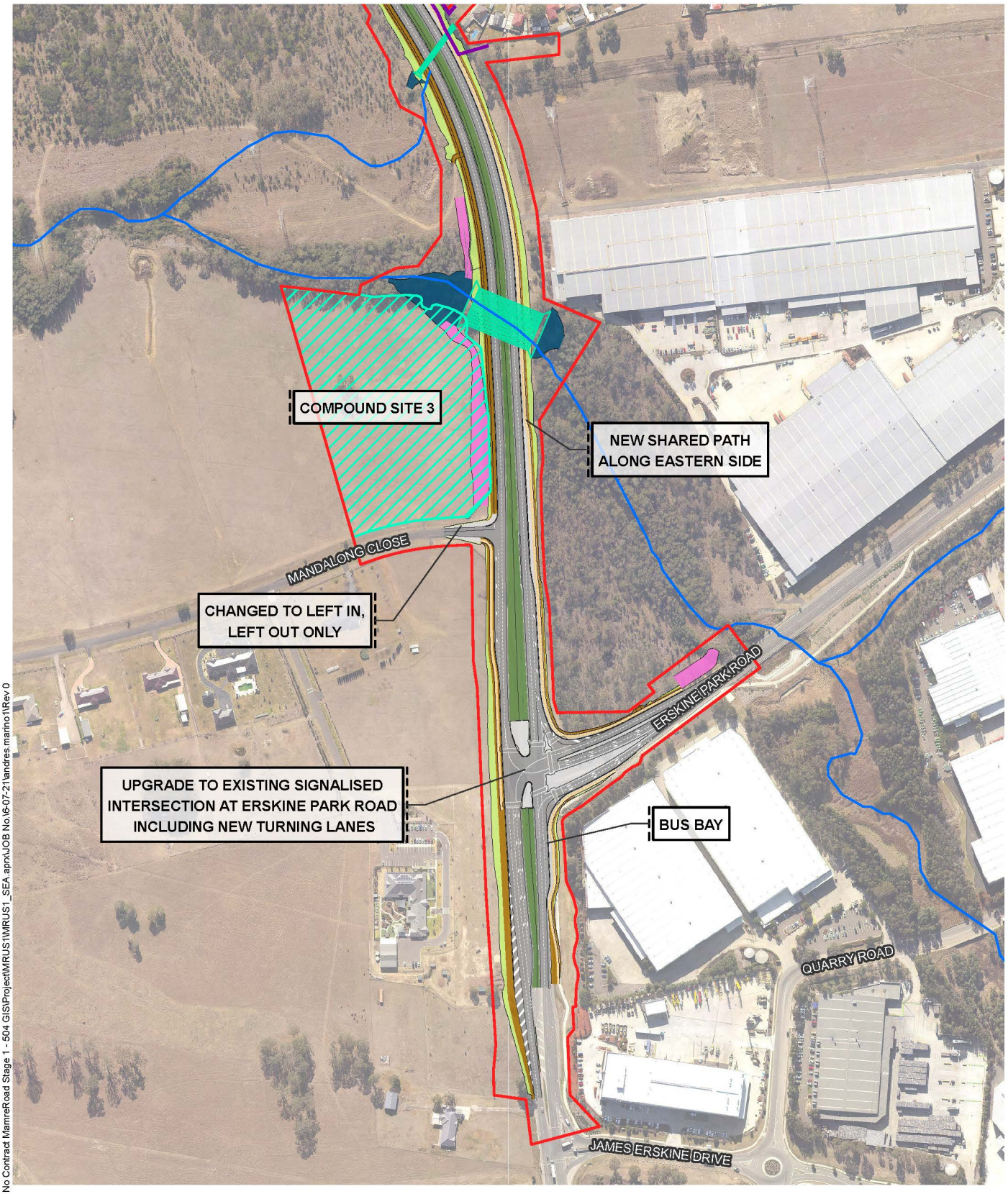
Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1

Figure 1-1c: Key features of the proposal



Waterways
Indicative noise wall
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Median
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Swale
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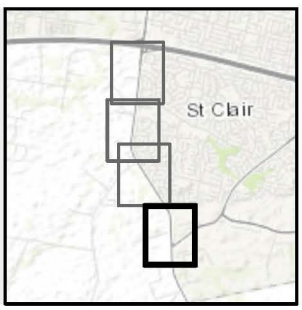

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Mamre Road Upgrade Stage 1

Figure 1-1d: Key features of the proposal

1.2 Purpose and scope of this report

The proposal is subject to environmental assessment under Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), which requires TfNSW to prepare a review of environmental factors (REF) for the proposal.

Aurecon Australasia Pty Ltd (Aurecon) has been commissioned by TfNSW to prepare a water and soil technical assessment of the proposal (this report) to support the REF. The objectives of this assessment are to:

- describe the existing environment of the study area in relation to surface water, groundwater and soils
- assess the potential impacts to the surface water, groundwater and soil environment as a result of the proposal and if required, recommend management measures to mitigate potential impacts

This water and soil technical assessment includes the following scope of works:

- desktop review and description of the existing environment in relation to surface water, groundwater and soils including:
  - climate
  - existing catchment context and major / minor waterways and wetlands
  - soils, soil landscapes, geology and hydrogeology
  - groundwater conditions, users and groundwater dependent ecosystems
  - erosion risks
  - contamination
  - flooding
  - identification of any downstream sensitive receiving environments
- identification of relevant legislation, policy and guidelines
- review of flood modelling results and proposed drainage design and water quality treatment strategy to inform assessment of potential impacts to surface waters and sensitive receiving environments
- assessment of potential impacts to receiving water environments from construction and operation of the proposal
- assessment of potential cumulative impacts to receiving water environments for both construction and operation stage activities
- assessment of proposed mitigation strategies to control potential risks to surface and groundwater sensitive receiving environments from construction and operation of the proposal
- recommendation of any additional management measures to mitigate potential impacts

Further details of the methodology is provided in **Section 2.1**.

1.3 Report structure

The structure of this report is outlined below:

- Section 1 – Introduction
- Section 2 – Methodology
- Section 3 – Relevant legislation policy and guidelines
- Section 4 – Environmental values and guidelines
- Section 5 – Existing environment
- Section 6 – Proposal description
- Section 7 – Impact assessment
- Section 8 – Management of impacts
- Section 9 – Conclusion
- Section 10 - References

2 Methodology

2.1 Overview of approach

The overview of approach for the water quality and soils impact assessment is presented in Table 2-1.

Table 2-1 Overview of approach

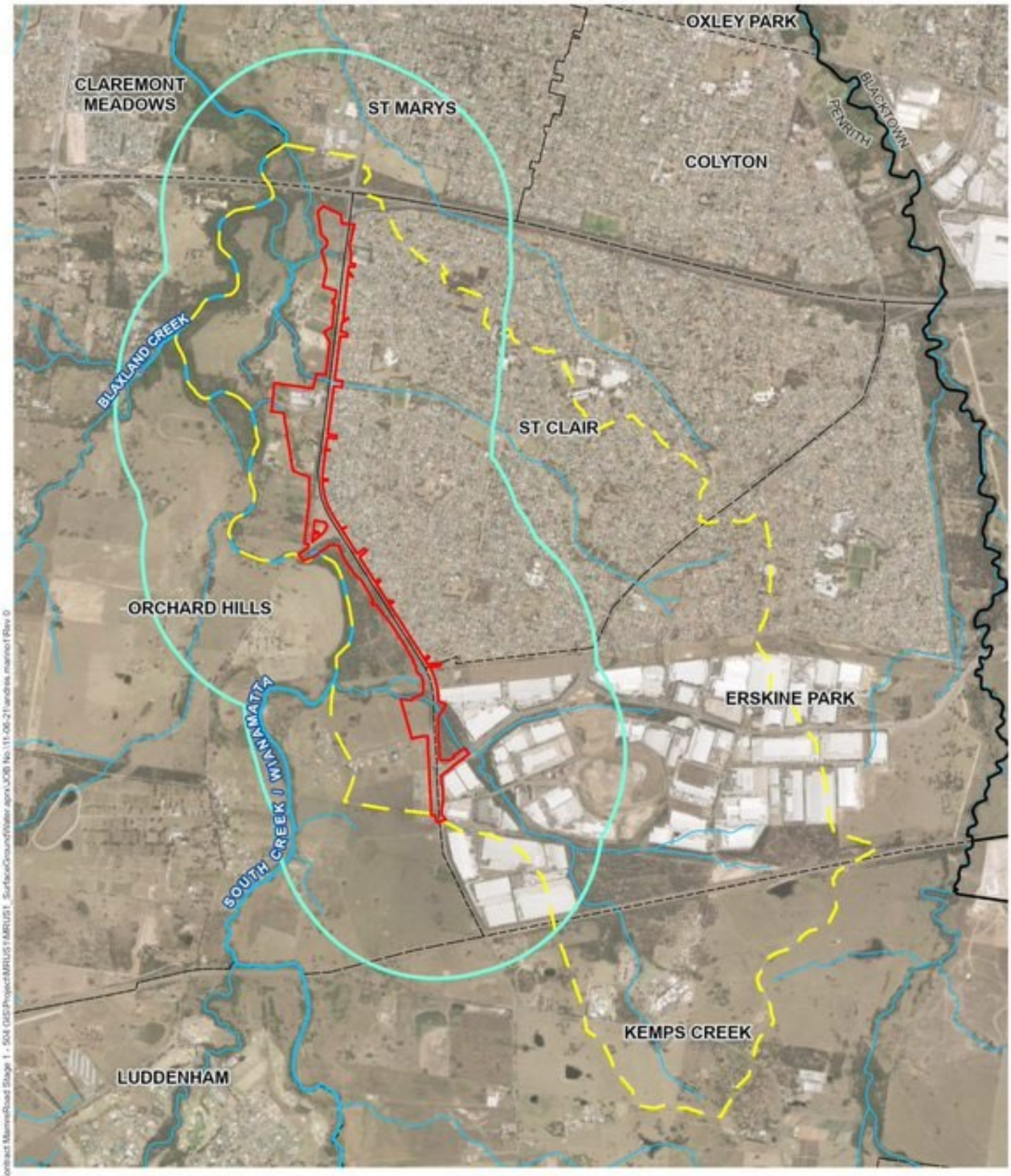
Task	Approach overview
Relevant legislation, policy and guidelines	
General	Relevant surface water, groundwater and soil legislation, policy and guidelines were reviewed and their relevance to the proposal described.
Water quality and flow objectives	Water quality objectives for the Hawkesbury-Nepean catchment were obtained from the Hawkesbury-Nepean catchment Interim Water Quality Objectives (HRC, 1998). Draft water quality and flow objectives for South Creek were obtained from the NSW Department of Planning, Industry and Environment (DPIE) draft performance criteria for the Wianamatta-South Creek (DPIE, n.d)
Existing environment	
Climate	Historical records of rainfall, temperature and evaporation were collected and analysed for the surrounding are from Bureau of Meteorology (BoM, BoM, 2020) and Scientific Information for Land Owners (SILO, SILO 2020). Climate change effects on these parameters were investigated.
Regional catchment	South Creek regional catchment was defined based on catchment delineation processes using GIS.
Watercourses and local catchment	Local watercourses were identified using NSW Hydroline GIS data. The local catchment was delineated using LiDAR data.
Wetlands	A desktop review was undertaken of the SEED mapping database (SEED, 2020) for *State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP 2018)* coastal wetland, NSW wetland and Ramsar wetlands and Nationally Important Wetland GIS data.
Surface water quality	Desktop review of water quality data from a WaterNSW monitoring station and Penrith City Council was collected to identify baseline conditions for the surface water environment in the vicinity to the proposal.
Flooding	Review of the Flooding Assessment included in the 80% Design Report.
Soils, geology and hydrogeology	Desktop review of the eSpade2 web database (eSpade, 2020) for geology, soil landscapes, acid sulfate soils and hydrogeological landscapes
Acid sulfate soils	Desktop review of the eSpade2 web database (eSpade 2020) for geology, soil landscapes, acid sulfate soils and hydrogeological landscapes
Contamination	Desktop review of the NSW EPA list of notified sites and record of notices to identify contaminated sites in the area. Review of *Mamre Road Upgrade Stage 1 PSI/DSI* report (Aurecon 2021).
Groundwater levels and quality	Review of BoM and WaterNSW real-time data to identify boreholes within one kilometre of the proposal area and available groundwater information.
Groundwater dependant ecosystems	Review of the Groundwater Dependent Ecosystems Atlas (GDE Atlas) to identify GDEs within one kilometre of the proposal area (BoM 2020).

Task	Approach overview
Water users	Review of WaterNSW groundwater register to identify groundwater users within one kilometre downstream of the proposal.
Construction impact assessment	
Surface water	Qualitative assessment of potential impacts to surface water quality and hydrology as a result of construction activities.
Groundwater	Qualitative assessment of potential impacts to groundwater quality and levels as a result of construction activities.
Soils	Qualitative assessment of potential erosion and sedimentation impacts during construction.
Operational impact assessment	
Surface water	MUSIC modelling was undertaken to estimate change in flow and pollutant loads as a result of the proposal. The Penrith Council WSUD Technical guidelines (Penrith City Council 2015) and NSW MUSIC modelling guidelines (BMT WBM 2015) were used to establish hydrology and pollutant modelling parameters. The assessment was undertaken as follows: ■ The road alignment and external catchment were modelled separately for pre and post development. ■ The existing and proposed road footprint was modelled as a road. ■ Google streetview was used to estimate the extent of swale provided adjacent to the existing road. This was accounted for in the modelling as a single treatment node. ■ The proposed road was divided into areas of no treatment, swale treatment or bioretention treatment. The contributing catchments to each treatment type were combined and the treatment node was modelled as a single treatment node ■ All other areas were modelled based on relevant LEP land zoning data and their corresponding MUSIC node as listed in BMT WBM (2015) ■ The external 'local catchment' was as per **Figure 5-4** Modelling results were used to assess: ■ stormwater treatment measure performance for the road alignment ■ flow and pollutant load impacts to receiving waterways The modelling results were used to inform a qualitative assessment of potential impacts to surface water quality and hydrology during operation. Further details of the methodology are provided in Appendix A.
Groundwater	Qualitative assessment of potential impacts to groundwater quality and levels as a result of construction activities.

2.2 Study area

The study area for the surface water assessment comprises the catchment of the local watercourses and drainage lines which traverse the proposal area up until South Creek. The study area for the groundwater assessment comprised all land within one kilometre of the proposal area. The soil investigation study area includes the proposal area.

The study area is shown in **Figure 2-1.**



- Waterways
- REF proposal area
- Surface water study area
- Groundwater study area
- Suburb
- Local government area

Source: Aurecon, Spatial Services, Nearmap, Esri

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Mamre Road Upgrade Stage 1 REF

FIGURE 2-1: Study area

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3 Relevant legislation, policy and guidelines

Table 3-1 presents a summary of the relevant legislation and guidelines that are applicable to the proposal with respect to water quality and soils.

Table 3-1 Summary of relevant legislation, policies and guidelines

Legislation/Policy/Guideline	Brief description and intent	Relevance
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)	The Water Quality Guidelines provide authoritative guidance on the management of water quality for natural and semi-natural water resources in Australia and New Zealand. The 2018 revision of the Water Quality Guidelines is presented as an online platform, to improve usability and facilitate updates as new information becomes available.	Given the absence of site-specific guideline values, the ANZG's give directions to default guideline values (DGVs) for a range of stressors relevant to different community values, such as aquatic ecosystems, human health and primary industries. As regional physical and chemical stressor default guideline values are not yet provided for the project's ecoregion and local jurisdictions have not yet derived finer scale guideline values, these guidelines direct back to the regional DGVs provided in the ANZECC & ARMCANZ (2000) guidelines (see below).
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000)	The ANZECC Water Quality Guidelines provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters and list a range of environmental values assigned to that waterbody. The ANZECC Water Quality Guidelines provide recommended trigger values for various levels of protection which have been considered when describing the existing water quality and key indicators of concern. The level of protection applied in this assessment when assessing ambient water quality is for slightly to moderately disturbed ecosystems.	The ANZECC Water Quality Guidelines provide recommended trigger values for various levels of protection which have been considered when describing the existing water quality and key indicators of concern. The level of protection applied in this assessment when assessing ambient water quality is for slightly disturbed ecosystems in NSW Lowland Rivers.
Contaminated Land Management Act 1997 (CLM Act)	The CLM Act enables the EPA to respond to contamination that it has reason to believe is significant enough to warrant regulation. It gives the EPA power to declare land to be significantly contaminated land and give orders to investigate and/or manage that land.	There is no contaminated land notified to the NSW EPA recorded within the study area.

Legislation/Policy/Guideline	Brief description and intent	Relevance
National Water Quality Management Strategy (NWQMS) (DAWR 2018):	The NWQMS (ANZECC and ARMCANZ 2000a) provides a nationally consistent approach to water quality management and the information and tools to help water resource managers, planning and management agencies, regulatory agencies and community groups manage and protect their water resources. The main policy objective of the NWQMS is to achieve sustainable use of water resources, by protecting and enhancing their quality, while maintaining economic and social development.	Construction and operational phases of the proposal have the potential to impact water quality within the adjacent creek. As such, construction and operational phases should integrate water quality management strategies (consistent with NWQMS) such that the environmental values of the sensitive receiving waterways are not adversely impacted. These should be included in the construction and operational environmental management plans.
Environmental Planning and Assessment Act 1979 (EP&A Act)	The EP&A Act is an Act to institute a system of environmental planning and assessment for the State of New South Wales.	As the proposal is for the widening of a road, which is included in the definition of road infrastructure facilities and is to be carried out by TfNSW, it can be assessed under Division 5.1 of the EP&A Act. Development consent from council is not required.
Fisheries Management Act 1994 (FM Act)	The FM Act aims 'to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. To meet the aims, Part 7 of the FM Act outlines legislative provisions to protect fish habitat and Part 7A outlines provisions to conserve threatened species of fish and marine vegetation and their habitat. A Policy definition was created to define key fish habitat and a series of maps were created to show the location of defined key fish habitats.	South Creek is a key fish habitat zone as defined in conjunction with the FM Act. The proposal would involve construction of headwalls for drainage pipes that are required to outlet at South Creek, which may involve minor modification of South Creek at the outlet. This work may meet the definition of 'dredging and/or reclamation work' under FM Act. As a result, TfNSW are required to consult with the Minister for Agriculture and Western NSW and NSW Department of Primary Industries – Fisheries (DPI Fisheries) in accordance with section 199 of the FM Act prior to starting dredging or reclamation work.

Legislation/Policy/Guideline	Brief description and intent	Relevance
Healthy Rivers Commission (HRC, 1998) Inquiry	The HRC was established in 1995 by the NSW Government to make recommendations on: ■ Suitable objectives for water quality, flows and other goals central to achieving ecologically sustainable development in a realistic time frame ■ The known or likely views of stakeholder groups on the recommended objectives ■ The economic and environmental consequences of the recommended objectives ■ Strategies, instruments and changes in management practices that are needed to implement the recommended objectives	The Inquiry established environmental values for the catchment, however these were superseded by the ANZECC Guidelines as part of the National Water Quality Management Strategy (NWQMS). The HRC guidelines provide additional clarification on environmental values to be protected and would be considered.
Australian Runoff Quality (Engineers Australia, 2006)	Australian Runoff Quality (ARQ) guide provides an overview of current best practice in the management of urban stormwater in Australia, within the context of total urban water cycle management and integration of management practices into the urban built form.	The expected stormwater runoff qualities would inform the necessary management and/or treatment requirements.
Lower Hawkesbury-Nepean River Nutrient Management Strategy (DECCW, 2010)	Priority nutrient sources have been identified through consultation with stakeholders and recent studies and data on river health, including environmental monitoring data and land-use mapping data. The Strategy targets both diffuse sources, such as urban and agricultural runoff, and point sources, such as sewage treatment plant discharges.	The proposal area is located within the strategy's catchment boundaries. The South Creek catchment is identified as one of the highest diffuse nutrient load sources. The strategy provides a framework as well as actions to manage nutrient loads in the catchment.
Managing Urban Stormwater, Soils and Construction Volume 1, 4th Edition (Landcom, 2004)	These guidelines, commonly known as the 'Blue Book', provide support for councils and industry to reduce the impacts of land disturbance activities on waterways by better management of soil erosion and sediment control.	During the construction and operation phases of the project due consideration should be given to the erosion and sediment control mechanisms that are to be put in place to reduce the impacts of land disturbance.
NSW Aquifer Interference Policy (DPI, 2012)	The Aquifer Interference Policy details the way the NSW Office of Water will assess aquifer interference projects to determine their potential impacts on water resources. It also explains the information and modelling that proponents will need to provide to enable the impacts to be assessed.	Potential impacts on groundwater-dependent ecosystems (impacts related to GDEs are discussed in **Section 7**)

Legislation/Policy/Guideline	Brief description and intent	Relevance
NSW Groundwater Dependent Ecosystems Policy (DLWC, 2002)	GDEs refer to both terrestrial and aquatic ecosystems that require access to groundwater to meet all or some of their water requirements for their ecological processes and ecosystem services. This policy identifies objectives and management tools to achieve protection of GDEs. The construction and operation of the proposal should account for the principles and processes expressed in this policy in protecting GDEs (impacts related to GDEs are discussed in Section 7).	The construction and operation of the proposal should account for the principles and processes expressed in this policy in protecting GDEs. Safeguards and management measures proposed to GDEs are provided in **Section 1.**
NSW State Groundwater Quality Protection Policy (DLWC, 1998)	This policy identifies objectives and management tools to achieve protection of groundwater quality.	The construction and operation of the proposal should account for the principles and processes expressed in this policy in protecting groundwater quality. Safeguards and management measures proposed to protect groundwater quality are provided in **Section 1.**
NSW Water Quality Objectives (DEC, 2006)	The NSW WQOs are the agreed environmental values and long-term goals for NSW's surface water (DECCW, 2006). They set out: The community's values and uses (i.e. healthy aquatic ecosystem, water suitable for recreation or drinking water etc) for the NSW waterways (rivers, creeks, lakes and estuaries) A range of water quality indicators to assess whether the current condition of the waterway supports these values and uses.	Not directly applicable, as at the time the environmental objectives were approved by the Government (September 1999) the Healthy Rivers Commission (HRC) had completed or substantially completed public inquiries for the catchments of the Clarence, Hawkesbury-Nepean, Williams and Shoalhaven rivers. The HRC recommended Water Quality Objectives in its Final Reports for these catchments, as detailed below.
Protection of the Environment Operations Act 1997 (POEO Act)	The POEO Act has a requirement for Environmental Protection Licence (EPL) to be obtained for scheduled activities that are of a nature and scale that have a potential to cause environmental pollution.	The proposal would meet the definition of road construction, which is a scheduled activity under Clause 35, Schedule 1 of the POEO Act. This is because the proposal would involve an upgrade of Mamre Road, which is a classified main road, over a continuous length of about 3.8 kilometres within a metropolitan area and would result in the existence of four or more traffic lanes. Therefore, an EPL would be required for the proposal in accordance with the POEO Act.
Sydney Regional Environmental Plan No 20 – Hawkesbury-Nepean River (No 2 – 1997)	Part 2, Clauses 5 and 6 of *Sydney Regional Environmental Plan No 20 – Hawkesbury-Nepean River* set out general planning considerations and specific planning policies and recommended strategies respectively. Clause 4 requires that those considerations, policies and recommended strategies be taken into consideration by public authorities proposing to undertake development that does not require consent.	The proposal is a development to be carried out by TfNSW (a public authority) and which does not require development consent. As stated in Clause 4, the considerations, policies and strategies outlined in clause 5 and 6 have been considered throughout this report.

Legislation/Policy/Guideline	Brief description and intent	Relevance
Using the ANZECC Guidelines and Water Quality Objectives in NSW (DEC, 2006)	The ANZECC guidelines document is a large one, containing detailed scientific information and instructions for a vast array of water-quality issues. The booklet was developed to explain the principles behind the ANZECC guidelines and how to apply them.	The ANZECC Water Quality Guidelines have been applied with guidance from this booklet to understand the current health of the waterways in the vicinity of the project and the ability to support nominated environmental values, particularly the protection of aquatic ecosystems.
Water Management Act 2000 and *Water Management (General) Regulation 2018*	The *Water Management Act 2000* recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land. The main tool in the Act for managing the state's water resources are water sharing plans. These are used to set out the rules for the sharing of water in a particular water source between water users and the environment and rules for the trading of water in a particular water source. The 2018 Regulation specifies procedural, technical and licence requirements under the *Water Management Act 2000*, as well as the functions and powers of water supply authorities.	The proposal is located within the Upper South Creek Management Zone as defined by the water sharing plan for the greater metropolitan region which is managed under the *Water Management Act 2000*. TfNSW is exempt from controlled activity approvals under Subdivision 4, Clause 41 of the Water Management (General) Regulation 2018 as they are a public authority.

4 Environmental values and guidelines

Two different sets of water quality objectives are relevant to the proposal:

- South Creek catchment and tributaries: Wianamatta-South Creek performance criteria as drafted by NSW DPIE (DPIE, 2020)
- Hawkesbury-Nepean catchment: Interim Water Quality Objectives (HRC, 1998) and ANZG Water Quality Guidelines (Commonwealth of Australia, 2020)

The two sets of criteria are detailed in the following sections.

4.1 South Creek catchment and tributaries WQOs

The NSW Department of Planning, Industry and Environment (DPIE) have drafted performance criteria for the Wianamatta-South Creek (and its tributaries) to inform the planning of the Western Parkland City (DPIE, 2020) . The criteria were developed to support the vision for Wianamatta-South Creek (and its tributaries): *"To become a cool green corridor through the Western Parkland City and be the core element of liveability and amenity for the residents. This vision relies on urban planners to explicitly keep water in the landscape by integrating waterways into the design of the city and residential neighbourhoods, and for the waterways to be healthy so they can provide the essential services and functions expected of a cool green corridor."*

Two sets of criteria have been developed to support delivery of this vision, and are applicable to all urban developments on land in the Aerotropolis precincts:

- Ambient water quality of waterways and waterbodies (listed in **Table 4-1**)
- Ambient stream flows and requirements of waterways and water dependent ecosystems (WDEs) (listed in **Table 4-2**)

Whilst the draft criteria are currently only applicable to urban developments on land in the Aerotropolis precincts, in the future, the objectives could potentially apply to downstream reaches of South Creek within proximity of the proposal area, so have been included for reference.

Table 4-1 Wianamatta-South Creek draft performance criteria: Ambient water quality

Water Quality Variable	Unit	Performance Criteria
***Total Nitrogen (TN)**	mg/L	1.72
Dissolved Inorganic Nitrogen (DIN)	mg/L	0.74
Ammonia (NH_3-N)	mg/L	0.08
Oxidised Nitrogen (NO_x)	mg/L	0.66
***Total Phosphorus (TP)**	mg/L	0.14
Dissolved Inorganic Phosphorus (DIP)	mg/L	0.04
Turbidity (NTU)	N/A	50
Total Suspended Solids (TSS)	mg/L	30
Conductivity	µS/cm	1,103
pH		6.2 – 7.6
Dissolved Oxygen (DO)	%SAT	43 – 75
Dissolved Oxygen (DO)	mg/L	8

*when showing compliance towards TN and TP through industry models, the DIN and DIP performance criteria should be instead to recognise that stormwater discharges of nutrients are mostly in dissolved form

Table 4-2 Wianamatta-South Creek draft performance criteria: Ambient stream flows

Flow Variable	Unit	Performance Criteria	
		1-2 Order Streams	≥ 3rd Order Streams
Median Daily Flow Volume	L/ha/d	0.00007 ± 0.00002	0.00109 ± 0.00016
Mean Daily Flow Volume	ML/ha/d	0.00235 ± 0.00060	0.00554 ± 0.00032
High Spell ≥ 90th Percentile Flow Volume	ML/ha/d	0.00205 ± 0.00074	0.01009 ± 0.00077
High Spell - Frequency **High Spell - Average Duration**	number/y days/y	6.9 ± 0.4 6.1 ± 0.4	19.2 ± 1.0 2.2 ± 0.2
Freshes ≥ 75th and ≤ 90th Percentile Flow Volume	ML/ha/d	0.00033 ± 0.00009	0.00264 ± 0.00020
Freshes - Frequency **Freshes - Average Duration**	number/y days/y	4.0 ± 0.9 38.2 ± 5.8	24.6 ± 0.7 2.5 ± 0.1
Baseflow	ML/ha/y	0.00005	0.0008 ± 0.0001
Cease to Flow	proportion of time/y	0.34 ± 0.04	0.03 ± 0.007
Cease to Flow – Duration	days/y	36.8 ± 6	6 ± 1.1

4.2 Hawkesbury-Nepean catchment WQOs

The ANZG Water Quality Guidelines (Commonwealth of Australia, 2020) have been used as the basis for the surface water assessment. The preferred approaches to deriving guideline values are usually through the use of field and/or laboratory biological-effects (toxicity) data (ANZG, 2018). These are expensive to collect, however, and require a lengthy period of monitoring so the proposed approach in this assessment is to derive catchment-specific guideline values based on reference-site data. This approach is ratified in ANZG 2018 and the NSW Department of Industry (DPI, 2018).

The proposal is located within the South Creek catchment, which forms part of the Hawkesbury-Nepean catchment. The Hawksbury-Nepean catchment has no defined current water quality objectives (WQOs), however interim WQOs for the Hawkesbury-Nepean catchment were defined by the Healthy Rivers Commission under Inquiry into the Hawkesbury-Nepean system (HRC, 1998) for nutrients and chlorophyll-a and approved by the NSW government in September 1999. The inquiry recommended that non nutrient criteria be adopted from ANZECC (now ANZG 2018). Environmental values and WQOs and are listed in **Table 4-1.**

It is noted that DPIE are currently in the process of reviewing the NSW Water Quality Objectives in three pilot coastal catchments, one of these being the South Creek – Wianamatta catchment.

Table 4-3 Water quality objectives: Hawkesbury-Nepean

Environmental Value	Indicator	Guideline value	Key applicability to the proposal
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies	Total Phosphorus (TP)	30 µg/L	Road runoff during operation
	Total Nitrogen (TN)	500 µg/L	Road runoff during operation

Environmental Value	Indicator	Guideline value	Key applicability to the proposal
and riparian zones over the long term. *ANZECC Guideline Trigger Values for lowland rivers in south-east Australia with slightly disturbed ecosystems indicated.*	Chlorophyll-a	10-15 µg/L	Waterway impact due to elevated nutrients in road runoff
	Turbidity	6 - 50 Nephelometric Turbidity Unit (NTU)	Sediment laden runoff during construction and operation.
	Salinity (electrical conductivity)	125 – 2,200 µS/cm	Construction discharges
	Dissolved Oxygen (DO)	85 - 110% saturation	Road runoff during operation
	pH	6.5 – 8.0	Construction discharges
	Toxicants	As per ANZG 2018 toxicant guidelines for slightly to moderately disturbed ecosystems	Heavy metals in road runoff
Visual amenity – aesthetic qualities of waters	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.	Road runoff flowing into drainage lines flowing into South Creek.
	Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and matter.	Oils and petrochemicals in road runoff
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts No quantitative value specified	Potential impact in waterway as a result of nutrient impacts.
Secondary contact recreation – maintaining or improving water quality of activities such as boating and wading, where there is a low probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	As per the Guidelines for managing risks in recreational water (NHMRC, 2008)	N/A
	Nuisance organisms	As per the visual amenity guidelines. Large numbers of midges and aquatic works are undesirable.	As per the visual amenity relevance.
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable of recreation. Toxic substances should not exceed values provided in the Guidelines for managing risks in recreational water (NHMRC, 2008)	Heavy metals in road runoff
	Visual clarity and colour	As per the visual amenity guidelines.	As per the visual amenity relevance.
	Surface films	As per the visual amenity guidelines.	As per the visual amenity relevance.

Environmental Value	Indicator	Guideline value	Key applicability to the proposal
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	As per the Guidelines for managing risks in recreational water (NHMRC, 2008)	N/A
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water.	N/A
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed values provided in the Guidelines for managing risks in recreational water (NHMRC, 2008)	Road runoff flowing into drainage lines flowing into South Creek.
	Visual clarity and colour	As per the visual amenity guidelines.	As per the visual amenity relevance.
	Temperature	16° - 34°C for prolonged exposure.	Road runoff and construction discharges

4.3 Adopted Water Quality Objectives

The following approach was undertaken to selecting water quality objectives:

- Where available, the recently developed draft performance criteria for Wianamatta - South Creek were adopted as the aquatic ecosystem criteria given they are the most local criteria available
- Where no Wianamatta – South Creek criteria were available, the HRC (1998) criteria were adopted as aquatic ecosystem criteria as these are broader catchment specific criteria
- In the absence of either Wianamatta – South Creek or Hawkesbury Nepean (HRC, 1998) criteria being available, ANZECC (2000) & ANZG (2018) default guideline values were adopted.
- The adopted Water Quality Objective was selected as the most stringent of the adopted Aquatic Ecosystem criteria, Primary and Secondary Contact criteria and Visual Amenity criteria.

The adopted water quality objectives are presented in **Table 4-4**.

Table 4-4 Summary of Water Quality Objectives and selected values

Indicator	Units	Aquatic Ecosystem Criteria				Primary and Secondary Contact Criteria	Visual Amenity Criteria	Selected Water Quality Objective
		ANZECC (2000) / ANZG (2018)	Hawkesbury Nepean	South Creek	Adopted Aquatic Ecosystem Criteria			
Temperature	°C	N/A	N/A	N/A	N/A	**16 – 34**	N/A	**16 – 34**
Total Phosphorus (TP)	mg/L	0.05	0.03	0.14 (DIP 0.04)	0.14 (DIP **0.04**)	N/A	N/A	**0.04**
Total Nitrogen (TN)	mg/L	0.5	0.5	1.72 (DIN 0.74)	1.72 (DIN **0.74**)	N/A	N/A	**0.74**
Oxides of nitrogen	mg/L	0.04	N/A	0.66	**0.66**	N/A	N/A	**0.66**
Chlorophyll-a	mg/L	0.005	0.01-0.015	N/A	**0.01**	N/A	N/A	**0.01**
Turbidity	NTU	6 - 50	N/A	50	**50**	N/A	N/A	**50**
Salinity (electrical conductivity)	µS/cm	125 -2200	N/A	1,103	**1,103**	N/A	N/A	**1,103**
Dissolved Oxygen (DO)	mg/L	N/A	N/A	8	**8**	N/A	N/A	**8**
Dissolved Oxygen (DO)	%SAT	85 – 110	N/A	43 – 75	**43 – 75**	>80	N/A	**43 – 75**
Total Suspended Solids (TSS)	mg/L	N/A	N/A	30	**30**	N/A	N/A	**30**
pH		6.5 – 8.0	N/A	6.2 – 7.6	**6.2 – 7.6**	6.5 – 8.5	N/A	**6.2 – 7.6**

Indicator	Units	Aquatic Ecosystem Criteria				Primary and Secondary Contact Criteria	Visual Amenity Criteria	Selected Water Quality Objective
		ANZECC (2000) / ANZG (2018)	Hawkesbury Nepean	South Creek	Adopted Aquatic Ecosystem Criteria			
Arsenic (As III)	mg/L	0.024	N/A	N/A	0.024	**0.007**	N/A	**0.007**
Arsenic (As V)	mg/L	0.013	N/A	N/A	0.013		N/A	**0.007**
Cadmium	mg/L	0.0002	N/A	N/A	**0.0002**	0.002	N/A	**0.0002**
Chromium (Cr III)	mg/L	0.0033	N/A	N/A	**0.0033**	0.05	N/A	**0.0033**
Chromium (Cr VI)	mg/L	0.001	N/A	N/A	**0.001**		N/A	**0.001**
Copper	mg/L	0.0014	N/A	N/A	**0.0014**	1	N/A	**0.0014**
Iron	mg/L	-	N/A	N/A	-	0.3	N/A	**0.3**
Lead	mg/L	0.0034	N/A	N/A	**0.0034**	0.01	N/A	**0.0034**
Manganese	mg/L	1.9	N/A	N/A	1.9	**0.1**	N/A	**0.1**
Mercury	mg/L	0.00006	N/A	N/A	**0.00006**	0.001	N/A	**0.00006**
Nickel	mg/L	0.011	N/A	N/A	**0.011**	0.02	N/A	**0.011**
Zinc	mg/L	0.008	N/A	N/A	**0.008**	3	N/A	**0.008**
Ammonia	mg/L	0.9	N/A	0.08	**0.08**	0.5	N/A	**0.08**

Indicator	Units	Aquatic Ecosystem Criteria				Primary and Secondary Contact Criteria	Visual Amenity Criteria	Selected Water Quality Objective
		ANZECC (2000) / ANZG (2018)	Hawkesbury Nepean	South Creek	Adopted Aquatic Ecosystem Criteria			
Oil and Grease	N/A	N/A	N/A	N/A		Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour	**Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour**	**Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour**

ANZEC 2000 & ANZG 2018: *Physical and chemical stressors were based upon the South-east Australian lowland rivers of the Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand water quality guidelines (ANZECC & ARMCANZ 2000). Toxicants were based upon the default guideline values for Slightly to Moderately Disturbed Rivers of the Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018).*
Primary and Secondary Contact: *Guidelines for Managing Risks in Recreational Water (NHMRC 2008)*
Visual Amenity: *ANZECC & ARMCANZ 2000*
Hawkesbury Nepean*: Independent Inquiry into the Hawkesbury Nepean River System (HRC 1998) urban areas – main stream criteria*
Wianamatta-South Creek draft performance criteria *(DPIE, 2020)*
Bold values *indicate adopted water quality objective*

5 Existing environment

5.1 Climate

5.1.1 Historical records

Climate data online (BoM, 2020) was used to identify weather observation stations close to the proposal area. The identified stations were further assessed to determine the most representative set of records. The results are summarised in **Table 5-1**.

Table 5-1 Local rainfall gauges metadata

Gauge ID	Location	Distance (km)	Elevation (m)	Years active	Percent complete	MAP*
067066	Erskine Park Reservoir	3.1	85	Jul 2013 – Mar 2020 [7 yr]	99%	649
067084	Orchard Hills Treatment Works	5.8	93	Dec 1970 – Jan 2020 [50 yr]	97%	780
067116	Willmot (Resolution Ave)	8.4	30	Oct 1995 – Feb 2016 [20 yr]	97%	754
067081	Shanes Park (South Creek Road)	9	26	Nov 2017 – October 2020 [3 yr]	76%	643
*Mean Annual Precipitation (MAP) is calculated over the years with complete datasets						

The following primary factors were used to assess the data records:

- Completeness of rainfall record
- Distance from the proposal area
- Record length

Considering the above factors, the Orchard Hills Treatment Works (067084) station's data record was selected as the representative record, given the longer and more complete dataset.

Representative evaporation data was sourced from the SILO database (SILO, 2020). The metadata associated with the stations closest to site is summarised in **Table 5-2**. Based on similar considerations mentioned above, the Orchard Hills dataset was considered most appropriate and used to characterise the expected pan evaporation rates for the proposal area.

Table 5-2 Details of gauges with available evaporation data close to study area

Gauge ID	Location	Elevation (m)	Data availability	MAE (mm)
67084	Orchard Hills Treatment Works	93	Jan 1970 – April 2020	1,459
***Mean Annual Evaporation (MAE) is calculated over the years with complete datasets**				

The annual total rainfall and pan evaporation values over the 1971 to 2019 monitoring period (excluding the years with prolonged periods of missing data) are shown in **Figure 5-1**. Review of the historical data associated with this station reveals a variable annual rainfall rate. Wetter years, i.e. 1978 and 1990, may experience rainfall in excess of 1,200 mm and drier years record less than 500 mm. The pan evaporation data fluctuates between 1,200 mm and 1,900 mm with an increasing trend observed in the total annual evaporation since 2012.

The monthly rainfall and evaporation data for Orchard Hills are shown in **Figure 5-1**. This monthly breakdown, data suggests rainfall throughout the year but that generally November to May" are wetter months and June to October are dryer months.

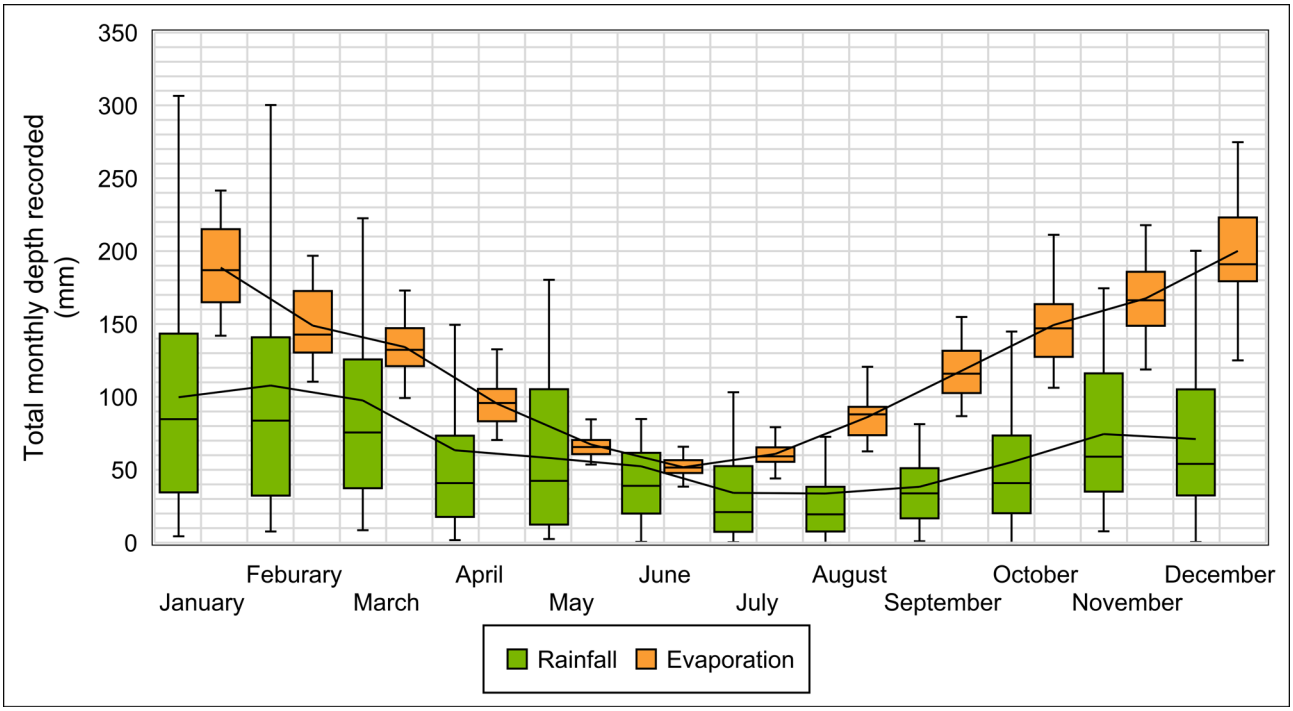


Figure 5-1 Range of total monthly rainfall and evaporation (1971-2019)

Notes: Whiskers show 10th and 90th percentiles. Boxes depict median values, upper and lower quartiles. Trend lines reflect monthly averages.

A summary of temperature variation at Orchard Hills Treatment Works (067084) is provided in **Figure 5-2.** Analysis of the these records, presented in **Figure 5-2,** indicates a temperate climate with warm to hot summers (average maximum temperatures around 29°C) and cooler winter periods with average maximum temperatures below 20°C and minimum temperatures averaging around 6°C.

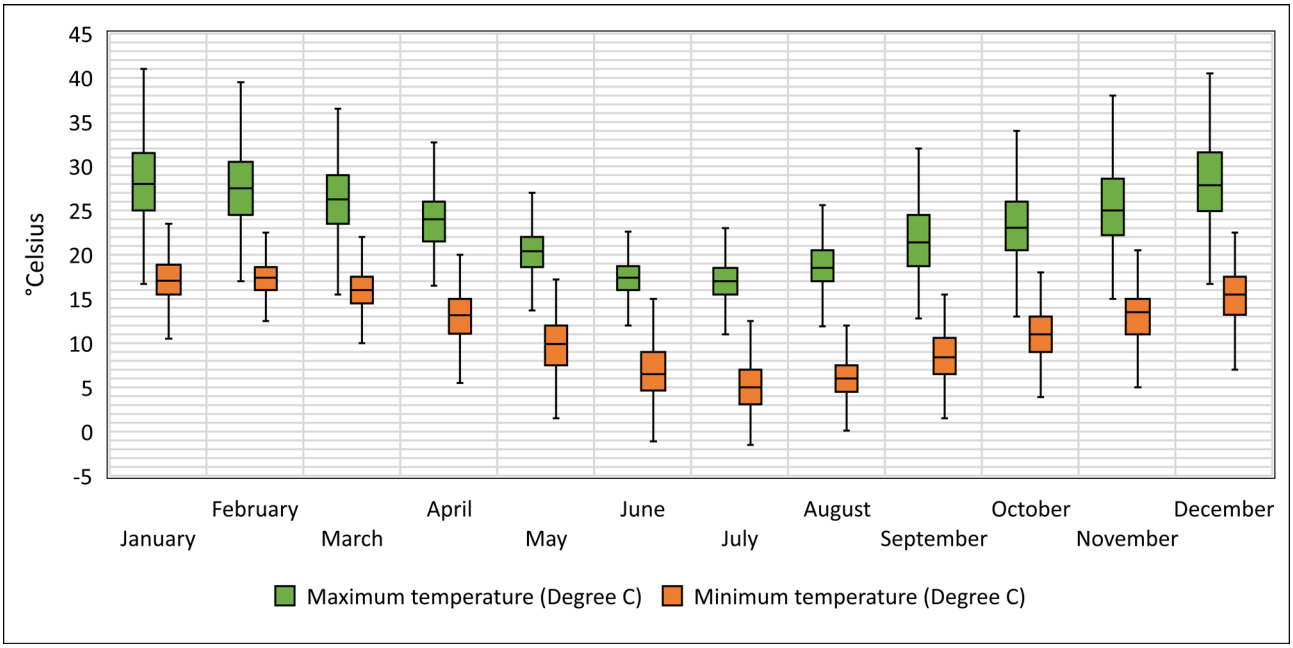


Figure 5-2 Monthly maximum and minimum temperature ranges (1971- 1989)

Notes: Whiskers show 10th and 90th percentiles. Boxes depict median values, upper and lower quartiles.

5.1.2 Climate change

Consideration of potential climate change is a crucial factor in assessing the future water resources, as it has the potential to influence the general environmental water balance as well as groundwater availability, soil and water salinity and water quality. The NSW Office of Environment and Heritage (OEH) has published several documents detailing the expected effects of climate change on water resources. Study results documented in

a 2015 report, "*Climate change impacts on surface runoff and recharge to groundwater*" (OEH, 2015), have been used to assess expected local climatic changes.

Utilising NARCliM (the NSW and ACT Regional Climate Modelling project), which is an ensemble of regional climate projections for south-east Australia, the OEH study predicted near future (2020-2039) and far future (2060-2079) changes to rainfall, runoff and recharge to groundwater. **Table 5-3** presents a summary of the statistical analysis for Metropolitan Sydney.

Table 5-3 Percent changes to multi-model mean annual rainfall, surface runoff and recharge

	Percentage change in near future (2020-2039)			Percent change in far future (2060-2079)		
State planning region	**Rainfall**	**Runoff**	**Recharge**	**Rainfall**	**Runoff**	**Recharge**
Metropolitan Sydney	0.4	4.0	-5.0	8.1	17.6	12.5

The results of this model for the Hawkesbury catchment are presented in **Table 5-4**. In summary, the study predicted that changes in near future, were likely to be a reduction in the rainfall and recharge to the groundwater and increase in the surface runoff, while in far future, the model predicted an increase in all three parameters (rainfall, surface runoff and recharge to the groundwater).

Table 5-4 Percentage change in rainfall, runoff and groundwater recharge for the Hawkesbury catchment

	Percentage change in near future (2020-2039)			Percent change in far future (2060-2079)		
State planning region	**Rainfall**	**Runoff**	**Recharge**	**Rainfall**	**Runoff**	**Recharge**
Hawkesbury Nepean Catchment	-0.1	0.9	-9.3	6.1	13.4	5.6

Understanding of the physical processes that cause extreme rainfall, coupled with modelled projections, indicate with high confidence a future increase in the intensity of extreme rainfall events, although the magnitude of the increases cannot be confidently projected. The publication does not provide details regarding changes to flood-producing rainfall events other than to confirm that changes to rainfall intensity are predicted.

The "*Practical Consideration of Climate Change*" (NSW Government Department of Environment and Climate Change, 2007) publication references modelling carried out by the CSIRO in 2007 for the NSW Government to assess the impacts of climate change on rainfall intensities. The results showed a trend of increased rainfall intensities for the 40-year ARI one-day rainfall event across New South Wales (**Table 5-5**).

Table 5-5 CSIRO indicative change in rainfall and evaporation one-day total (CSIRO, 2007)

Location	40 Year 1-day rainfall total projected change 2030	40 Year 1-day rainfall total projected change 2070	Evaporation projected change 2030	Evaporation projected change 2070
Sydney Metropolitan	-3% to +12%	-7% to +10%	+1% to +8%	+2% to +24%
Hawkesbury Nepean	-3% to +12%	-7% to +10%	+1% to +8%	+2% to +24%
New South Wales Average	-2% to +15%	-1% to +15%	+1% to +12%	+3% to +38%

These expected rainfall and evaporation changes largely support the predictions presented in **Table 5-4**, as higher intensity storms will result in higher runoff volumes, whereas the increased evaporation rates will likely lead to reduced recharge, as suggested in the near future results.

Temperature projections for Eastern Australia indicate higher average temperatures for the near future (2030) with the daily average expected to rise between 0.5 and 1.4°C above the average value recorded between 1986 and 2005. By late in the century (2090), for a high emission scenario (RCP8.5) the projected range of warming is 2.8 to 5.0 °C. Under an intermediate scenario (RCP4.5) the projected warming is 1.3 to 2.6 °C. (OEH, 2014).

5.2 Surface water

5.2.1 Topography

The general topography of the area is relatively consistent. The study area is fairly flat with gentle undulating low slopes. South Creek flows south to north on the west-side of the study area and local watercourses within the study area generally flow north westerly towards South Creek.

The study area ranges in elevation between around 90 mAHD in the south east to around 25 mAHD elevated in the north west. The proposal area is elevated at around 40 mAHD at its southern extent and 35 mAHD at its northern extent.

5.2.2 Regional catchment

South Creek is a tributary of the Hawkesbury River that drains a 414 square kilometre catchment in Western Sydney extending from its headwaters near Narellan in the south, to its confluence with the Hawkesbury River near Windsor (Penrith City Council, 2019). The South Creek catchment is generally bound by Windsor in the north, Narellan in the south, Penrith in the west and Blacktown in the east. South Creek generally flows from south to north through the catchment. The South Creek catchment consists of urbanized areas including residential, rural, industrial and agricultural areas with very little undisturbed vegetation. The South Creek catchment is shown in **Figure 5-3.**

South Creek has seventeen tributaries, the major tributaries being Badgerys Creek, Ropes Creek, Kemps Creek and Eastern Creek. Two minor unnamed tributaries of South Creek cross the study area. The unnamed tributary catchments are predominantly urbanized upstream of the study area, refer to **Figure 5-4.**

5.2.3 Local watercourses

South Creek generally flows from south to north, meandering alongside the proposal area. The proposal area extends into South Creek at the proposed location of new drainage outlets to the south of Luddenham Road.

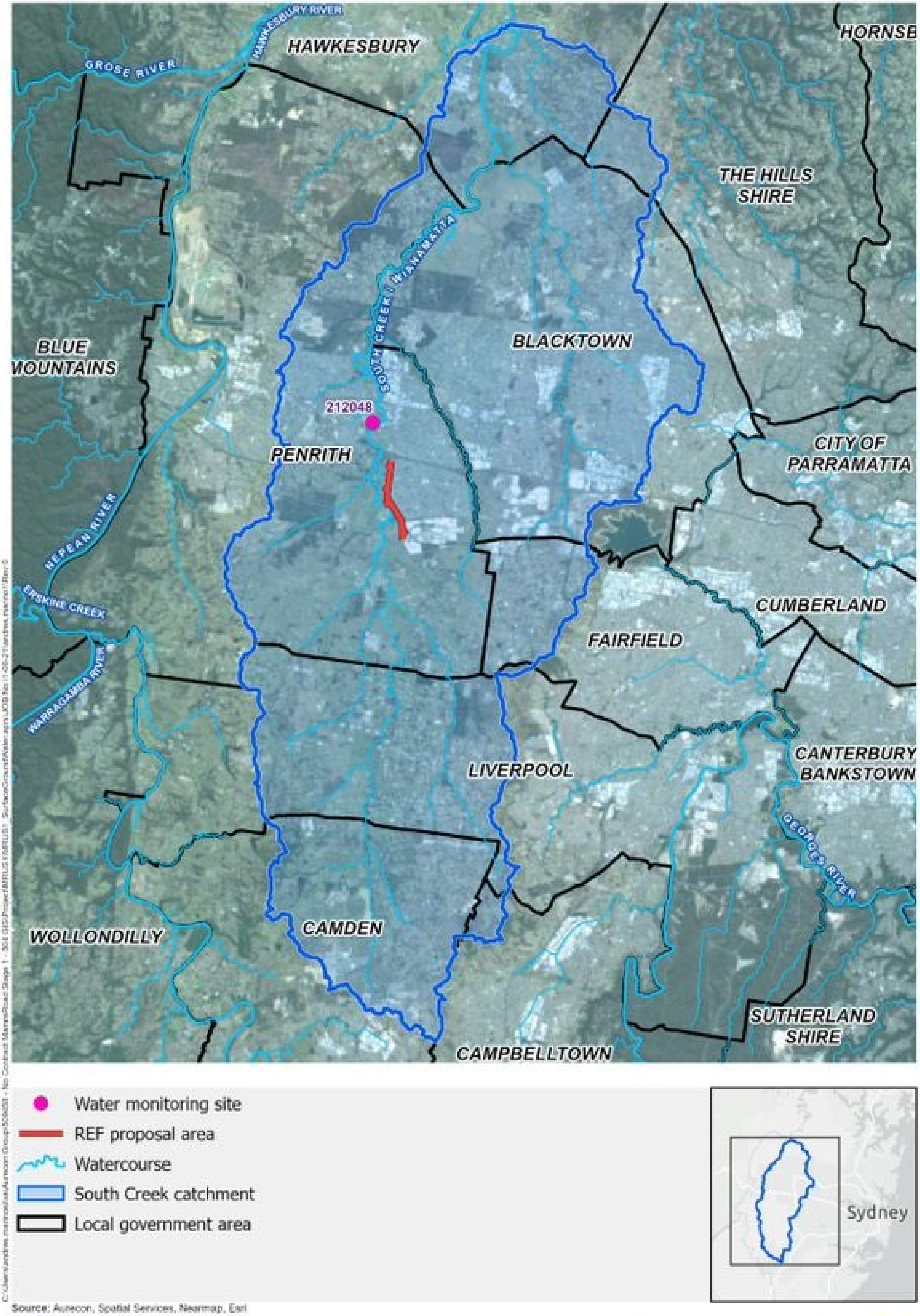
Two unnamed tributaries of South Creek, flowing north westerly traverse the proposal area (1A and 2A), refer to **Figure 5-4**. Branches of these tributaries (1B and 2B) and another minor tributary of South Creek (3) are also located within the proposal area. Several other local drainage lines also traverse the proposal area. Indicative locations of where transverse drainage lines cross the proposal boundary are shown in **Figure 5-4.**

The unnamed tributary 1A catchment and local drainage catchment is entirely urbanized with residential land use to the east of the proposal boundary. Most of the northern portion of the unnamed tributary 2A catchment is urbanized with a mix of residential and industrial land use, with the southern portion of the catchment currently consisting of agricultural land and remnant vegetation.

5.2.4 Wetlands

There are no mapped wetlands within the study area or within proximity downstream of the proposal boundary. (NSW Government n.d.)

The nearest wetlands downstream of the proposal boundary are listed under the Coastal Management SEPP 2018 and located near Vineyard at the confluence of South Creek and Eastern Creek approximately 17 kilometres from the proposal.



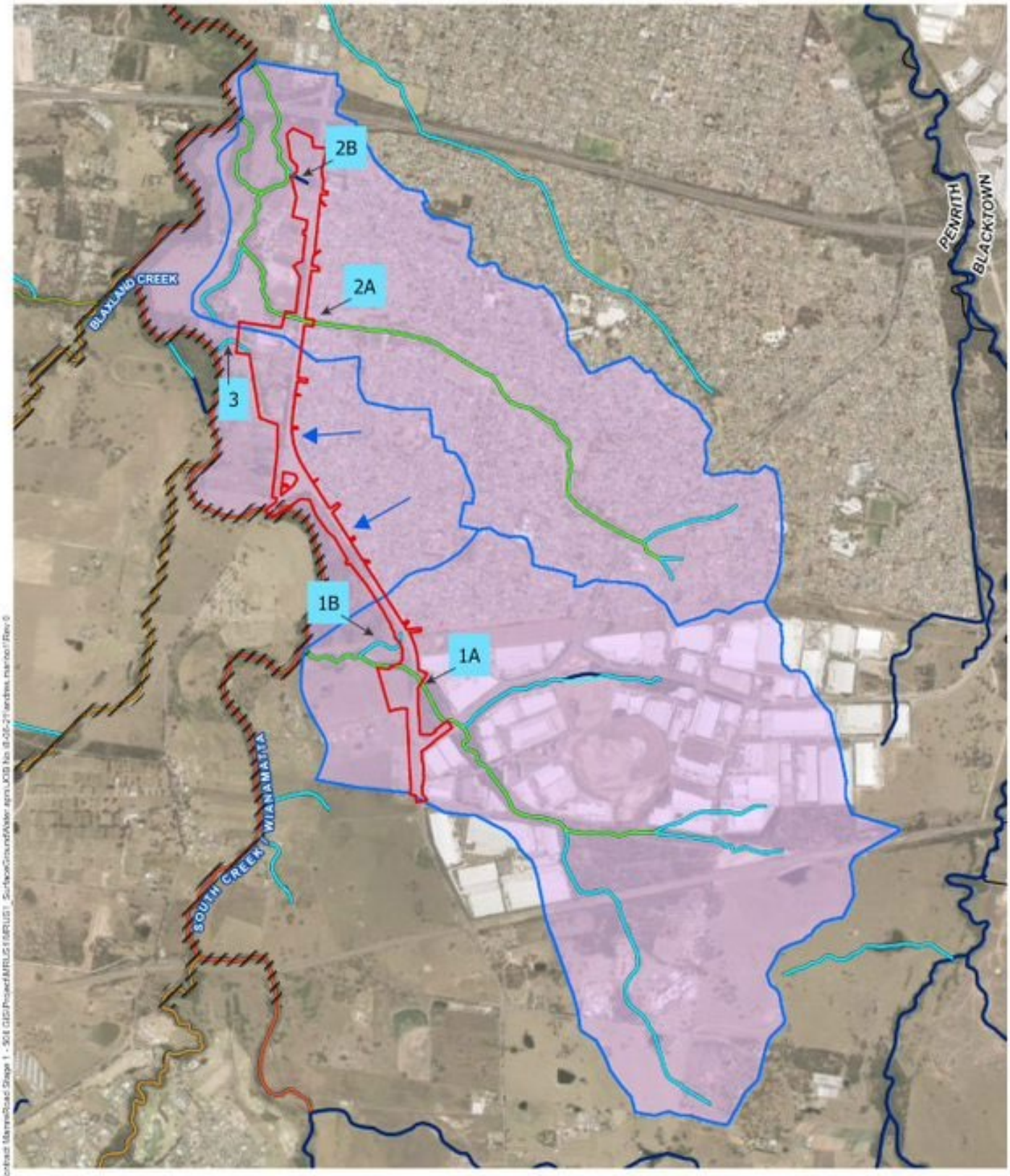
Source: Aurecon, Spatial Services, Nearmap, Esri

Date: 1/06/2021 Version: 1

Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1 REF

FIGURE 5-3: Regional Surface Water Catchment



Local drainage
Watercourse
Contour 5m
REF proposal area
South Creek tributary catchment
Local government area
Surface water study area
Key fish habitat

Un-named tributaries

Strahler Stream Order

1
2
3
4
6

Source: Aurecon, Spatial Services, Nearmap, Esri

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0 500 1,000m

Date: 8/05/2021 Version: 1

Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1 REF

FIGURE 5-4: Local Catchment and Surface Water Features

5.2.5 Surface water quality and quantity

Flow and water quality data recorded at the WaterNSW Water Monitoring Site (ID: 212048) (WaterNSW, 2020) on South Creek is provided in Table 5-6 below. The location of monitoring site 212048 is shown on Figure 5-3.

Water quality monitoring data collected in South Creek by Penrith Council at the Luddenham Road crossing is provided in Table 5-7**.** The data has been compared with the Water Quality Objectives as described in **Section 4.**

Table 5-6 Summary Statistics from WaterNSW Water Monitoring Site (ID: 212048).

	Water Level (metres)	*Discharge (ML/d)*	*EC @ 25C (uS/cm)*	*EC (uS/cm)*	*Water Temp (c)*
10%	0.136	1.087	512.1	435	10.4
Median	0.223	10.009	816.4	679.1	17.5
90%	0.427	90.939	1092.82	855.72	25.1

*Data Range: 01/01/2018-22/10/2020

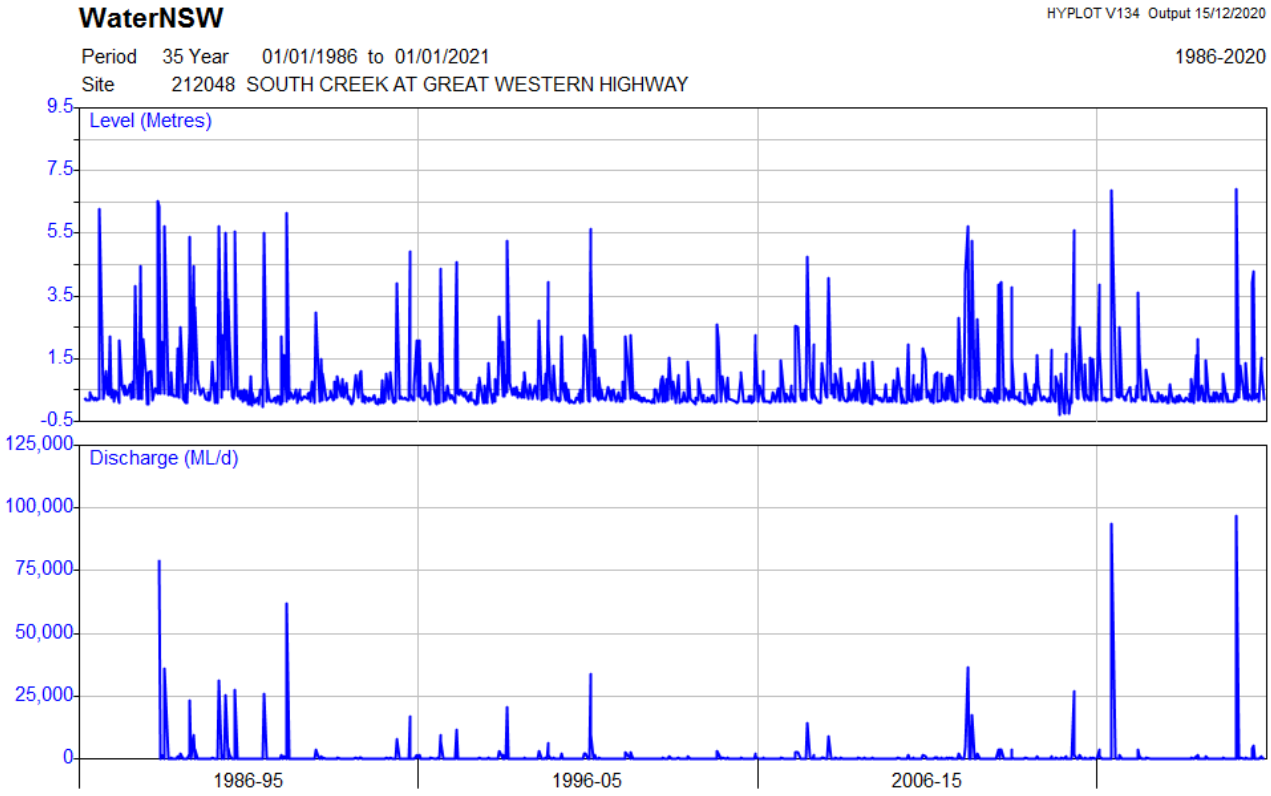


Figure 5-5 Water NSW Monitoring Site 212048 level and flow variation

The monitoring results indicate that South Creek is a freshwater flowing stream within the proposal area.

Table 5-7 Summary of South Creek water quality monitoring data at Luddenham Road

Analyte	Units	Water Quality Objective	20th percentile	Median	80th percentile
Temperature	°C	16 - 34	**11.08**	17.08	21.61
pH	N/A	6.2-7.6	7.006	7.31	7.534
Conductivity	uS/cm	<1,103	554.8	908	**1386.4**
Dissolved Oxygen	%	43-75	**34.768**	52	**81.25**
Faecal Coliforms		N/A	68	250	1260
Total Nitrogen	mg/L	0.74	**0.778**	**1.095**	**2.284**
Total Phosphorus	mg/L	0.04	**0.0636**	**0.1**	**0.1604**
Turbidity	NTU	50	9.36	22.7	**75.06**
Total Suspended Solids	mg/L	N/A	11	28	42
Zinc	mg/L	0.008	0.007	**0.0105**	**0.0268**
Copper	mg/L	0.0014	**0.002**	**0.003**	**0.007**
Lead	mg/L	0.0034	0.001	0.002	**0.0036**

Bold values indicate Water Quality Objective is exceeded

The water quality monitoring results show that the South Creek water quality objectives are frequently exceeded at Luddenham Road. This indicates that the existing South Creek water quality is impacted by the upstream catchment due to urban development and agricultural activities.

5.2.6 Sensitive receiving environments

Key fish habitat areas of interest to the proposal are located within South Creek to the west of the proposal. The key fish habitat are located for a large stretch of South Creek continuing upstream and downstream of the proposal, at the closest point the proposal area intersects the key fish habitat at Luddenham Road and at the furthest point approximately 900 metres from the proposal area. The areas are identified as those aquatic habitats that are important to the sustainability of the recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species (DPI, 2020).

5.3 Flooding

A Hydrology and Hydraulics Assessment was undertaken for the proposal (Aurecon, 2021). This includes a flood impact assessment. A brief summary of the present day flooding and flood impacts due to the proposal are provided below. Refer to the Hydrology and Hydraulics Assessment for further details and mapping.

5.3.1 Present day flooding

Mamre Road is susceptible to flooding as a result of main stream flooding of South Creek and local catchment flooding as a result of local overland flow paths from residential and industrial areas on the eastern side of Mamre Road.

The portion of Mamre Road most prone to indundation during a South Creek flood event is near Luddenham Road, since South Creek meanders closer to Mamre Road at this location. As the South Creek main stream flood level is higher than the some of the transverse structure invert levels, backwatering occurs on the eastern side of Mamre Road. Mamre Road has a five per cent Average Exceedance Probability (AEP) hydrologic standard with Banks Drive intersection and Luddenham Road intersection inundated during this event. Mamre Road's connecting roads range in hydrologic standard of between one per cent AEP and less than five per cent AEP.

The existing hydrologic standard of Mamre Road is less than a 0.5 Equivalent Year (EY) hydrologic standard as a result of local catchment flooding, with Dryberry Avenue inundated / overtopped during this event. The

connecting roads to Mamre Road range in hydrologic standard between <0.5 EY and 0.5 EY as a result of local catchment flooding.

Mamre Road experiences shallow overtopping as a result of the local catchment flooding at several locations during a one per cent AEP flood event. During a PMF local catchment flood event, Mamre Road will be inundated along the entire length of the road between the M4 Motorway and Erskine Park Road except at some isolated locations.

5.4 Geology and soils

5.4.1 Geology

Based on the Penrith 1:100 000 Geological Map (Clark N.R and Jones D.C 1991), the study area geology consists of sedimentary rocks from the Middle Triassic Mesozoic Wianamatta Group (major Bringelly Shale with minor Ashfield Shale and Minchinbury Sandstone) that are made up of shale, carbonaceous claystone, laminite, lithic sandstone and rare coal. Quaternary fine grain sands, silt and clays derived from the surrounding rocks are present along South Creek and current streams, refer to **Figure 5-6.**

5.4.2 Soil landscapes and characteristics

The Soil Landscapes of Penrith 1:100,000 Sheet (Chapman and Murphy, 1989) shows the proposal intersects the Blacktown and South Creek soil landscapes. **Figure 5-7** shows the proposal area relative to NSW soil landscape mapping.

The key characteristics and limitations to development of the NSW soil landscapes are presented in **Table 5-8**.

Table 5-8 Summary of soil landscape key characteristics and key limitations.

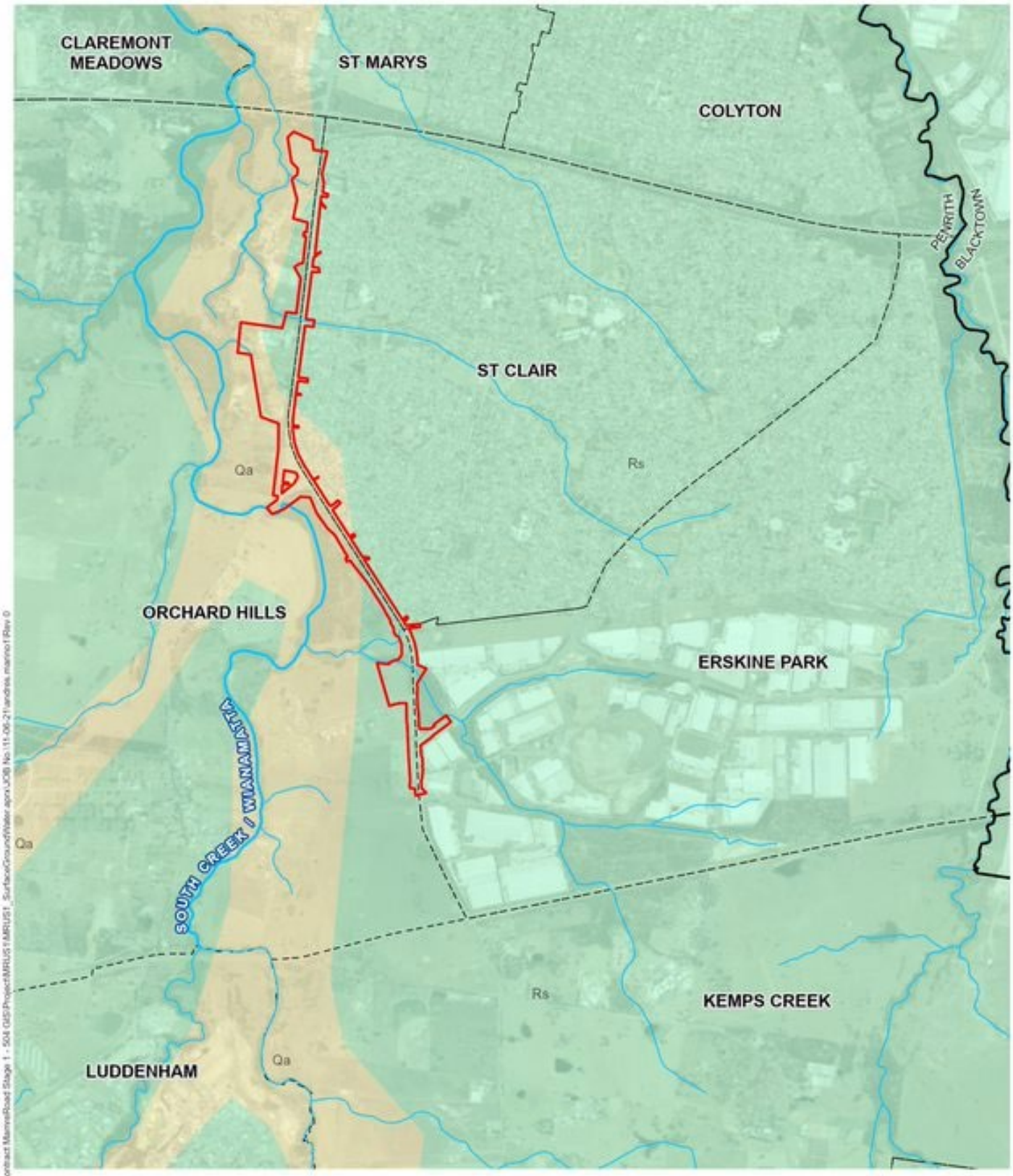
Soil Landscape	Key Characteristics	Key Limitations of the soil landscape
Blacktown	Shallow to moderately deep (>100 cm) hardsetting mottled texture contrast soils, red and brown podzolic soils (Dr3.21, Dr3.31, Db2.11, Db2.21) on crests grading to yellow podzolic soils (Dy2.11, Dy3.11) on lower slopes and in drainage lines.	■ Low to moderate fertility ■ Moderate erodibility ■ Erosion hazard for non-concentrated flow is slight to moderate but ranges from low to very high and for concentrated flows is moderate to high. ■ Landscape limitations (seasonal waterlogging (localised), water erosion hazard (localised)
South Creek	Often very deep layered sediments over bedrock or relict soils. Where pedogenesis has occurred structured plastic clays (Uf6.13) or structured loams (Um6.1) in and immediately adjacent to drainage lines; red and yellow podzolic soils (Dr5.11, Dy2.41, Dr2.21) are most common terraces with small areas of structured grey clays (Gn4.54), leached clay (Uf4.42) and yellow solodic soils (Dy4.42, Dy5.23).	■ Low fertility ■ High erodibility ■ Landscape limitations (flood hazard, seasonal waterlogging, permanently high water tables (localised))

The proposal is located in an area containing group D soils from the hydrologic soil group classification (Horton Model) (DPIE, 2020). Soils in group D have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential. Soils with high shrink-swell potential causes much damage to building foundations, roads and other structures.

A high shrink/swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

5.4.3 Acid sulfate soils

No acid sulfate soils (ASS) are recorded in the proposal area based on ASS mapping database (NSW Government n.d., DPIE 2020). ASS are therefore unlikely to be uncovered during construction of the proposal (DPIE, 2020).



Waterways
REF proposal area
Suburb
Local government area

Geology

Quaternary alluvial deposits (Qa)
Triassic sedimentary rocks (Rs)

Source: Aurecon, Spatial Services, Nearmap, Esri

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Date: 11/06/2021 Version: 1

Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1 REF

FIGURE 5-6: Surface Geology

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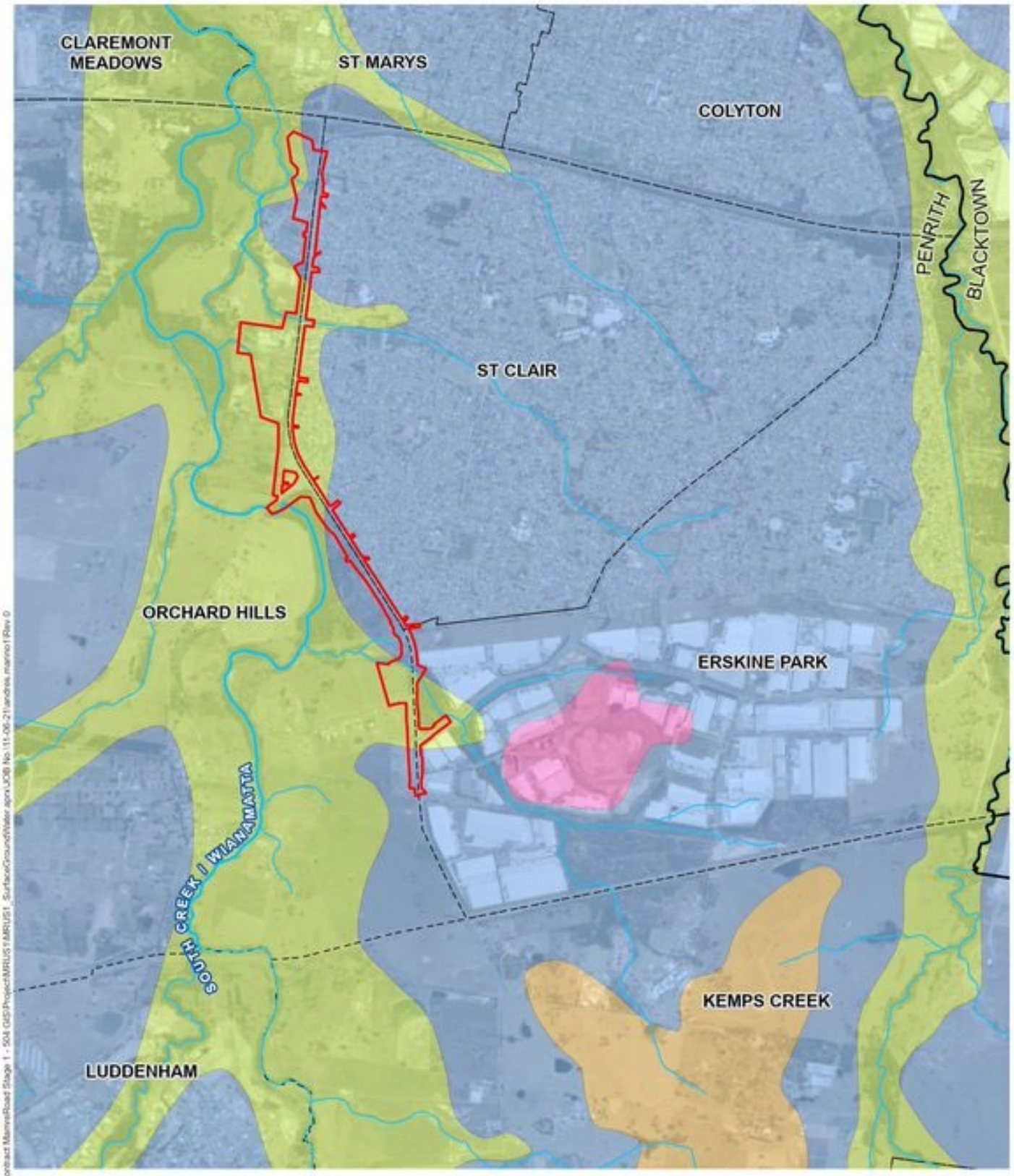

Waterways
REF proposal area
Suburb
Local government area

Soil landscape
Blacktown
Disturbed Terrain
Luddenham
South Creek

Source: Aurecon, Spatial Services, Nearmap, Esri

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Date: 11/06/2021 Version: 1

Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1 REF

FIGURE 5-7: Soil landscapes

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5.5 Groundwater

The proposal is located within the Shale Plains hydrogeological landscapes (HGLs) which are characterised by low hills and rises on Triassic shale and sandstone within the Sydney Basin.

Groundwater levels are reported as generally intermediate ranging from two metres below ground level to six metres below ground level (DPIE, 2020a).

Groundwater flow in the Shale Plains HGL is unconfined along structures of bedding, joints, faults in the fractured bedrock. Lateral flow occurs through alluvial sediments on slopes and plains (DPIE, 2020a). As such, groundwater levels are considered variable seasonally, in particular during high rainfall events.

Hydraulic conductivity (the ability of water to pass through pores and fractured rocks) is moderate (between 10^{-2}m per day and 10m per day) and transmissivity (the ability of the aquifer to transmit groundwater throughout its entire saturated thickness measured as a rate) is low to moderate (between less than 2 and 20m^2 per day). Groundwater systems are local with short flow lengths and are loosely defined by topographic catchments (DPIE, 2020a).

Groundwater quality within these systems is brackish to saline with base flow salinity generally between 1.6 and 4.8 dS/m. The residence times are medium (years) and these landscapes have a medium response time to changes in land management (years) (DPIE, 2020a).

Figure 5-8 depicts a conceptual diagram of the cross-section of the Hydrogeological Landscape in the proposal area.

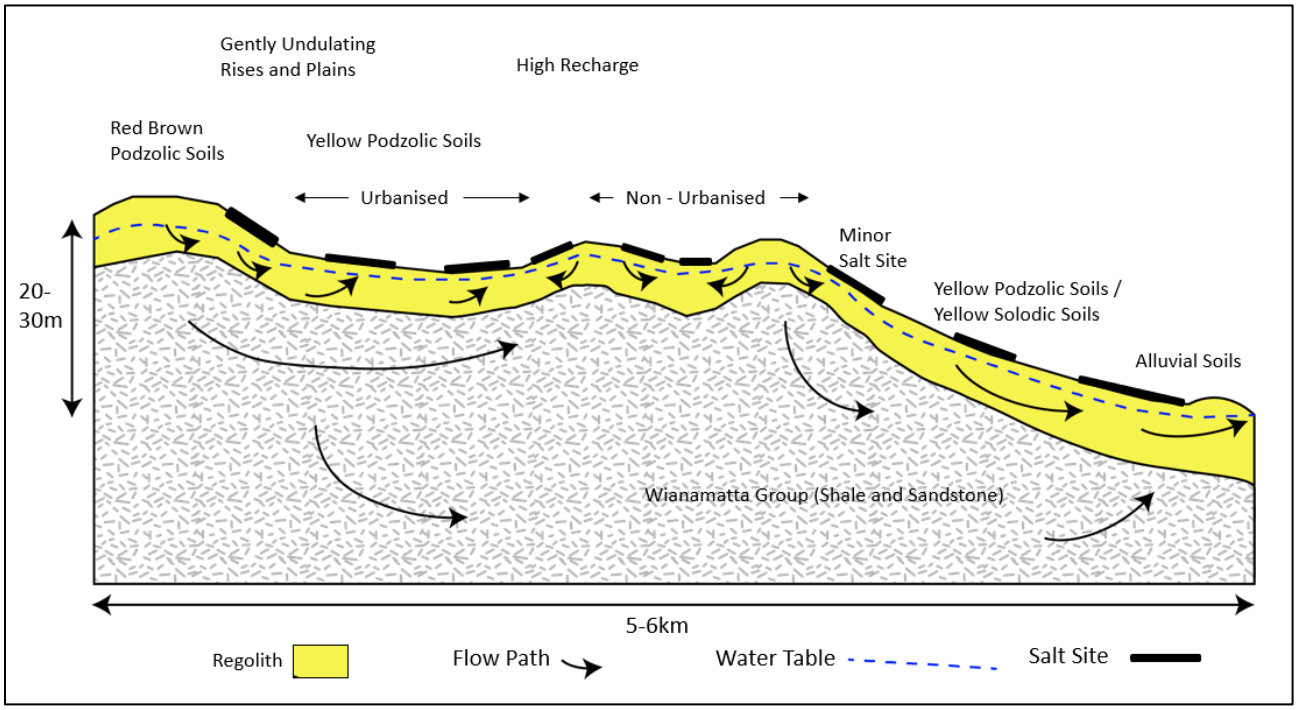


Figure 5-8 Conceptual Shale Plains Hydrogeological Landscape cross-section showing the distribution of regolith, landforms, salt sites and flow paths (adapted from DPIE, 2020a)

TfNSW undertook groundwater monitoring at six monitoring locations. A summary of the results in metres below ground level (m BGL) is provided below. The monitoring locations are shown in **Figure 5-9**. Wells registered on the NSW Water Register are also summarised in **Table 5-10**.

Table 5-9 TfNSW groundwater monitoring

Borehole ID	Monitoring period	Highest Groundwater depth (m BGL)	Lowest groundwater depth (m BGL)
BH01	June 2020 to February 2021	0.66	4.89
BH03	June 2020 to February 2021	2.24	2.84
BHW102	February 2021 to March 2021	4.26	4.35
BHW103	February 2021 to March 2021	2.90	3.05
BHW104	February 2021 to March 2021	3.73	3.84
BHW106	February 2021 to March 2021	2.21	2.45

There are 12 registered boreholes within a one-kilometre radius of the proposal area listed on the NSW Water Register. Their locations are presented on **Figure 5-9** and their details are summarised in **Table 5-10.**

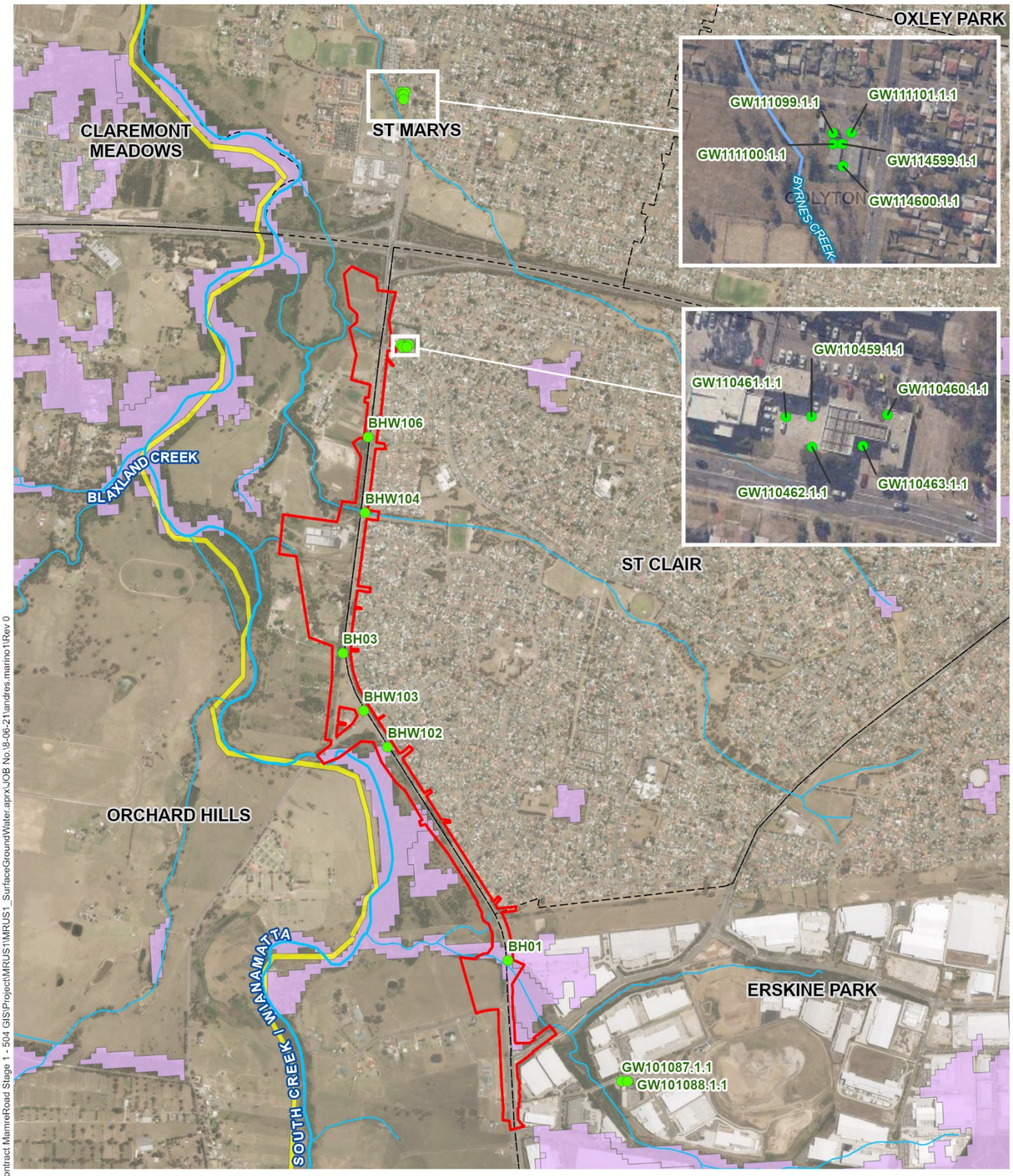
Table 5-10 Registered boreholes within one kilometre of proposal

Bore ID	Bore Depth (m)	Depth to Groundwater (m)	Drilled Date	Purpose	Latitude	Longitude
GW101087.1.1	90.3	ND	1996-05-31	Monitoring	-33.8187	150.7814
GW101088.1.1	60.2	ND	1996-05-30	Monitoring	-33.8187	150.7817
GW110459.1.1	6	2.9	2009-06-15	Monitoring	-33.7882	150.7714
GW110460.1.1	6	2.2	2009-06-15	Monitoring	-33.7882	150.7717
GW110461.1.1	6	3.1	2009-06-15	Monitoring	-33.7882	150.7713
GW110462.1.1	6	3.8	2009-06-15	Monitoring	-33.7883	150.7714
GW110463.1.1	6	2.6	2009-06-15	Monitoring	-33.7883	150.7716
GW111099.1.1	7	ND	2010-04-26	Monitoring	-33.7778	150.7716
GW111100.1.1	8	ND	2010-04-26	Monitoring	-33.7779	150.7716
GW111101.1.1	7	ND	2010-04-26	Monitoring	-33.7778	150.7718
GW114599.1.1	6	ND	2011-02-04	Monitoring	-33.7779	150.7717
GW114600.1.1	6.3	ND	2011-02-04	Monitoring	-33.7781	150.7717

5.5.1 Groundwater dependent ecosystems

Groundwater dependant ecosystems (GDEs) were identified near the proposal and are presented in **Figure 5-9**.

South Creek is classified as *high potential aquatic GDE*. The terrestrial GDEs within the study areas are classified as *high potential GDEs*, these include the Cumberland Shale Plains Woodland and the Cumberland River Flat Forest lining South Creek to the west of the proposal (DPIE, 2020c).



- Boreholes
- Waterways
- REF proposal area
- Local government area
- Suburb
- Aquatic GDEs
- Terrestrial GDEs

Source: Aurecon, Spatial Services, Nearmap, Esri

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0 250 500m

Date: 8/06/2021 Version: 1

Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1 **REF**

FIGURE 5-9: Groundwater

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5.6 Contamination

A review of site history information indicates that Mamre Road has been a road since before 1960 with increasing commercial and residential development in the vicinity over the years. The only potential source of subsurface impact noted is the use of uncontrolled fill historically and ACM has been noted in the area previously. There were no sites identified with potential sources of contamination in close proximity to the proposal area.

The EPA POEO sites along or near the proposal area are confined to the south in Erskine Park and west to Orchard Hills. The current licences are listed in **Table 5-11.**

Table 5-11 Current EPA issued licences

License Number	Name	Location	Type
1602275	N/A	4 Quarry Road, Erskine Park, NSW 2759	s.58 Licence Variation
1600240	Bluescope Steel Limited	Templar Road, Erskine Park, NSW 2759	Compliance Audit
1602571	Cleanaway PTY LTD	85-87 Quarry Road, Erskine Park, NSW 2759	s.58 Licence Variation
20163	DHL Supply Chain (Australia) Pty Ltd	Building B1, 23-107 Erskine Park Road, Erskine Park, NSW 2759	POEO licence
1569274	Enviroguard PTY Limited	4 Quarry Road, Erskine Park, NSW 2759	s.58 Licence Variation
1582339	Retail Ready Operations Australia PTY. LTD.	54-70 Templar Road, Erskine Park, NSW 2759	s.58 Licence Variation
1581199	Saputo Dairy Australia PTY LTD	111-113 Quarry Road, Erskine Park, NSW 2759	s.58 Licence Variation
21401	Twentieth Super Pace Nominees PTY. LTD.	Rolling Stock Operated On A Licensed Rail Network, Erskine Park, NSW 2759	POEO licence
1587553	N/A	Between Eaton Road, Luddenham And Glenmore Parkway, Orchard Hills, NSW 2748	s.58 Licence Variation
1595122	N/A	123 - 129 Patons Lane, Orchard Hills, NSW 2748	s.58 Licence Variation
1594007	CPB Contractors PTY Limited	Between Eaton Road, Luddenham And Glenmore Parkway, Orchard Hills, NSW 2748	s.58 Licence Variation
1052234	Erskine Park Quarry (NSW) PTY LTD	123-179 Patons Lane, Orchard Hills, NSW 2748	s.58 Licence Variation
1577073	SRC Operations PTY Limited	123 - 129 Patons Lane, Orchard Hills, NSW 2748	s.58 Licence Variation
3173526043	Top Demolition & Excavation PTY LTD	338/356 Wentworth Rd, Orchard Hills, NSW 2748	Penalty Notice

Between December 2020 and January 2021 and in March 2021, Aurecon conducted an intrusive investigation within the proposal area, which included advancement of 51 test pit locations and 15 hand augers. Aurecon also observed test pitting activities undertaken by the TfNSW geotechnical team at 16 additional test pit locations during their investigation. The test pits were advanced to a maximum depth of 3.0 metres below ground level (m BGL) with the majority terminated at shallower depths (<1m) due to encountering natural soil and claystone. The purpose of the observations was to visually assess for indications of subsurface contamination, particularly asbestos at each investigation location.

The investigation identified the following with respect to risk to the environment:

- There are 11 distinct areas where asbestos was identified through observation and laboratory analysis. This can be distinguished as areas where asbestos was identified at the surface, and areas where asbestos was identified within fill.
- Two samples exceeded Benzo(a)pyrene against National Environmental Protection Measures (NEPM) Ecological Screening Levels.
- Nine samples exceeded nickel against the Ecological Investigation Level (Residential).
- 16 samples exceeded zinc against the Ecological Investigation Level (Residential).

The elevated concentration of nickel and zinc are likely attributed to background conditions and the underlying geology of the Sydney Basin.

The PSI and DSI identified some distinct areas as Areas of Potential Environmental Concern (APEC). These are outlined in Table 5-12.

Table 5-12 Contamination - Areas of Potential Environmental Concern

Area of Potential Environmental Concern	Associated Contaminants	Area Description
***1* (TP117, TP118, TP273)**	ACM, TRH, BTEXN, PAH, heavy metals	The northern most area near Banks Avenue has ACM at surface and in soil (TP117, TP118, TP273). The area appears to have been impacted by historical earthworks and filling.
2 (TP259, TP110, TP215 and TP107)	ACM, TRH, BTEXN, PAH, heavy metals	The fill that was identified within TP259, TP110, TP215 and TP107 are associated with infrastructure including built up areas associated with traffic barriers and alterations to waterways.
3 (Surface)	ACM	On the western side of Mamre Road, a disused moulded asbestos service pit had been located within the norther portion of the alignment. No further service pits of this kind were located during the investigation. However, the presence of other asbestos service pits cannot be discounted as this implies the possibility of others in the area.
4 (Surface)	ACM	The samples identified at the surface suggests that some locations have been subject to illegal dumping of ACM materials.
5 (TP241, TP240, TP239 and TP238)	Heavy metals in fill	Soil impacted by heavy metals are generally restricted to the area immediately north of Luddenham Road, Orchard Hills. Similarly, to the ACM impacted areas associated with infrastructure, as the area appears to have been built up near a creek to support Mamre Road.

5.7 Water Use

There are 12 registered boreholes within a one-kilometre radius of the proposal area listed on the NSW Water Register as described in **Table 5-10**. Based on the records provided, all of the boreholes are used for groundwater monitoring rather than water supply.

A search of the NSW Water Register returned one water access licence within the immediate vicinity and one a kilometre downstream of the proposal (Water NSW, 2020).

6 Proposal description

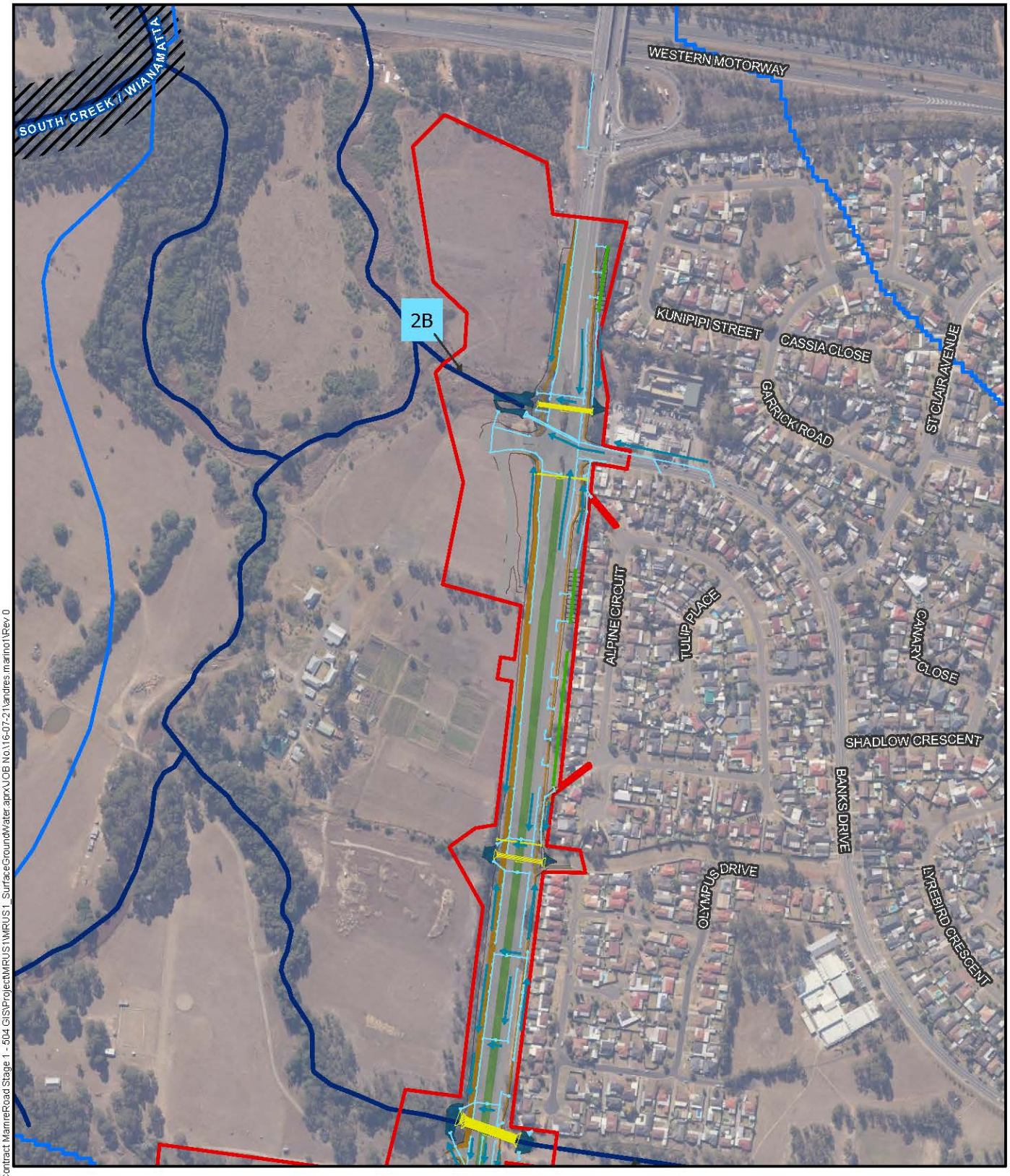
A conceptual stormwater drainage design has been developed for the proposal, which would include the following road drainage infrastructure:

- longitudinal drains, which would run along length of the road and are designed to remove water from the road surface as quickly as possible. This would include a system of pits and pipes within the median and kerb of the road.
- transverse drains, which transfer water under the road and are generally installed along natural low points on a road to allow natural stormwater runoff from the surrounding land to drain across a road to minimise disturbance to the existing flow patterns. This would include:
  - replacement of thirteen existing culvert structures with new upgraded culvert / bridge culvert structures to achieve improved flood immunity
  - longitudinal drainage pipes
- water quality management and stormwater treatment measures that could include:
  - water quality basins
  - grass swales
  - replacement of the existing gross pollutant trap near the Banks Drive intersection
  - scour protection at transverse culverts, longitudinal pipes and channels to prevent erosion and scour from the flow of water

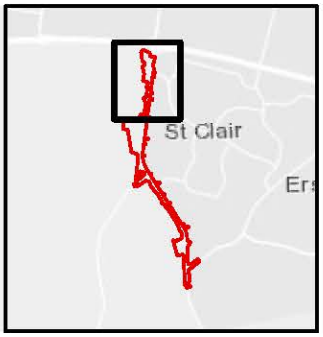
The road drainage infrastructure and road alignment would be designed to achieve flood immunity for a one per cent AEP flood event along the section of Mamre Road.

A schematic representation of the key features of the conceptual stormwater drainage design is shown in **Figure 6-1**.

A concept temporary basin assessment was undertaken to identify catchments which trigger the need for a temporary sediment basin in accordance with the 'Blue Book' (Landcom, 2004). Three basins were proposed at catchment SB11, SB12 (adjacent to Rotorua Road) and SB17 (adjacent to McIntyre Avenue), refer **Figure 6-1**.



Longitudinal drainage
Drainage direction
Grassed Swales
Indicative transverse drainage locations
Watercourse
Un-named tributaries
Key fish habitat
Channel work
Median
Road
Verge
REF proposal area
South Creek tributary catchment
Local government area



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Source: Aurecon, Spatial Services, Nearmap, Esri

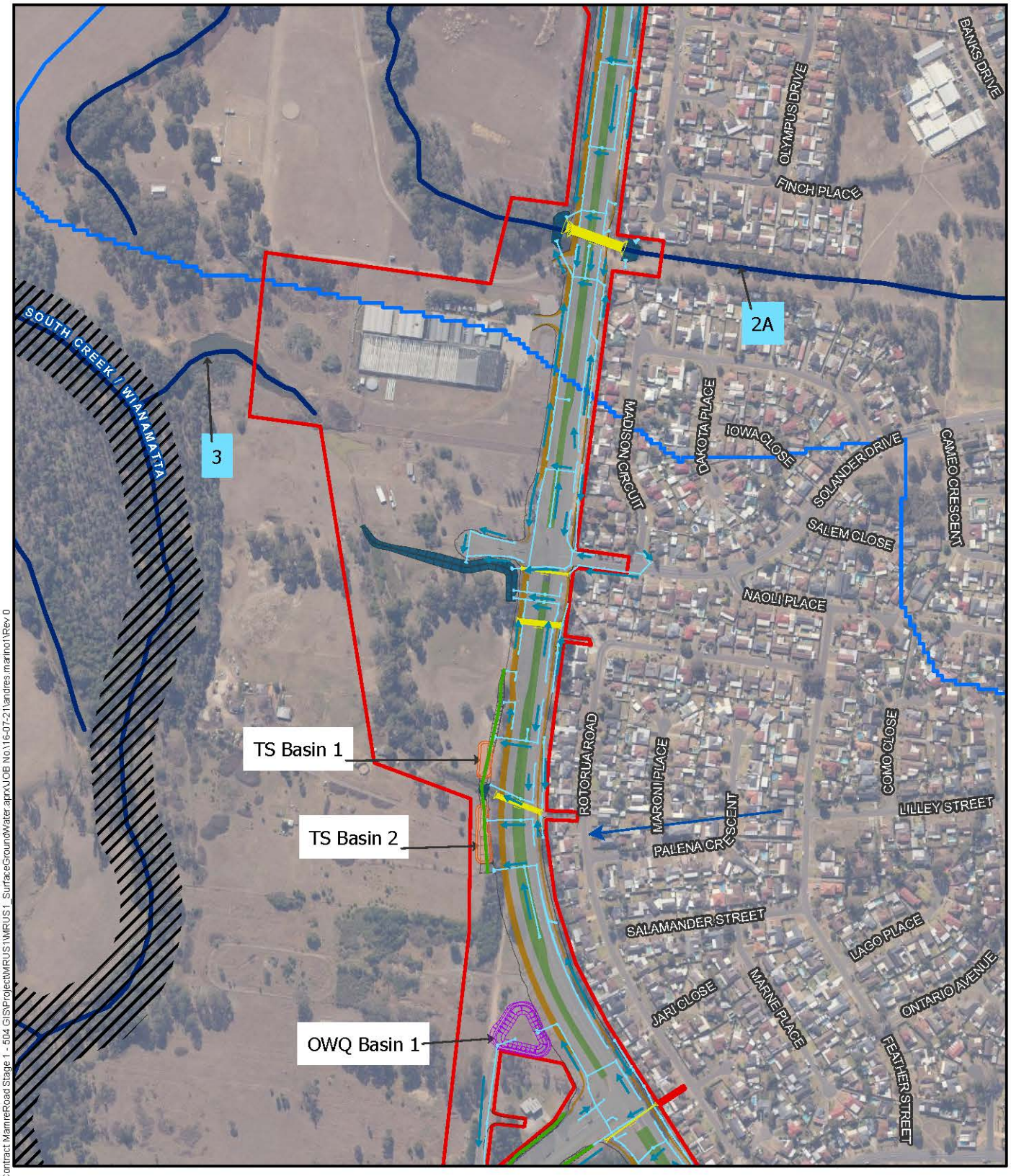
0 500 1,000m

Date: 16/07/2021 Version: 1

Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1 **REF**

FIGURE 6-1a: Drainage Works



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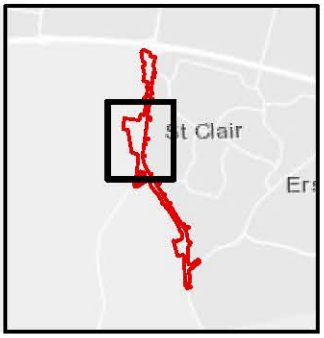
- Local drainage
- Longitudinal drainage
- Drainage direction
- Grassed Swales
- Indicative transverse drainage locations
- Operational water quality basin
- Temporary sediment basin
- Indicative extent of channel works
- Watercourse
- Un-named tributaries
- Key fish habitat
- Channel work
- Median
- Road
- Verge
- REF proposal area
- South Creek tributary catchment
- Local government area



Source: Aurecon, Spatial Services, Nearmap, Esri

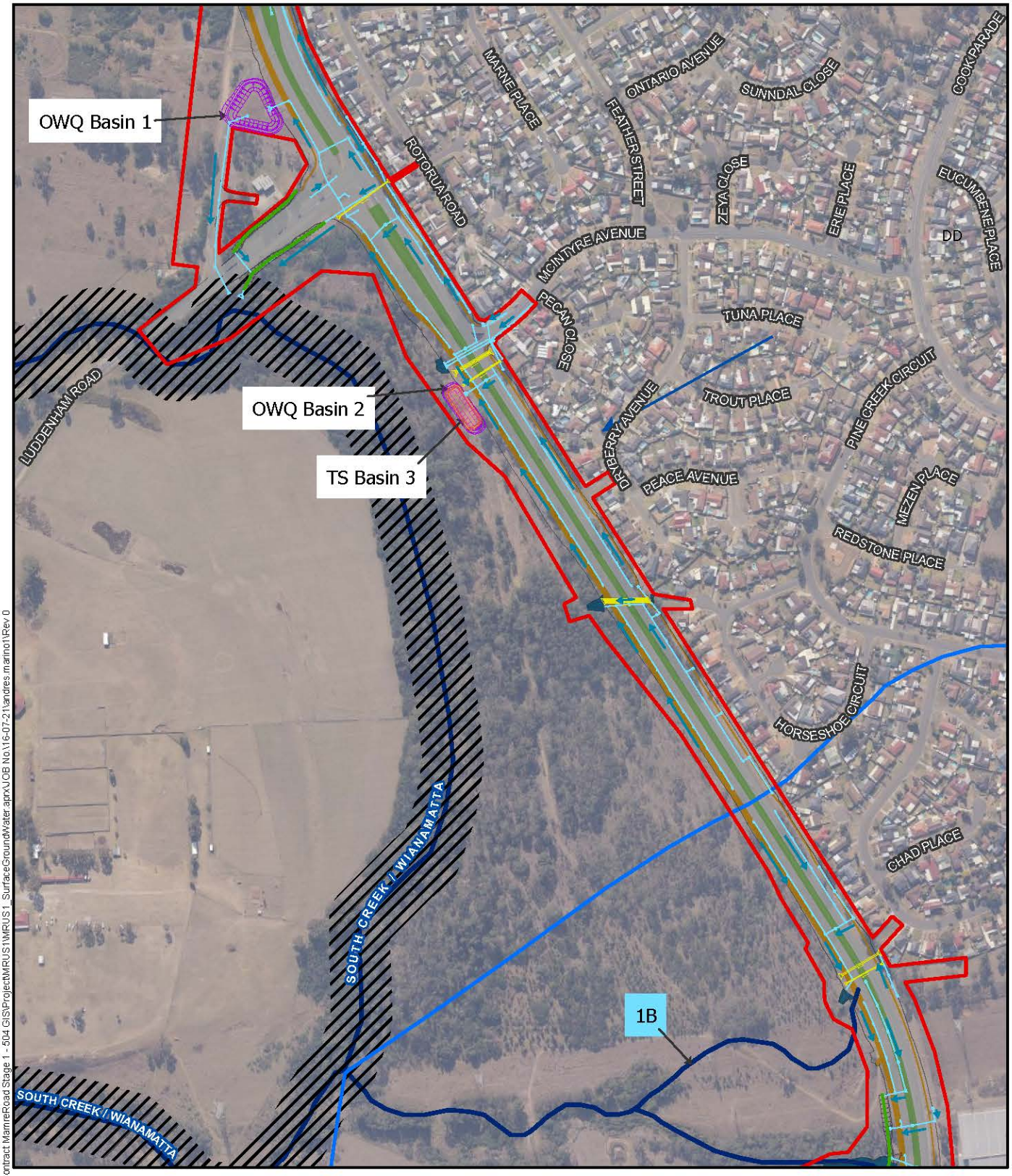
0 500 1,000m

Date: 16/07/2021 Version: 1

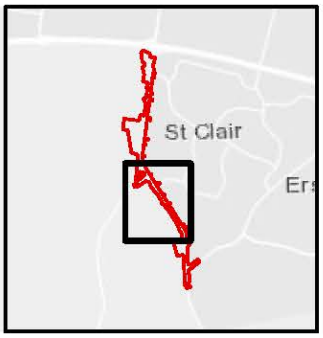
Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1 **REF**

FIGURE 6-1b: Drainage Works



- Local drainage
- Longitudinal drainage
- Drainage direction
- Grassed Swales
- Indicative transverse drainage locations
- Operational water quality basin
- Temporary sediment basin
- Watercourse
- Un-named tributaries
- Key fish habitat
- Channel work
- Median
- Road
- Verge
- REF proposal area
- South Creek tributary catchment
- Local government area



Source: Aurecon, Spatial Services, Nearmap, Esri

0 500 1,000m

Date: 16/07/2021 Version: 1

Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1 **REF**

FIGURE 6-1c: Drainage Works

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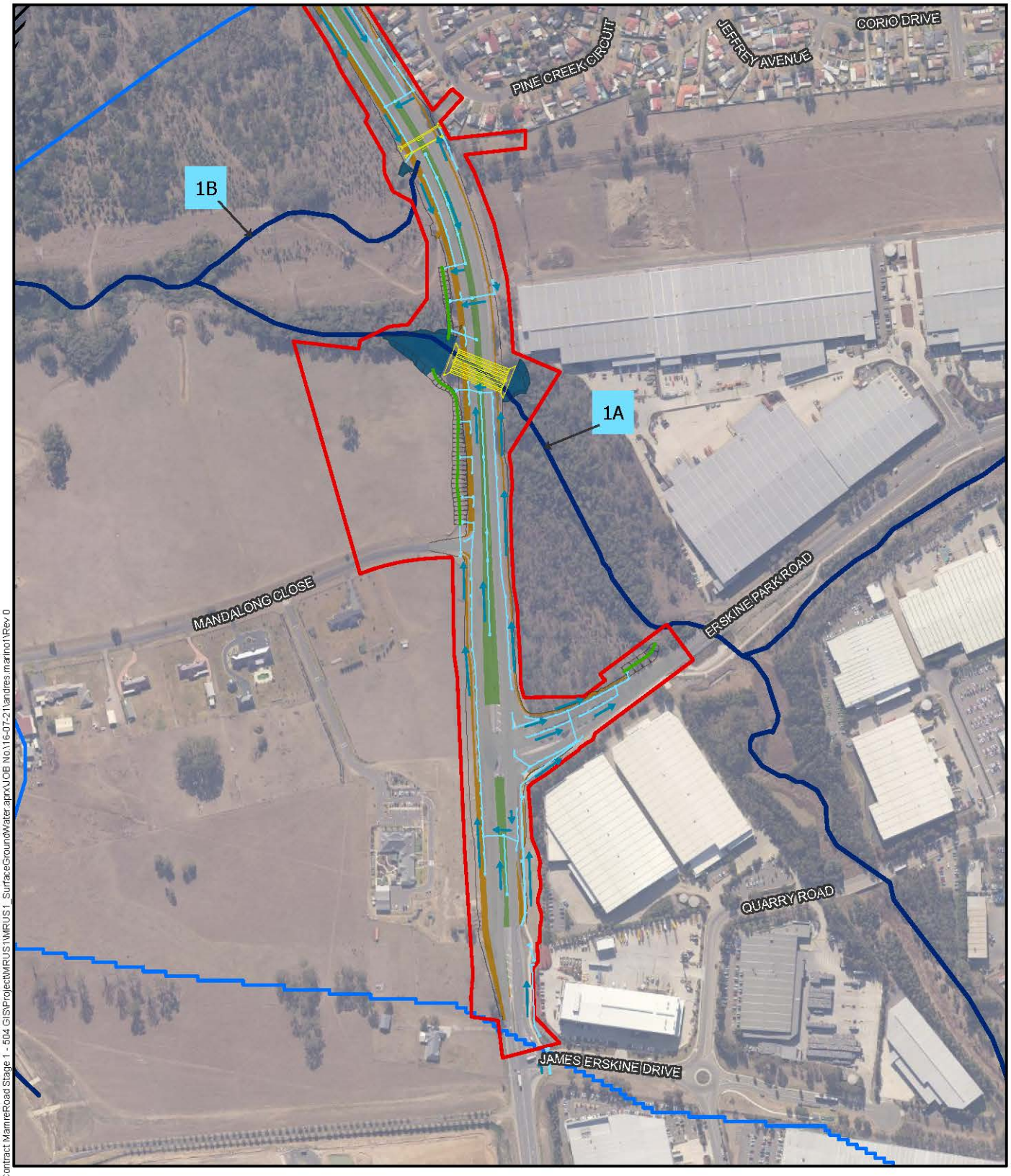

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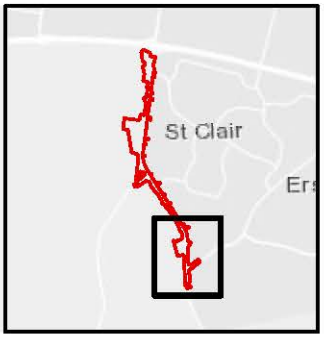
- Longitudinal drainage
- Drainage direction
- Grassed Swales
- Indicative transverse drainage locations
- Indicative extent of channel works
- Watercourse
- Un-named tributaries
- Channel work
- Median
- Road
- Verge
- REF proposal area
- South Creek tributary catchment
- Local government area



Source: Aurecon, Spatial Services, Nearmap, Esri

0 500 1,000m

Date: 16/07/2021 Version: 1

Projection: GDA2020 MGA Zone 56

Mamre Road Upgrade Stage 1 **REF**

FIGURE 6-1d: Drainage Works

7 Impact assessment

An impact assessment for the construction and the operational phases of this proposal are outlined in **Section 7.1** and **7.2**, respectively.

The residual impact has been assessed in Table 7-1 and Table 7-4 for construction and operational impacts respectively. The residual impact are based on the following scale:

- **Negligible**: Potential adverse impact could result in a minimal/not noticeable decline in the resource in the study area.
- **Minor:** Potential adverse impact could result in a decline in the resource/quality of a resource in the study area. Impact can often be managed through standard safeguards.
- **Major:** Potential adverse impact could result in a decline in the resource/quality of a resource to lower-than-baseline/worse-than-baseline. Impacts would require specific management as impact could have large community/environmental issues.
- **Significant:** Potential adverse impact could result in significant decline in the resource/quality of a resource to significantly lower-than-baseline/worse-than-baseline condition. Impacts would require specific management as impact would have significant community/environmental issues.

7.1 Construction impacts

If not managed correctly, the following construction activities could potentially lead to adverse impacts to the surface water and groundwater environment:

- Construction across waterways including two tributaries of South Creek and a number of minor drainage line crossings
- Vegetation removal and earthworks along the entire extend of the proposal area
- Leaks and spills within construction areas within the proposal areas
- Construction and operation of ancillary facilities including a concrete batching plant
- Stockpiles
- Transportation of materials

The potential impacts of the construction activities are assessed in **Table 7-1**. Further assessment is provided in **Section 7.1.1** and **7.1.2**. Management and mitigation measures are provided in **Section 8**.

7.1.1 Surface Water

Vegetation removal and earthworks

Removal of vegetation, stripping of topsoil and earthworks along the entire length of the proposal could potentially lead to erosion of soils and mobilisation of sediment to nearby surface waters which may lead to turbidity impacts in South Creek or the unnamed tributaries.

Works within proximity to Luddenham Road where South Creek flows immediately adjacent to the proposal area and works within proximity to the two unnamed tributaries (refer **Figure 5-4**) present the greatest risk of water quality impacts occurring.

Erosion and sediment control measures to manage potential impacts would be included in the Soil and Water Management Plan, refer to **Section 8.2**. A Concept Temporary Basin assessment was undertaken (Aurecon, 2021) to identify which catchments trigger the need for a temporary sediment basin during construction to allow sediment in runoff to settle out prior to release. The locations identified included catchments SB11, SB12 and SB17, refer **Figure 6-1**.

Earthworks within potentially contaminated areas could potentially expose contaminants in soil which may be mobilised as part of dewatering activities or via runoff to local waterways if poorly managed. Elevated levels of heavy metals in soil are attributed to background levels, therefore there is considered to be minimal risk to the local environment which would be adapted to these metal concentrations as they are ubiquitous in the Sydney Basin. Overall, the PSI and DSI concluded that potential risks to the environment as a result of soil contamination are low to moderate and can be managed during future construction works with standard practices and strategies.

Soil contamination management measures would be included in the Remediation Action Plan (RAP), refer to **Section 8.2**.

Construction within waterways and waterfront land

The road alignment crosses two unnamed tributaries, a number of local drainage lines and intersects South Creek near the intersection of Luddenham Road and Mamre Road. Thirteen transverse drainage structure upgrades are proposed, which would require removal of redundant culverts, construction of new culverts and associated scour protection and channel work (tail-in and tail-out works). The transverse drainage structures are shown in **Figure 6-1**.

The channel work generally occurs close to the transverse drainage structures. More extensive tail out works are proposed to the south of Solander Drive and upstream and downstream of the transverse drainage structure at unnamed tributary 1A, refer **Figure 6-1.** The works to the south of Solander Drive impact a drainage line which becomes un-named tributary 3.

The proposed channel work would permanently alter the bed and bank of watercourses within the proposal area. There is potential for erosion to occur during construction leading to sedimentation and water quality impacts in the watercourse until the work area is suitably stabilised.

Outlets would be provided at the end of the longitudinal drainage lines including two new outlet headwalls to South Creek. Outlet construction would permanently alter the channel form at the outlet location and increase erosion risk during construction prior to the work area being stabilised. Impacts are likely to be minor and localised.

Work within watercourses, including channel work and construction of transverse drainage structures, could obstruct and change flow paths increasing the potential for localised scour and erosion, particularly within proximity to the new culverts. Temporary obstruction and interference with normal drainage channels may cause subsequent ponding or damming of water upstream in the unnamed tributaries and local drainage lines. Temporary waterway crossings may be established during construction for construction access. These are likely to include temporary pipes (plastic or HDPE) with gravel or similar track over the top to maintain water flow through the structure. Potential impacts associated with establishment of temporary waterway crossings would be minimised by designing the structure to include appropriate pipe outlets, scour protection and flood immunity.

Refer to **Section 8.2** for control measures to manage impacts associated with waterway crossings, channel works and outlet works.

Any work within the waterfront land of South Creek and the unnamed tributaries increases the risk of sediment and other construction materials being mobilised into the waterways, if uncontrolled. This could potentially lead to water quality impacts within the unnamed tributaries and South Creek. Erosion and sediment control measures to manage potential impacts would be included in the Soil and Water Management Plan, refer to **Section 8.2.**

Construction and use of ancillary facilities

The possible location of the ancillary facilities/compound sites are depicted on **Figure 1-1.** All three possible locations are located approximately 300 metres, 330 metres and 475 metres upstream of South Creek and an unnamed tributary. It is expected that these areas would contain stockpile and laydown areas, temporary access tracks and concrete batching plants.

The proposed ancillary facilities are located in the South Creek floodplain which increases the risk of stockpiled soils and pollutants associated with concrete mixing operations being mobilised into waterways.

Potential impacts associated with stockpiles are discussed below. Concrete batching operations can lead to soil and water pollution (increase in pH, TSS, TDS and minor levels of Aluminium, Iron and Magnesium oxides) as a result of cement laden runoff not being properly contained or being accidentally released to surface waters. Poor cement handling, storage and disposal practices can also contribute to the aforementioned impacts.

Measures for cement handling, storage and disposal procedures will be documented within the CEMP. Measures to manage the potential water quality impacts associated with runoff and washwater associated with concrete batching would be included in the Soil and Water Management Plan, refer to **Section 8.2.**

Stockpiles

Stockpile sites would be used to temporarily store raw materials, excess spoil and wastes before their use or reuse on-site or disposal off-site. Stockpiles of raw materials or spoil would be sited within a suitable location to avoid obstruction of local flow paths and mobilisation of materials offsite. Sediment management measures would be used on the stockpile sites to minimise the potential for sediment laden runoff to be discharged offsite and lead to sedimentation impacts to receiving waters.

All three proposed compounds sites are at least partially within the one per cent AEP floodplain. Any stockpiles located within the floodplain would reduce floodplain storage and obstruct flows which could potentially lead to flood impacts. Loose material stored within the floodplain also has the potential to be mobilised during a flood which may impact receiving water quality.

Stockpile sites would be confirmed during detailed design and managed in accordance with *Environmental Procedure Management of Wastes on Roads and Maritime Services Land* (RMS, 2014) and *Stockpile Site Management Guideline* (RMS, 2015). Further consideration of how to manage stockpiles with respect to floodwaters would be undertaken during detailed design.

Dewatering

Dewatering of excavations and the three temporary sediment basins (refer **Figure 6-1**), if managed poorly, may result in sediments being mobilised to waterways. This may potentially increase the turbidity of the receiving waters and other water quality impacts through sediment bound nutrients and heavy metals.

Discharges from sediment basins would be regulated by an Environmental Protection Licence (EPL) under the POEO Act. An assessment of the impact of discharges from each sediment basin would be undertaken during detailed design in accordance with the *Draft Guideline for Assessing the Impacts of Treated Water Discharge from Water Quality Treatment Controls* (TfNSW, 2020). This assessment would inform the EPL application and take into consideration the water quality objectives listed in Table 4-4 and the flow characteristics of the receiving drainage lines that each sediment basin would discharge to as well as South Creek. The proposed sediment basin locations are expected to discharge to intermittently flowing drainage lines, which drain to South Creek. South Creek is expected to be flowing for the vast majority of the time. The flow characteristics of each receiving waterway would be validated during detailed design by an appropriate catchment analysis. Measures to control the quality of water being released from the temporary sediment basins will be included in Soil and Water Management Plan, refer to **Section 8.2.**

The potential for the proposal to intercept groundwater is discussed in **Section 7.1.2**. It is expected that groundwater inflow to excavations would be minor. Where groundwater is intercepted, the quality of the groundwater must be considered during groundwater dewatering, management and release. Measures to manage dewatering of excavations would be included within the Soil and Water Management Plan, refer **Section 8.2**.

Leaks and spills

Potentially harmful chemicals and substances could accidentally be released to the surface water environment during construction spills or as result of maintenance works, refuelling and inappropriate storage or handling. Leakage from construction worker facilities or wastewater collection points with subsequent runoff into receiving watercourses. This could potentially lead to contamination of exposed soils or mobilisation of contaminated soils and liquids into local watercourses which could result in water quality impacts.

Measures to minimise the potential impacts associated with accidental leaks and spills during construction would be incorporated into a site specific emergency spill plan, refer to **Table 8-1**.

Transportation of materials

Spillage of waste or construction materials during transportation could potentially lead to pollutants being conveyed in surface run-off to nearby drainage pathways and downstream waterways. Measures to manage materials during transport would be included within the Construction Environmental Management Plan, refer to **Section 8.2.**

7.1.2 Groundwater

Earthworks, construction of ancillary facilities and dewatering

Groundwater has been intercepted at between 0.7 and 4.9 m BGL within the proposal area.

Earthworks associated with road construction are generally likely to be shallow and include shaping of the upper soil profile so groundwater is unlikely to be intercepted during most construction activities. The temporary ancillary facilities are unlikely to require any significant earthworks.

Slightly deeper excavations may be required for utility and service trenches, construction of drainage infrastructure and piling for construction of the noise walls. There is potential for some minor volumes of groundwater to enter trenches and drainage works excavations. However, these excavations would be temporary and localised and given the low permeability of the local clay soils, inflow volumes are likely to be low. Similarly piling works are only likely to require minor volumes of groundwater to be extracted. Where groundwater is intercepted, the quality of the groundwater must be considered during groundwater dewatering, management and release. Measures to manage groundwater in excavations would be included within the Soil and Water Management Plan, refer **Section 8.2.**

As significant dewatering or groundwater extraction is unlikely to be required groundwater flows and quality are unlikely to be significantly impacted by the proposed earthworks. Therefore, impacts to terrestrial and aquatic groundwater dependant ecosystems within proximity to the proposal (refer to **Figure 5-9**) as a result of changes in groundwater level are likely to be minor. Direct impacts associated with removal of terrestrial vegetation located within the proposal corridor which are identified as a groundwater dependant ecosystems are addressed in the Biodiversity Development Assessment Report.

7.1.3 Summary of construction impacts

A summary of the potential impacts to the environment and the assessed residual impact with the proposed management measures in place is provided in Table 7-1.

Table 7-1 Construction impact assessment summary

Activity	Potential Impact	Potential effect in receiving environment	Management measures	Assessed residual impact
Clearance of vegetation, earthworks	Increased runoff volume, frequency and rate of discharges to waterways due to modified (shortened) flow paths and reduced infiltration and evapotranspiration	Erosion, scour and degradation of ecological habitat in South Creek and its tributaries (the receiving waterways)	Erosion and sediment control measures to manage potential impacts would be included in the Soil and Water Management Plan, refer to **Section 8.2.**	Negligible
	Discharge of sediment-laden runoff from cleared areas to receiving waterways	Sedimentation, water quality impacts and habitat degradation within the receiving waterways		Negligible
	Earthworks into groundwater table leading to groundwater intrusion in excavations. This could lead to leaching of pollutants to groundwater and localised interference to groundwater flow.	Localised disruption of groundwater flow and groundwater quality impacts which could potentially impact groundwater dependant ecosystems		Negligible
Dewatering of excavations and sediment basins and discharge of runoff	Release of sediment and contaminant laden waters to waterways	Sedimentation, water quality impacts and habitat degradation within the receiving waterways	An assessment of the impact of discharges from each sediment basin would be undertaken during detailed design in accordance with the *Draft Guideline for Assessing the Impacts of Treated Water Discharge from Water Quality Treatment Controls* (TfNSW 2020), refer **Section 8.2.**. Erosion and sediment control measures and dewatering management measures would be included in the Soil and Water Management Plan**,** refer to **Section 8.2.**	Negligible

Activity	Potential Impact	Potential effect in receiving environment	Management measures	Assessed residual impact
Disturbance of contaminated land	Contaminant laden runoff discharging to the receiving waterways.	Water quality impacts and habitat degradation within the receiving waterways	Measures to manage contamination will be included in the Remediation Action Plan (RAP) and Unexpected Finds Protocol (UFP), refer to **Section 8.2.**	Negligible
Construction across waterways and within waterfront land	Disturbance of the bed and banks of watercourses including South Creek and its tributaries	Alter the channel form and stability locally and lead to sedimentation, water quality impacts and habitat degradation in the receiving waterways.	Measures to manage construction activities across waterways will be included in the Soil and Water Management Plan**,** refer to **Section 8.2.**	Minor, temporary
	Interfere / divert existing flow paths.	Increased potential for localised scour and erosion which could lead to water quality impacts. Localised ponding.		Negligible
Channel work	Disturbance of the bed and banks of drainage lines and unnamed tributaries.	Permanent change in channel form and materials within works extent	Measures to manage construction activities within waterways will be included in the Soil and Water Management Plan**,** refer to **Section 8.2.**	Minor, permanent
		Increased potential for localised scour and erosion which could lead to water quality impacts.		Minor, temporary

Activity	Potential Impact	Potential effect in receiving environment	Management measures	Assessed residual impact
Outlet work	Disturbance of the bed and banks of drainage lines, unnamed tributaries and South Creek	Permanent change in channel form and materials within proximity to headwall	Measures to manage construction activities within waterways will be included in the Soil and Water Management Plan, refer to **Section 8.2.**	Minor, permanent
		Increased potential for localised scour and erosion which could lead to water quality impacts.		Minor, temporary
Construction of ancillary facilities	Cement laden runoff or concrete wash water entering soils and local waterways.	Water quality impacts in surface water and groundwater.	Measures to manage concrete wash water will be included within the Soil and Water Management Plan, refer to **Section 8.2**.	Negligible
Leaks and Spills	Potentially harmful chemicals and substances accidentally released during construction spills or as result of maintenance works, refuelling and inappropriate storage or handling. This could lead to soil contamination, leaching of contaminants to groundwater or conveyance of contaminants in runoff to waterways	Water quality impacts in groundwater and receiving waterways	Measures to minimise the potential impacts associated with accidental leaks and spills during construction will be incorporated into a Site Specific Emergency Spill Plan, refer to **Section 8.2**.	Negligible
	Leakage from construction worker ablation and toilet facilities or wastewater collection points with subsequent runoff into receiving watercourses.	Nutrient and microbiological water impacts in groundwater and receiving waterways		Negligible

Activity	Potential Impact	Potential effect in receiving environment	Management measures	Assessed residual impact
Stockpiles	Loose material stored within the floodplain and overland flow paths mobilised to drainage lines during rainfall.	Sedimentation, water quality impacts and habitat degradation within receiving waterways.	Stockpiles site locations would be confirmed during detailed designed within the ancillary facilities and managed in accordance with *Environmental Procedure Management of Wastes on Roads and Maritime Services Land* (RMS, 2014) and the *Stockpile Site Management Guideline* (RMS, 2015). Refer to **Section 8.2**. Further consideration of how to manage stockpiles with respect to floodwaters would be undertaken during detailed design.	Negligible
	Stockpiles located within the floodplain would reduce floodplain storage and obstruct flows.	Disruption of overland flow and localised flood impacts.		Negligible
Transportation of materials	Waste materials such as concrete, plasterboard, timber, asbestos and contaminated soil spreading via surface run-off to near site drainage pathways	Sedimentation, water quality impacts and habitat degradation within receiving waterways.	Measures to manage materials during transport will be included within the Construction Environmental Management Plan, refer to **Section 8.2.**	Negligible

7.2 Operational impacts

Potential impacts and risks to the receiving water environment during the operational phase are discussed in **Sections 7.2.1** and **7.2.2** for surface water and groundwater respectively.

A summary of the potential impacts and the assessed residual impact with the proposed management measures in place is provided in **Table 7-4**. Environmental safeguards to manage the potential impacts are described in **Section 8.2**.

7.2.1 Surface water

Stormwater runoff

The proposal has the potential to increase the pollutant load being released from the study area as a result of the proposed increase in pavement footprint.

The key pollutants contained in road runoff include:

- suspended solids as a result of pavement wear, tyre wear, atmospheric deposition and deposition from vehicles
- heavy metals bound to dust particles washed off pavement surface
- oil and grease and other hydrocarbons deposited by vehicles
- nutrients as a result of atmospheric deposition

The increase in pollutant load could potentially result in water quality impacts such as sedimentation, reduced water clarity, increased toxicant and nutrient concentrations and lower dissolved oxygen levels within the local tributaries and South Creek. Increases in flows (frequency and volume) due to an increase in impervious area may also impact waterway health.

The road alignment (around 26 ha) only makes up a small proportion of the urbanised local catchment traversing the study area (around 1,268 ha), refer to **Figure 5-4**. Therefore, the proposed increase in impervious area (around 11 ha) as a result of the increase in road pavement compared to the estimated effective impervious area (around 487 ha) within the local catchment is relatively insignificant (around a two per cent increase).

The operational stormwater treatment strategy is described in Section 6. Water sensitive measures such as swales and water quality basins are proposed to slow and filter runoff and allow evapotranspiration prior to discharge to reduce the potential impact to South Creek within higher risk catchments.

An existing gross pollutant trap near the Banks Drive intersection, impacted by the proposal area would also be replaced. This like for like replacement would not impact stormwater quality.

Each road catchment was assessed with consideration to the proximity of outlets to sensitive environments (e.g. South Creek), catchment size and road features. Where feasible, water quality basins with spill containment have been located at areas considered to be of higher risk and swales are proposed to treat other areas where feasible. The available space within the proposal area for water treatment was highly constrained. This was due to hydraulic constraints, the presence of other existing or proposed infrastructure (e.g. utility corridor), environmental controls (noise wall) and the presence of a an established Biobank and vegetation conservation areas. As a result, around 47 per cent of the proposed road catchment runoff was unable to be treated due to one or a combination of these constraints.

A MUSIC model was developed to estimate the change in pollutant load and annual runoff volume as a result of the proposal. This MUSIC model considered the proposed stormwater treatment strategy as well as existing local catchment runoff and pollutant loading. The extent of the local catchment assessment is shown in Figure 5-4. The results are provided in Table 7-2 and Table 7-3. Further details of the modelling assumptions and approach are provided in **Appendix A**.

The modelling shows that the stormwater quality treatment targets for the proposal (as per Penrith City Councils mean annual pollutant load reduction targets) are unable to be achieved by the proposed operational

stormwater treatment strategy due to the constraints described above. However, the MUSIC modelling results indicate that pollutant load increases to South Creek and the unnamed tributaries are likely to be minor (less than three per cent) in comparison to the pollutant load generated from the local urbanised catchment within the study area. The actual impact to South Creek would be further diminished by its much larger upstream catchment (refer Figure 5-3) which has not been modelled as part of this assessment. The additional un-modelled flow and pollutant load from South Creek's upstream catchment would reduce the relative impact as a result of the proposal.

Water quality monitoring within South Creek at Luddenham Road (refer **Table 5-7**) shows that the water quality objectives for TP and TN are currently not being met for the majority of the time and turbidity exceeds the water quality objective at times.

The minor increase in TSS, TP and TN loads within the study area as a result of the proposal is likely to have a negligible impact on the overall TSS, TP and TN concentrations within South Creek. The proposal would have a similar impact in terms of heavy metals, such that impacts to the water quality of South Creek from operation of the proposal are also likely to be negligible. Therefore the operation of the proposal is not expected to worsen water quality within South Creek to a noticeable extent such that future efforts within the wider catchment to maintain or improve water quality to achieve the water quality objectives in South Creek are not compromised.

Similarly, changes in flow volume in South Creek and the unnamed tributaries as a result of the increased road footprint are minor (less than 0.5 per cent) therefore impacts on flow frequency are also likely to be minor. This is due to the increase in impervious area from the proposal being minor in the context of the wider local catchment. As described above, the impact to South Creek is further diminished by its much larger upstream catchment, refer Figure 5-3. Therefore, the proposal is also likely to have a negligible impact on future efforts within the wider catchment to achieve the draft flow objectives for South Creek (refer Table 4-2).

Table 7-2 Road alignment treatment performance

	Source	Residual	Mean Annual Load Reduction (%)	Penrith Council Target (%)	Target Achieved
Flow (ML/year)	104	104	0%	-	-
TSS (kg/year)	36,600	19,600	46%	85%	No
TP (kg/year)	62	39	38%	65%	No
TN (kg/year)	251	215	14%	45%	No
Gross pollutants (kg/year)	3,030	1,430	53%	90%	No

Table 7-3 Local catchment runoff volume and pollutant load impact assessment

	Pre-Development	Post-Development	Impact (%)
Flow (ML/year)	3,606	3,644	1.1%
TSS (kg/year)	621,100	633,600	2.0%
TP (kg/year)	1,016	1,039	2.3%
TN (kg/year)	7,537	7,635	1.3%
Gross pollutants (kg/year)	101,536	102,430	0.9%

Flooding

During the South Creek main-stream flood event, flood impacts were observed to occur as a result of lifting Mamre Road and Luddenham Road to provide higher flood immunity. The proposal would result in reduced

floodplain storage and cause a redistribution of flow at the eastern edge of the floodplain. During the local catchment flood event, higher overtopping levels of the proposed road would cause floodwater to pond higher upstream. Upgrades to transverse drainage structures generates downstream flood impacts due to their increased flow capacity, except when drowned out by high tailwater levels. Changes in flow paths and flow velocities could potentially cause localised scour or erosion.

Flood velocity mapping was undertaken to identify whether the proposal would increase scour potential outside the proposal area. The velocity mapping indicated that scour risk is not increased as a result of the proposal. Localised flow velocity increases were observed within the proposal area in the vicinity of the culvert outlets. This would be managed through installation of scour protection.

Flood impacts are described in detail in the Hydrology and Hydraulics Assessment.

New outlets

New drainage outlets to South Creek, local drainage lines and tributaries of South Creek are proposed. This may result in concentrated flow causing scour and erosion within the waterways within proximity to the outlet during operation. New outlets will be designed with appropriate scour and dissipation measures, refer **Section 8.2**, to control the potential impacts such that impacts are likely to be negligible.

Accidental Spills

Accidental spills of oils or other chemicals being transported or as a result of maintenance activities could potentially lead to contaminants being released into local tributaries and drainage lines. This could lead to water quality impacts within the tributaries or in South Creek downstream.

Measures to minimise the potential impacts associated with accidental leaks and spills during operation will be incorporated into a site specific emergency spill plan, refer to **Section 8.2**

Spill containment is proposed to be incorporated into the water quality basins within catchments which are considered to have a higher risk of spills occurring during operation. Further refinement of the spill containment facilities would be undertaken during detailed design.

7.2.2 Groundwater

Accidental spills of oils or other chemicals being transported or as a result of maintenance activities could potentially lead to contaminants leaching into exposed soils and groundwater.

Measures to minimise the potential impacts associated with accidental leaks and spills during operation will be incorporated into a site specific emergency spill plan, refer to **Section 8.2.**

With the proposed management measures in place impacts to groundwater are likely to be negligible.

7.2.3 Summary

A summary of the potential operational impacts and the assessed residual impact with the proposed management measures in place is provided in Table 7-4.

Table 7-4 Operational impact assessment summary

Hazard	Potential Impact	Potential effect in receiving environment	Management measures	Residual Impact
Stormwater runoff from road	Increased pollutant loading to the receiving waterways due to the increased road footprint.	Worsening of water quality within South Creek and its tributaries Degradation of ecological habitat in South Creek and its tributaries.	Design of stormwater drainage infrastructure and treatment options.	Minor, permanent
	Increase in the volume, frequency and rate of runoff to the receiving waterways due to increased road footprint	Increased erosion in South Creek and its tributaries Degradation of ecological habitat in South Creek and its tributaries		Minor, permanent
Discharge from new stormwater outlets	Concentrated flows at outlet locations	Local scour and erosion at outlet location	Scour protection at stormwater outlets	Negligible
Flood impacts due to new road	Changes in flood conditions (flow paths, increased inundation and increased flood velocities) resulting in an increase in erosion in waterways or within the floodplain	Modelling indicates no increased scour is likely to occur.	Confirmation of the flood risk during detailed design.	Negligible
Major spillage on roadway	Contaminants being washed into drainage lines, local tributaries and ultimately South Creek	Water quality impacts in South Creek and its tributaries Temporary degradation of ecological habitat in South Creek and its tributaries.	Spill containment facilities at high risk areas and accidental spill response measures, refer Section 8.2	Minor, temporary
	Contaminants leaching into soils and therefore leaching of contaminants to groundwater.	Worsening water quality in groundwater	Accidental spill response measures, refer Section 8.2	Negligible
Minor leaks and spills on roadway or operational activities	Contaminants being washed into drainage lines, local tributaries and ultimately South Creek	Water quality impacts in South Creek and its tributaries Degradation of ecological habitat in South Creek and its tributaries.	Spill containment facilities at higher risk areas and accidental spill response measures, refer Section 8.2	Negligible
	Contaminants leaching into soils and therefore leaching of contaminants to groundwater.	Worsening groundwater quality	Accidental spill response measures, refer Section 8.2	Negligible

8 Management of impacts

8.1 Overview of approach

A Soil and Water Management Plan (SWMP) would be prepared and implemented as part of the CEMP. The SWMP will identify all reasonably foreseeable risks relating to soil erosion and water pollution during construction and describe how these risks will be managed.

The SWMP will include an Erosion and Sediment Control Plan (ESCP) to delineate the specific erosion and sediment controls to be implemented and a Water Quality Monitoring Plan (WQMP) to describe the monitoring to be conducted during construction to facilitate a response to a potential water quality impact event.

Aurecon recommends a Remediation Action Plan (RAP) be prepared to evaluate potential remedial options and recommend a preferred option to manage the ACM during the construction of the road upgrades. The RAP should include a Long-Term Environmental Management Plan (LTEMP) for long term management of the ACM material should it remain in the proposal area during operation. The RAP should also include a preliminary plan to manage potential risks to human health and the environment during the remediation activities. An Unexpected Finds Protocol (UFP) should also be included in the RAP to ensure any identified contamination such as asbestos containing materials in fill or illegal dumping is managed appropriately during earthworks and construction materials in fill or illegal dumping is managed appropriately during earthworks and construction. Eventually, the RAP would form a portion of the overall CEMP developed for the construction of the proposal.

A site specific emergency spill plan will be developed to manage spill events during construction and operation. The plan would include spill control measures and emergency response measures.

The design and construction of works within and around watercourses would be undertaken in accordance with relevant TfNSW guidelines and specifications and with consideration to Department of Primary Industries, Office of Water guidelines for controlled activities on waterfront land.

Where feasible, road runoff would be treated by water quality treatment measures including swales, operational water quality basins. Where feasible with consideration to the local constraints, operational water quality basins have been located at higher risk discharge locations (located within close proximity to the sensitive environment of South Creek) to provide enhanced treatment of stormwater runoff. Spill containment facilities would be included within operational water quality basins.

All stormwater outlet locations will include appropriate dissipation and/or scour protection measures to control scour and erosion within the receiving waterway.

The layout and detail of the drainage system including drainage, water quality basins, spill containment, swales, discharge points and outlet scour protection measures will be refined during detailed design in consultation with TfNSW.

8.2 Summary of safeguards and mitigation measures

The following table provides a summary of the mitigation measures or environmental safeguards currently identified to be required for the proposal to manage potential water quality and soil impacts.

Table 8-1 Environmental safeguards

Impact	Environmental safeguard	Responsibility	Timing
Soil and water	A Soil and Water Management Plan (SWMP) will be prepared and implemented as part of the CEMP. The SWMP will identify all reasonably foreseeable risks relating to soil erosion and water pollution and describe how these risks will be addressed during construction. The Soil and Water Management Plan (SWMP) will be reviewed by a soil conservationist on the TfNSW list of Registered Contractors for Erosion, Sedimentation and Soil Conservation Consultancy Services. The SWMP will then be revised to address the outcomes of the review.	Contractor Contractor	Detailed design / pre-construction Detailed design / pre-construction
Soil and water	A site specific Erosion and Sediment Control Plan/s will be prepared and implemented as part of the Soil and Water Management Plan. The Plan will include arrangements for managing 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.	Contractor	Detailed design / Pre-construction
Soil and water	Stockpiles site locations would be confirmed during detailed design and managed in accordance with *Environmental Procedure Management of Wastes on Roads and Maritime Services Land* (RMS, 2014) and the *Stockpile Site Management Guideline* (RMS, 2015). This would consider measures to manage cross contamination within a stockpile area.	Contractor	Detailed design / Pre-construction
Soil and water	Further consideration of how to manage stockpiles, material laydown and chemical storage with respect to floodwaters would be undertaken during detailed design.	Contractor	Detailed design / Pre-construction
Soil and water	A construction water quality monitoring plan will be prepared and implemented as part of the Soil and Water Management Plan. The plan will be prepared in accordance with the TfNSW Guideline for Construction Water Quality and EPA publication “Approved Methods for the Sampling and Analysis of Water Pollutants in NSW”. As a minimum water quality monitoring is to be conducted upstream of the proposal, downstream of road works within close proximity to South Creek (near Luddenham Road) and downstream of construction sediment basin discharge locations.	Contractor	Detailed design / Pre-construction

Impact	Environmental safeguard	Responsibility	Timing
Soil and water	The design and construction of watercourse crossings, works within a watercourse or works on waterfront land as defined by the *Water Management Act 2000* are to be undertaken with consideration to the *Guidelines for instream works on waterfront land*, Department of Primary Industries, Office of Water, July 2012, *Guidelines for watercourse crossings on waterfront land*, Department of Primary Industries, Office of Water, July 2012 and in accordance with relevant TfNSW specifications and guidelines.	TfNSW / Contractor	Detailed design / Pre-construction
Soil and water	An assessment of the impact of discharges from each temporary sediment basin would be undertaken during detailed design in accordance with the *Draft Guideline for Assessing the Impacts of Treated Water Discharge from Water Quality Treatment Controls* (TfNSW 2020). The assessment would adopt relevant water quality objectives for South Creek listed in Table 4-4 and a catchment analysis to confirm the flow characteristics of the receiving waterways is required.	TfNSW / Contractor	Detailed design / Pre-construction
Contaminated land	A Contaminated Land Management Plan will be prepared in accordance with the *Guideline for the Management of Contamination* (Transport for NSW, 2013) and implemented as part of the CEMP. The plan will include, but not be limited to: • capture and management of any surface runoff contaminated by exposure to the contaminated land • further investigations required to determine the extent, concentration and type of contamination, as identified in the detailed site investigation (Phase 2) • management of the remediation and subsequent validation of the contaminated land, including any certification required • measures to ensure the safety of site personnel and local communities during construction. A Remediation Action Plan and an Unexpected Find Protocol will also be prepared and implemented. The Remediation Action Plan (RAP) will be prepared to evaluate potential remedial options and recommend a preferred option to manage the ACM during the construction of the road upgrades. The RAP should include a Long-Term Environmental Management Plan (LTEMP) for long term management of the ACM material should it remain in the project alignment. The RAP should also include a preliminary plan to manage potential risks to human health and the environment during the remediation activities. An Unexpected Finds Protocol (UFP) should also be included in the RAP to ensure any identified contamination such as asbestos containing materials in fill or illegal dumping is managed appropriately during earthworks and construction materials in fill or illegal dumping is managed appropriately during earthworks and construction.	Contractor	Detailed design / Pre-construction / Construction

Impact	Environmental safeguard	Responsibility	Timing
Contaminated land	If contaminated areas are encountered during construction, appropriate control measures will be implemented to manage the immediate risks of contamination. All other works that may impact on the contaminated area will cease until the nature and extent of the contamination has been confirmed and any necessary site-specific controls or further actions identified in consultation with the TfNSW Environment Manager and/or EPA.	Contractor	Detailed design / Pre-construction
Accidental spill	A site specific emergency spill plan will be developed, and include spill management measures in accordance with the TfNSW *Code of Practice for Water Management* (RTA, 1999) and relevant EPA guidelines. The plan will address measures to be implemented in the event of a spill, including initial response and containment, notification of emergency services and relevant authorities (including TfNSW and EPA officers).	Contractor	Detailed design / Pre-construction
Accidental spill	Spill containment to be provided within operational water quality basins.	TfNSW	Detailed design
Stormwater	The layout and detail of the drainage system including drainage, water quality basins, spill containment, swales, discharge points and outlet scour protection measures will be refined during detailed design in consultation with TfNSW.	TfNSW	Detailed design
Stormwater	Stormwater outlets to local drainage lines and waterways are to be designed with consideration to the Guidelines for outlet structures on waterfront land, Department of Primary Industries, Office of Water, July 2012 and relevant TfNSW specifications and guidelines.	TfNSW	Detailed design

9 Conclusion

The key potential impacts of the proposal on surface water, groundwater and soils are as follows:

- Surface water quality impacts due to sediment laden runoff being released to waterways during construction activities such as earthworks, stockpiling, dewatering, waterway crossing construction and transportation of materials
- Surface water quality, groundwater quality and soil impacts during construction as a result of an accidental spill
- Direct disturbance of channel form and stability during construction of permanent and temporary waterway crossings
- Increased runoff volume, frequency, flow rate and pollutant load being discharged to receiving waterways including South Creek as a result of an increased pavement footprint. This may have a minor impact on water quality, waterway stability and aquatic habitat in the receiving waterways.
- Increased scour at newly proposed stormwater outlet locations

The key measures proposed to avoid, manage and/or mitigate impacts to surface water, groundwater and soils include:

- Preparation of a Soil and Water Management Plan as part of the Construction Environmental Management Plan to manage water quality impacts during construction of the proposal
- Assessment of the proposed temporary sediment basins in accordance with the *Draft Guideline for Assessing the Impacts of Treated Water Discharge from Water Quality Treatment Controls (TfNSW, 2020)*
- Incorporating swales and water quality basins with spill containment for water quality treatment during the design of the proposal to minimise operational water quality impacts.
- Preparation of a Remediation Action Plan and Unexpected Finds Protocol to manage the potential for soil or water quality contamination during construction of the proposal.
- Scour protection at new stormwater outlets

With the proposed control measures in place, soil and water impacts are expected to be negligible to minor.

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Appendix A – MUSIC Modelling inputs and assumptions

A.1 Rainfall

Rainfall data used in the MUSIC modelling was adopted from Table A24 as per Penrith City Council's WSUD Technical guidelines (Penrith City Council 2015).

Table A2 Rainfall data (Penrith City Council 2015).

Purpose	Time step required	Rainfall Station	Modelling Period
Water quality	6 minutes	67113 Penrith Lakes AWS	1999 to 2008

A.2 MUSIC node assumptions

Penrith LEP data was used to select a corresponding MUSIC land use node type using the NSW MUSIC Modelling guidelines (BMT WBM 2015) shown in Table A25 with the exception of the existing and proposed road footprint where a road MUSIC node was used.

Table A3 Suggested MUSIC Land use Parameters for New South Wales (BMT WBM Pty Ltd 2015)

Standard Instrument Zoning or Surface Type	Suggested MUSIC Land Use
Large Areas of Interest	
Residential - R1, R2, R3	Residential
Residential – R4	Business
Residential – R5	Rural
Business – B1, B2, B3, B4, B4, B8	Business
Business – B5, B6, B7	Industrial
Industrial – IN1, IN2, IN3, IN4	Industrial
Special purposes – SP1, SP2	Industrial
Special purposes – SP3	Business
Recreation – RE1	Residential
Recreation – RE2	Business
Environmental Protection -E1, E2	Forest
Environmental Protection – E3, E4	Rural
Rural – RU1	Quarries
Rural – RU2, RU3, RU4	Agricultural
Rural – RU5	Business
Rural – RU6	Rural

A.3 Rainfall runoff parameters

Default rainfall-runoff parameters for Penrith are shown in Table A26.

Table A4 MUSIC Rainfall-runoff parameters for Penrith Council (Penrith City Council 2015).

Impervious Area Parameters	
Rainfall threshold (mm)	1.4mm
Pervious Area Parameters	
Soil Storage Capacity (mm)	105
Initial Storage (% of capacity)	30
Field Capacity (mm)	70
Infiltration Capacity Coefficient – a	150
Infiltration Capacity Exponent - b	3.5
Groundwater Properties	
Initial depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	10
Daily Deep Seepage Rate (%)	0

A.4 Pollutant parameters

Pollutant parameters were adopted from WSUD Technical guidelines (Penrith City Council 2015), shown in Table A27. For land use categories not included in the table, pollutant parameters from Table 5-6 and 5-7 of NSW MUSIC Modelling guidelines (Table A28, BMT WBM 2015)

Table A5 Stormwater quality parameters for Penrith City Council (Penrith City Council 2015).

Land-use category		**Log10 TSS (mg/L)**		**Log10 TP (mg/L)**		**Log10 TN (mg/L)**	
		Storm Flow	**Base Flow**	**Storm Flow**	**Base Flow**	**Storm Flow**	**Base Flow**
General urban (incl. public open space)	Mean Std Dev	2.15 0.32	1.20 0.17	-0.60 0.25	-0.85 0.19	0.30 0.19	0.11 0.12
Residential							
Industrial							
Commercial							
Road Areas	Mean Std Dev	2.43 0.32	---* ---*	-0.30 0.25	---* ---*	0.34 0.19	---* ---*

Table A6 Baseflow and storm flow concentration parameters for NSW (BMT WBM Pty Ltd 2015)

Table 5-6 Base Flow Concentration Parameters (mg/L-log10) for NSW (adapted from Fletcher et al, 2004)

	TSS		TP		TN	
	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev
Large Areas of Interest						
Residential	1.20	0.17	-0.85	0.19	0.11	0.12
Business	1.20	0.17	-0.85	0.19	0.11	0.12
Industrial	1.20	0.17	-0.85	0.19	0.11	0.12
Rural	1.15	0.17	-1.22	0.19	-0.05	0.12
Agricultural	1.30	0.13	-1.05	0.13	0.04	0.13
Eroding gullies	1.20	0.17	-0.85	0.19	0.11	0.12
Quarries	1.20	0.17	-0.85	0.19	0.11	0.12
Re-vegetated land	1.15	0.17	-1.22	0.19	-0.05	0.12
Forest	0.78	0.13	-1.22	0.13	-0.52	0.13
Small Areas of Interest						
Roofs	n/a	n/a	n/a	n/a	n/a	n/a
Sealed road pavement	1.20	0.17	-0.85	0.19	0.11	0.12
Unsealed road pavement	1.20	0.17	-0.85	0.19	0.11	0.12
Landscaped areas	1.20	0.17	-0.85	0.19	0.11	0.12

Table 5-7 Storm Flow Concentration Parameters for NSW (mg/L-log10) for NSW (adapted from Fletcher et al, 2004)

	TSS		TP		TN	
	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev
Large Areas of Interest						
Residential	2.15	0.32	-0.60	0.25	0.30	0.19
Business	2.15	0.32	-0.60	0.25	0.30	0.19
Industrial	2.15	0.32	-0.60	0.25	0.30	0.19
Rural	1.95	0.32	-0.66	0.25	0.30	0.19
Agricultural	2.15	0.31	-0.22	0.30	0.48	0.26
Eroding gullies	3.00	0.32	-0.30	0.25	0.34	0.19
Quarries	3.00	0.32	-0.30	0.25	0.34	0.19
Re-vegetated land	1.95	0.32	-0.66	0.25	0.30	0.19
Forest	1.60	0.20	-1.10	0.22	-0.05	0.24
Small Areas of Interest						
Roofs	1.30	0.32	-0.89	0.25	0.30	0.19
Sealed road pavement	2.43	0.32	-0.30	0.25	0.34	0.19
Unsealed road pavement	3.00	0.32	-0.30	0.25	0.34	0.19
Landscaped areas	2.15	0.32	-0.60	0.25	0.30	0.19

A.5 Catchment

The road alignment and local catchment area with associated land zoning are shown in Figure A13.

The catchment inputs to the model are provided in Table A29 to Table A9.

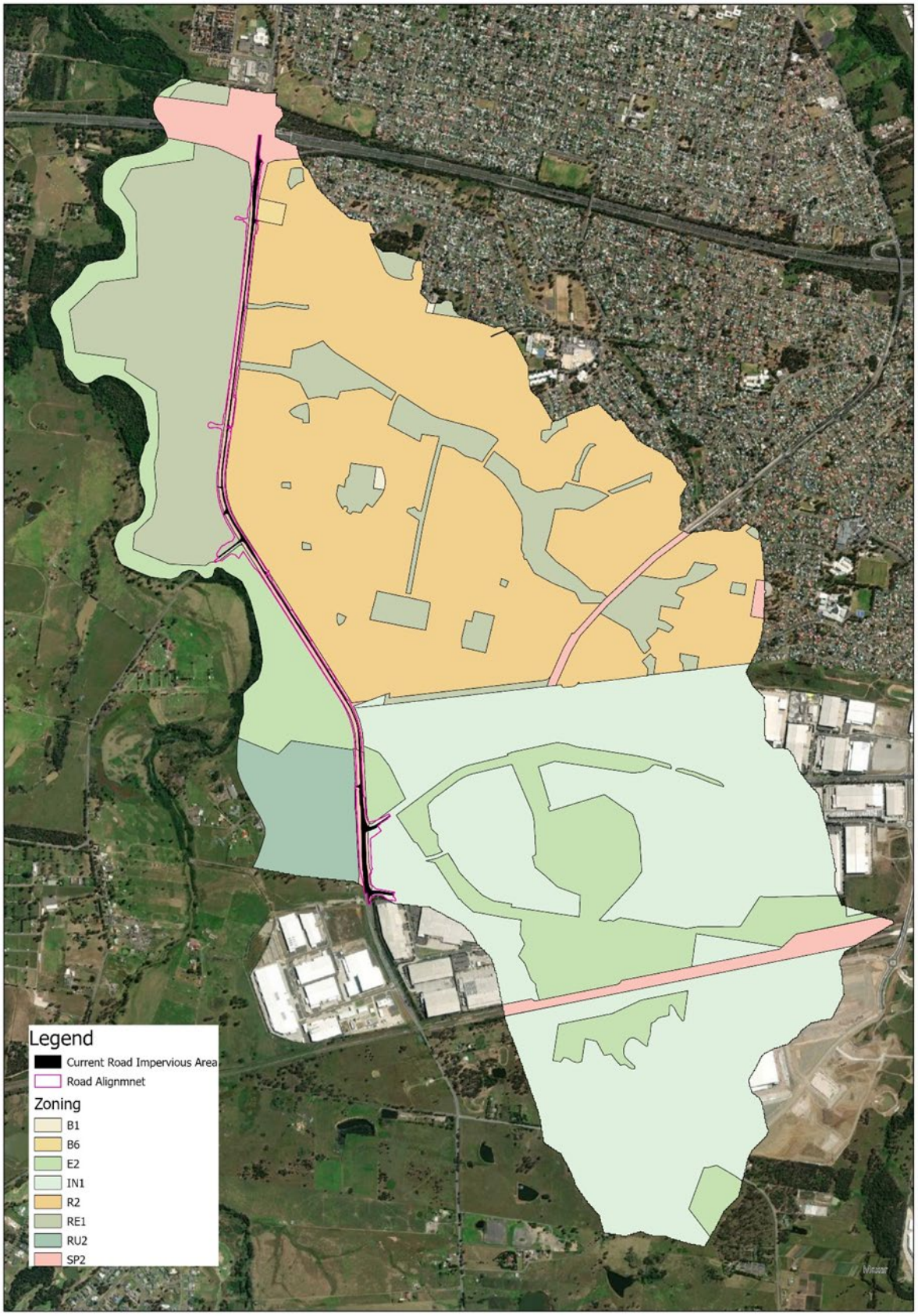

Figure A2 Catchment area for Music model including zoning

Table A7 Road catchment extent - pre- development

Zoning	Land Use (MUSIC)	Total Land-Use Area (TLA) (m2)	Assumed TIA (decimal)	EIA Factor	EIA
E2	Forest	0.93	0	0 X TLA	0
IN1	Industrial	0.90	0.8	0.9 X TIA	0.72
R2	Residential	0.12	0.65	0.6 X TIA	0.39
RE1	Residential	1.91	0	0.6 X TIA	0
RU2	Agricultural	0.003	0.05	0.0 X TLA	0
SP2	Industrial	9.03	0.05	0.9 X TIA	0.05
Road	Road	6.34	1.00	1 X TIA	1

Table A8 Road catchment extent – post development

Zoning	Land Use (MUSIC)	Total Land-Use Area (TLA) (m2)	Assumed TIA (decimal)	EIA Factor	EIA
Road	Road	19.23	0.90	1 X TIA	0.9

Table A9 External local catchment – pre and post development

Zoning	Land Use (MUSIC)	Total Land-Use Area (TLA) (m2)	Assumed TIA (decimal)	EIA Factor	EIA
B1	Business	0.82	0.9	0.8 X TIA	0.72
B6	Industrial	1.64	0.8	0.9 X TIA	0.72
E2	Forest	180.55	0	0 X TLA	0
IN1	Industrial	388.05	0.8	0.9 X TIA	0.72
R2	Residential	404.68	0.65	0.6 X TIA	0.39
RE1	Residential	191.22	0	0.6 X TIA	0
RU2	Agricultural	38.85	0.05	0.0 X TLA	0
SP2	Industrial	43.156	0.8	0.9 X TIA	0.72

Table A10 Treatments for Pre-Development and Post Development

Scenario	Treatment	Approximate percentage of Total Catchment draining to measure (%)	Road area (ha)	Suitable assumption for treatment	Additional info required
Pre-Development	Swale Only Treatment	72	4.61	Swale length	Current swale length = Approx 3250m Base Width = 0.5m Top Width = 3.5m Min Grade = 0.5% Side Slopes = 1 : 5 (V : H)
	No Treatment	28	1.73	NA	NA
Post-Development	No Treatment	47	9.04	NA	NA
	Swale Only Treatment	39	7.50	Swale length	Total swale length = Approx. 1050 m Base Width = 1 m, Top Width = 5m Min. Grade = 0.5% Side Slopes = 1 : 4 (V : H)
	Basin Treatment (Bioretention)	14	2.69	Total Basin footprint	Filter Depth = 300 mm Min, Extended Detention Depth = 300 mm Min. Filter Area = 150 m^2 Min.

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